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ABSTRACT

Using a Danish data set that follows 135,000 Danish children from birth through 9th grade, we examine the effect of maternal employment during a child's first three and first 15 years on that child's grade point average in 9th grade. We address the endogeneity of employment by including a rich set of household control variables, instrumenting for employment with the gender- and education-specific local unemployment rate, and by including maternal fixed effects. We find that maternal employment has a positive effect on children's academic performance in all specifications, particularly when women work part-time. This is in contrast with the larger literature on maternal employment, much of which takes place in other contexts, and which finds no or a small negative effect of maternal employment on children's cognitive development and academic performance.

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I. Introduction

The labor force participation rate of mothers with young children has increased substantially in developed countries over the past 50 years. In the United States, for example, 71% of mothers were working in 2011 (Bureau of Labor Statistics 2012). Given the continued primacy of mothers as the main providers of child care (Bianchi 2000; Bianchi, Milkie, Sayer, and Robinson 2000), these increases in maternal employment lead to concerns about the tradeoffs working mothers must face in terms of time investments in work vs. time spent at home. To increase the quantity and quality of the time mothers spend with their infants, and based on the belief that the early months of a child's life are important for future cognitive and emotional development (Lewis and Brooks-Gunn 1979; Harris 1983), many countries and states have passed laws allowing women to take more paid and/or unpaid leave following their child's birth, including the U.S. in 1993, Canada in 2000, Denmark in 2002, the United Kingdom in 2003 and 2007, and California in 2003. However, what is as yet unknown is how maternal employment over a longer time period causally influences child well-being.

This paper estimates the causal effect of employment among Danish women on one measure of children's well-being: their academic performance in high school. There are several ways that a mother's employment decisions may affect her child's cognitive development and academic performance. First, working generates household income that can be used to purchase inputs that directly or indirectly improve academic performance. Second, all else equal, a working mother will spend less time with her child than one who does not work. Depending on the quality of the time a mother spends with her child and the quality of the alternative, this may either improve or diminish cognitive development. Third, maternal employment may improve academic performance if working mothers serve as positive role models for their children.

A large body of research in the United States has examined the consequences of maternal employment for children (Korenman and Kaestner 2005; Smolensky and Gootman 2003; Blau and Currie 2004; Ruhm 2000, and Haveman and Wolfe 1994). Results are mixed, with some studies showing that maternal employment in the first months of life is associated with small, but significant, declines in children's subsequent cognitive outcomes (Hill, Waldfogel, Brooks-Gunn, and Han 2005), particularly when mothers worked more than 30 hours per week (Brooks-Gunn, Han, and Waldfogel 2002).

A child's characteristics may influence both his mother's labor supply decisions and his academic performance (Ruhm 2004). For example, mothers whose children are not doing well socially or academically may reduce their work hours to invest more time in child-rearing. Conversely, mothers with relatively high ability and education may be both more likely to work and to have children who receive good grades in school. Few of the early papers in this literature developed empirical methods to account for unobserved factors that could be linked to both maternal employment and child achievement. Failure to control for unobserved maternal characteristics is likely to bias estimates of the association between maternal employment and children's subsequent academic outcomes.

A number of recent studies, many of which use data from Europe or Canada, address this concern and attempt to estimate the causal effect of maternal employment on children's cognitive development or academic performance. These studies use methods such as a regression discontinuity or differences-in-differences design to take advantage of changes in maternal leave policies that affect birth cohorts differently (Dustman and Schonberg 2012; Carneiro, Løken, and Salvanes 2011; Rasumussen 2010; Baker and Milligan 2010; Liu and Skans 2010); maternal fixed effects to compare outcomes between children from the same family

(James-Burdamy 2005; Ruhm 2004); comparing the children of parents who lost their job when a plant closed to those who did not (Rege, Telle, and Votruba 2011); or exploiting exogenous variation in labor demand across markets to identify the effect of maternal employment in a structural model (Bernal 2008). The results of these studies are mixed: six studies find that maternal employment (or, in some cases, policies that extend maternal leave) either has no effect or a negligible effect on children's cognitive development, whereas three studies conclude that maternal employment worsens children's cognitive development. Notably, none of these studies concludes that maternal employment improves a child's test scores or academic performance.

Our paper makes several contributions to this literature. First, we take advantage of a unique data set that contains detailed household information and follows 135,000 Danish children who were born between 1987 and 1992 from birth through 9th grade. This allows us to examine the impact of maternal employment over an extended period of time (i.e., a child's first 15 years of life) on an important, long-run outcome: grades in 9th grade. Second, we develop three different methods to address the endogeneity of maternal employment. Third, we explore whether maternal employment improves children's educational performance by increasing the economic resources available for investing in human capital formation.

We address the endogeneity of maternal employment in three different ways. First, we use the extensive data available from the Danish registers to control for many household and children's characteristics that may affect both children's educational outcomes and maternal employment decisions. The registers contain a rich set of measures, including whether a child was born prematurely, had low birth weight or a chronic health condition; the age of the mother when the child was born, and the percentage of the child's first 15 (or three) years that the mother spent in school. Second, we instrument for maternal employment with the female

unemployment rate, conditional on a woman's education level, in her local area in a particular year. Our identifying assumption is that the local unemployment rate affects a child's subsequent GPA by affecting the mother's employment choices only, and does not have a direct effect on GPA through, for example, school funding levels.[1] Third, we use maternal fixed effects to exploit differences in maternal employment between siblings within the same family.

In our preferred instrumental variables specification we find a positive association between the intensity of maternal employment in a child's first three years and a child's GPA at age 15. The child of a woman who worked 10-19 hours per week while her child was under the age of four is predicted to have a GPA that is 2.6 percent higher than an otherwise similar child whose mother did not work at all. The effects of maternal employment are larger when we examine a mother's employment history over the child's first 15 years of life, indicating that the maternal employment effect is cumulative over many years, rather than being focused only on a child's first few years. Including a mother's pre-birth income or contemporaneous income does not materially change the coefficient estimates, which indicates that the beneficial impact of maternal employment does not appear to occur due to greater available household resources. These results stand in sharp contrast to the nine studies cited above, which find no relationship or a negative relationship between maternal employment and a child's cognitive development or academic performance.

The remainder of this paper is divided into six sections. We review the existing literature in Section II and describe social policies that may affect the relationship between maternal employment and children's academic performance in Denmark in Section III. Section IV introduces the unique Danish register data and discusses how these data are superior to survey

[1] In some of the IV specifications we include a full set of locality exposure variables to capture time-invariant differences across markets in the quality of education and ability of students.

data. In Section V we present the three models and discuss the advantages and shortcomings of our instrument and maternal fixed effects. We report the results for all three models in Section VI and conclude in Section VII.

II. Previous Research

One way to address the endogeneity of maternal employment is to include a rich set of household characteristics in an ordinary least squares or propensity score regression. Five recent studies that have taken this approach conclude that there is no association or a negative association between maternal employment and children's cognitive and behavioral development. Four of these studies use National Longitudinal Survey of Youth (NLSY) data from the United States to examine children's verbal and math skills beginning as early as three years of age and continuing thereafter (Baum 2003; Ruhm 2004; Berger, Hill, and Waldfogel 2005; and Ruhm 2008); Berger, Hill, and Waldfogel (2005) also examine a measure of children's externalizing behavior at age four.[2] Baum (2003) and Berger, Hill, and Waldfogel (2005) focus on whether a woman returns to work within 12 weeks of having a baby in order to match the maternal leave length allowed by the U.S. Family and Medical Leave Act (FMLA), whereas the two studies by Ruhm examine maternal employment during a child's first four (Ruhm 2004) or 10 (Ruhm 2008) years of life. A fifth study using this approach finds that the children of women in the United Kingdom who worked full-time in their child's first 18 months of life perform relatively poorly on cognitive tests between the ages of four and seven relative to children of women who worked part-time or not at all (Gregg, Washbrook, Propper, and Burgess 2005).

Two of the five recent OLS/propensity score studies mentioned above found that the association between maternal employment and children's cognitive development differed by

[2] The NLSY administers the Peabody Picture Vocabulary Test (PPVT) to children at age three and four, and the Peabody Individual Achievement tests of Mathematics (PIAT-M) and Reading Recognition (PIAT-R) to children at ages five and older.

household characteristics. The effect of maternal employment was more strongly negative among children of highly educated women (Gregg, Washbrook, Propper, and Burgess 2005) and women with high socioeconomic status (Ruhm 2008). Other studies find that children may fare best when mothers work part-time (Brooks-Gunn, Han and Waldfogel 2002; Ruhm 2008; Hill, Waldfogel, Brooks-Gunn and Han 2005).

One criticism of the above studies is that there may be important unobserved variables, such as the health and cognitive ability of a young child, that affect a woman's labor supply decisions, even with rich data sets such as the NLSY. Nine recent studies address this concern and try to estimate the causal effect of maternal employment on children's cognitive development or academic performance by using a regression discontinuity or differences-in-differences design, maternal fixed effects, or by exploiting plausibly exogenous variation in labor supply due to plant closings or differences across markets in labor demand.

The results of the studies that develop econometric methods to address the endogeneity of maternal employment are mixed: six of these recent studies find that maternal employment or expanding maternity leave either has no effect or a negligible effect on children's cognitive development or academic performance, whereas three studies conclude that maternal employment worsens children's cognitive development. Dustman and Schonberg (2012) find that extending maternity leave in Germany had a negligible effect on the probability of completing high school or on wages. Likewise, expanding maternity leave by six months in Canada had negligible effects on children's motor skills, social skills, and temperament (Baker and Milligan 2010), as did a 1984 policy in Denmark expanding maternity leave by six weeks on subsequent high school enrollment, high school completion rates, and high school grades (Rasmussen 2010). Rege, Telle, and Votruba (2011) find that children whose mothers lost their

jobs in Norway due to a plant closing while the children were in eighth or ninth grade had a similar grade point average in 10th grade as other children.[3] Using maternal fixed effects and NLSY data from the United States, Ruhm (2004) finds no statistically significant effect of maternal employment on children's test scores, and James-Burdumy (2005) finds negative, positive, and no effects depending on the test score used and the particular time period when maternal employment is measured (with the strongest negative effects occurring when mothers were employed in the first year of life).

As mentioned, three studies that attempt to estimate a causal effect of maternal employment report stronger evidence that maternal employment predicts reduced child outcomes than the six reviewed in the previous paragraph. Carneiro, Loken and Salvanes (2011) find that a four-month increase in maternity leave in Norway was associated with a decline in high school dropout rates and an increase in wages, while in Sweden, extended parental leave was associated with improvements in children's educational performance, but only among children with highly educated mothers (Liu and Skans 2010). Finally, Bernal (2008) uses NLSY data to estimate a structural model of children's educational performance and maternal employment, and concludes that full-time maternal employment in the first year reduces children's high school test scores. Notably, none of the 14 studies we review in this Section conclude that there is a beneficial impact of maternal employment on children's cognitive development.

The majority of studies in this area link maternal employment in the very earliest years of life to child outcomes. Only one study (Ruhm 2008), has examined at least 10 years of childhood, comparing earlier vs. later childhood employment effects on child development, finding that it is employment in the first three years of life that has the strongest, and negative, associations with child cognitive development.

[3] These authors find that if a father lost his job due to a plant closing, the child's 10th grade were adversely affected.

III. Maternal Employment and Social Policies in Denmark

In this section we discuss how and why maternal employment might be associated with child well-being in general, and how this may play out given the maternity leave, child care, and other social policies in place in Denmark. Maternal employment in Denmark is among the highest in the OECD. Among mothers of children between the ages of one and three, labor force participation increased from 70 percent in 2002 to 80 percent in 2008, and from 76 percent to 82 percent for mothers of children between the ages of four and six (Authors' calculations). While maternal employment rates are higher in Denmark compared to the U.S., work hours conditional on being employed are lower in part because weekly work hours cannot exceed 37 in Denmark (Greve 2011).

From a child development perspective, maternal employment involves a trade-off between time devoted to parenting and money, both of which should positively influence a child's cognitive development. Studies consistently show that children benefit when economic resources available to a household increase (Duncan and Brooks-Gunn 1997; Duncan, Ziol-Guest and Kalil 2010). Maternal employment patterns may reduce both the quality and quantity of time children spend with parents, which are key ingredients in healthy development (National Research Council and Institute of Medicine 2000). U.S. time-diary data show that working reduces the time mothers spend with children, although mothers protect quality time with children by cutting back least on activities directly engaging children (Bianchi 2000).

However, the time-related linkages between maternal employment and child well-being will be affected by maternal leave policies, the quality of child care available, and restrictions on the number of hours per week people can work once they return to the labor force. Denmark has a generous maternal leave policy. During our sample period (children born between 1987 and

1992), Danish women were entitled to four weeks of paid maternal leave before the delivery; 14 weeks immediately following delivery; and 10 weeks of additional parental leave that could be shared between parents.

Denmark also has a strong system of early care and education (ECE) programs, spending 1.2 percent of its GDP on ECE activities. As a result, Danish households spend on average only eight percent of their income on child care costs; in contrast, the U.S spends 0.4 percent of its GDP on ECE activities, and families spend 19 percent of their income, on average, on child care (Ruhm 2011).[4] Danish child care is provided at the municipality level, with the local governments providing center-based care as well as organizing a system of family-based care in private homes (Datta Gupta and Simonsen, 2010). The staff-to-child ratio in Denmark is among the lowest in the OECD (Datta Gupta, Smith and Verner 2008), indicating a high quality of child care. As a result of this investment, 63 percent of zero to two year olds and 94 percent of three year olds are in some type of formal child care in Denmark.

The extensive paid maternity leave time, relatively lower work hours, and generous ECE system in Denmark suggest that working mothers may face less constrained choices, and therefore the implications of maternal employment for child well-being may differ, compared to those in other countries. The goal of this paper is to examine the linkages between maternal employment and the academic progress of 15 year old Danish teens. Because of the large body of work, noted above, suggesting that maternal employment in the first three years of life has particular implications for child well-being, and a lack of studies examining maternal employment across childhood, we perform separate analyses looking at maternal employment in the first three years, and then in the first 15 years, of childhood. Because of evidence, cited

[4] Denmark ranks second out of all OECD countries, behind only Iceland, on percent of GDP devoted to ECE programs.

above, of non-linear associations between maternal work hours and child well-being, we examine how child GPA differs based on varying intensity of maternal work. Finally, because of studies indicating that the detrimental linkages between maternal employment and child well-being are concentrated among more advantaged mothers (Ruhm 2008), we perform some analyses stratifying our sample by maternal education.

IV. Data

Since 1980, Statistics Denmark has collected and recorded data on all individuals living in Denmark. The registers contain all public transfer payments between individuals and the federal/municipal government, such as income taxes, parental leave benefits, day care subsidies, unemployment benefits, and pension payments. Danish law requires individuals to inform the federal government of their residential location; individuals who fail to comply are not allowed to have a bank account or receive benefits from the state. As a result, the registers contain information on the entire Danish population, with attrition only due to deaths or migration.

Our sample includes all children born in Denmark between 1987 and 1992 to mothers who had at least two children during this time period. We focus on this time period because the registers contain grade point averages (GPA) in 9th grade for these children, which for most Danish children is when they are 15 years of age. We restrict the sample to families with at least two children born in this time period to have a consistent sample between the ordinary least squares, instrumental variables, and maternal fixed effects models (the latter of which, described below, are limited to mothers with at least two children).

The dependent variable in our analysis is a child's GPA in 9th grade. For the measure to be comparable between students, we use a GPA from three 9th grade courses that all Danish students take: Math, English, and Danish. Although some Danish schools offer additional

subjects such as German, French and Chinese, we exclude these grades from the GPA measure because these subjects are taught for only a few hours per week and only in later grades. Each school reports the grades annually to the Ministry of Education, which in turn forwards the information to Statistics Denmark.

In all regressions we include birth-year and birth-month fixed effects to control for national GPA trends in Denmark and age effects within a grade. In most regressions we include a more complete set of control variables, including: indicators for a child's birth order in his/her family, the child's gender, the mother's age when the child was born, and the mother's education the year before the child was born. We measure a woman's education with six separate indicator variables: less than a high school degree, high school degree only, vocational school, short-term further education, bachelor degree, and master's degree or more. We use mothers' age when the child was born, her education, and her pre-birth income as proxies for pre-birth ability. Mothers who have their children early have both a higher probability of dropping out of school and being unemployed.

Maternal labor supply decisions may be affected by the number of children, such that those with more children spend more time in home production, and also by child birth order, as mothers with older children may be able to rely on these children to provide help at home. A woman's decision regarding whether and how much to work following a child's birth may be affected by the child's health (Powers 2001). From the fertility register records we create indicator variables for children who were born prematurely (born earlier than the 37^{th} week), who had low birth weight (less than 2,500 grams), or who have chronic health conditions. The registers include the World Health Organization's (WHO) International Classification of Diseases (ICD) codes for all hospitalizations in Denmark. To classify a child as having a chronic

health condition, we use the same definition of chronic diseases as Christoffersen et al. (2003): diseases that are non-psychological and persistent, such as diabetes. Because the codes do not specify disease severity, we classify children as being chronically ill if they were hospitalized for one or more of the designated chronic diseases between 1987 and 1996, a period when all of the children in our sample were at least five years old.

Although the registers do not record a person's race, they do indicate whether a person immigrated to Denmark or whether the previous generation of the family immigrated to Denmark. We include indicators for whether a child is a first- or second-generation immigrant. We estimate a woman's net income based on her wages and other cash transfers, taking into account interest deductions. In some regressions we control for the mother's income the year prior to a child's birth as an additional control for her ability. Income is measured in thousands of Danish Kroner, where a thousand Kroner is about $170. In unreported regressions we include the average income a woman received over her child's first three (or 15) years rather than her income prior to the child's birth. The latter measure allows us to explore whether maternal employment improves children's cognitive outcomes by increasing the amount of resources available to the household.

Although hours worked are not directly recorded in the registers, using information on the magnitude of certain tax payments, we can place mothers into one of four employment categories in each calendar year: fewer than 10 hours worked per week, on average for that year; between 10 and 19 hours per week; between 20 and 29 hours per week; or 30 hours or more per week. Individuals who work at least one-half of a calendar year will pay the labor market additional pension, referred to as the ATP tax, and the magnitude of this tax allows us to infer their work hours. Thus, we assume that people working less than 10 hours per week are

unemployed. Additional analyses using survey data, not shown here, indicate that the vast majority of mothers classified as working 0-9 hours per week are indeed not working.[5]

Time spent on maternity leave is measured in the registers as being unemployed. During our sample period (children born between 1987 and 1992) Danish women were entitled to less than one-half a year of maternity leave: four weeks before the delivery; 14 weeks immediately following delivery; and 10 weeks of additional parental leave that could be shared between spouses. As a consequence, mothers who used all of their maternity leave during this time period and then worked full-time for the rest of the year will be categorized as working 30 hours or more for the entire calendar year. People who did not make any tax payments and did not receive unemployment benefits are classified as unemployed. This could occur for adults out of the labor force or immigrants who have not yet formalized their citizenship.

We are interested in estimating the effect of a woman's work effort during her child's first three years and first 15 years of life, on the child's grade point average at age 15. To estimate a woman's average weekly hours worked during a child's first 15 years of life (and similarly for the first three year of life), we create four indicator variables for each adult for each calendar year: 1) unemployed; 2) working 10-19 hours per week; 3) working 20-29 hours per week; and 4) working 30 or more hours per week. In some regression specifications we include the percentage of her child's first 15 (or three) years a woman spent in each of these work-hour groups, as follows:

$$av\_work\_0 = \frac{\sum years\ unemployed}{15}$$

[5] We cannot determine the actual work hours if people receive unemployment benefits for at least one-half of a calendar year; additionally, those who work fewer than 10 hours per week do not pay ATP. We assign people who receive unemployment benefits for at least one-half of a calendar year as working between zero and nine hours per week, although some of them may work more than 10 hours per week for part of the year.

$$av\_work\_1 = \frac{\sum years\ working\ 10-19\ hours}{15}$$

$$av\_work\_2 = \frac{\sum years\ working\ 20-29\ hours}{15}$$

$$av\_work\_3 = \frac{\sum years\ working\ 30+\ hours}{15}$$

We observe the full 15-year employment history for 56 percent of the mothers. About 15 percent of the women have missing work hours information in a given year, and this missing rate is fairly constant over the 1987 to 2007 time period when the children in the sample are less than 16 years old. Work hours are missing for women who retire early or drop out of the labor force altogether. Therefore, if a mother has missing work hours information in a given year, we assume that she is unemployed or working less than 10 hours per week in that year. For analyses looking at maternal employment measured over the first 15 years of life, we exclude about five percent of the women who have missing work hour information for all 15 years when their child is under the age of 16. When examining maternal employment over the first three years of life, we exclude 10.6 percent of women who have missing information for all three years when their child is under the age of four.

In some regression specifications we include an estimate of a woman's average hours worked per week over the first 15 years (or three years) of her child's life rather than a series of variables indicating the percentage of years working in each of the four hour categories. This allows us to utilize a continuous work hour variable, which is necessary for the two-stage least squares specification. Because the work hour categories are intervals, for purposes of estimating a continuous employment variable we assign hours in the middle of an interval (e.g., 15 hours per week for women working between 10 and 19 hours per week in a particular year). We

assume that women working 30 or more hours per week actually worked 35 hours, and women working less than 10 hours per week were actually unemployed.

Figure 1 depicts the pattern of maternal employment by a child's age for the first 15 years of a child's life. About 75 percent of Danish mothers worked when their child was one year old, with the majority of the employed mothers working more than 30 hours per week. The percentage of mothers working more than 30 hours per week increases as children age, increasing from 47 percent when a child is one, to 61 percent when a child is five, to 76 percent when a child is 10, and to 82 percent when a child is 15 years old. The percentage of non-working mothers decreases as children grow up; by age 15, six percent of the mothers are unemployed or working less than 10 hours per week. Twelve percent of the mothers work part-time (10 to 19 hours or 20 to 29 hours per week) when children are 15 years old, in contrast to 28 percent when children are one.

In Table 1 we examine common employment patterns for women in the sample. The Table reports the percentage of women by the number of years (out of 15) they spend in a particular work-hour category. Sixteen percent of the mothers worked 30 or more hours every year when their child was under the age of 16, and almost one-half worked 30 or more hours in at least 10 of these 15 years. Thirty-five percent of the women worked fewer than 10 hours (including zero) in at least one of the 15 years, although only one percent worked fewer than 10 hours in 10 or more of the 15 years. Many women worked 10-19 or 20-29 hours at some point when their child was under the age of 16.

Once we omit households with missing values, 119,310 children remain in the analytic data set used to examine a woman's employment in her child's first three years of life, and 134,595 used to examine a child's first 15 years of life. We report sample statistics in Table 2

for the former sample, separately by the average number of hours per week that a mother worked during her child's first three years of life based on the continuous work hour variable. The children of women who work relatively long hours have relatively high GPAs. Women who work relatively long hours also are more educated, are more likely to live in Copenhagen, tend to have children at an older age, and tend to have healthier children. These differences emphasize the importance of controlling for both children's and mother's characteristics in the regression models, and of trying to control for differences across employment categories in unobserved characteristics that affect children's GPAs. We elaborate on our approach to this challenge in the following section.

V. Method

Our basic empirical approach is to regress a child's GPA at age 15 on his/her mother's employment status and work hours during the first three years of the child's life, and separately during the first 15 years of the child's life. The regression coefficient on the maternal employment variable(s) would indicate whether maternal employment is positively or negatively associated with children's school outcomes. In the ordinary least squares regression models, we regress child c's GPA in year t on the mother m's employment status during the child's first three or 15 years of life, and various control variables (X) for the child and mother:

$$(1)\quad Y_{c,m,t} = \beta_0 + \beta_1 H_{m,15} + \beta_2 X_c + \beta_3 X_m + \beta_4 \text{Income}_m + \varepsilon_{c,m,t}$$

We report results where H is either a continuous variable measuring a mother's average hours worked per week over the 15-year period, or a set of variables measuring the percentage of the 15 years a mother spent working fewer than 10 hours a week, between 10 and 19 hours, between 20 and 29 hours, and 30 or more hours. We also report a similar set of results using a mother's

work hours in her child's first three years of life. Standard errors are clustered by household to account for the fact that our data contain siblings.

There are advantages and disadvantages of using a child's grades at age 15 as the outcome measure. If a mother's employment decisions are associated with a child's grades in 9th grade, then these employment decisions are also likely to affect the child's lifetime earnings (Murnane, Willett and Levy 1995). However, it may be difficult to find an association because many factors other than maternal employment will affect a child's performance in 9th grade.

Working reduces the amount of time and/or energy a mother can invest in her child's wellbeing, but increases the ability to invest financially in her child's wellbeing. In some regression specifications we include the mother's income in year t-1, the year prior to the child's birth, in order to control for pre-existing resources the mother has available to invest in the child. In other analyses, we also include a control for income over the child's first 15 years (and three years) in order to account for the fact that a key mechanism through which maternal employment may influence children is through the additional financial resources such employment brings.

The greatest empirical challenge is that a mother's ability and education may be associated both with her work hours, and with her child's grades in school. On the one hand, mothers with greater ability and education may achieve higher status jobs with longer work hours, and also have children with positive educational outcomes (due to differences in genetics, parenting, or other factors between mothers of different abilities and education). On the other hand, mothers with lower ability and education may need to work longer hours in order to make ends meet, and may also have children doing poorly in school. Without controlling for these potentially unobserved maternal characteristics, β_1 is likely to be biased. The sample statistics in Table 2 confirm that in our data set this challenge is real. Children whose mother averaged more

than 30 hours of working per week when the child was under the age of 15 have a 9th grade GPA that is 0.6 points higher than children whose mother averaged fewer than 10 hours of work per week.

We address the endogeneity of maternal employment in three different ways. First, we use the extensive data available from the Danish registers to control for many household and children's characteristics that may affect both children's educational outcomes and maternal employment decisions. To demonstrate the importance of controlling for a rich set of characteristics that are unavailable in some data sets, we first present regression results that control only for birth year and birth month. In subsequent regressions we add the full set of control variables. The controls include both household and child characteristics: child's gender, birth order, mother's education level, the parents' immigration status, whether a child was born prematurely, had low birth weight, or had a chronic health condition when young, and the age of the mother when the child was born. The third regression also includes the mother's income in the year prior to the child's birth as an additional control for the mother's ability.

Our second method of addressing the endogeneity of maternal employment is to instrument for a mother's hours worked in year t with the unemployment rate in her municipality in the prior year among women with her education level. This approach is similar to that of Greve (2011), who uses the Danish register data to examine the effect of maternal employment on child obesity. She shows that a woman's employment status in 1999 (when the children in her sample are three years old) is negatively correlated with the unemployment rate in her municipality. Before a municipal merger reform in 2007 reducing the number of Danish municipalities to 98, Denmark consisted of 271 municipalities, and the unemployment rate ranged from 2.2 to 11.0 across municipalities in 1999. Because we examine employment

decisions for 15 years, we first calculate the average female unemployment rate in a woman's municipality, stratified by education level, over the 15-year period when her child(ren) were under the age of 16. In the first stage of a two-stage-least-squares regression, we regress a woman's average hours worked per week over the 15-year period on the average unemployment rate in her municipality (for women with the same education level), along with the other controls.[6]

The gender- and education-specific unemployment rate in a municipality should affect whether women receive job offers and/or the wages offered conditional on a job offer. Identification in the IV model comes from variation in hours worked due to variation in the gender- and education-specific unemployment rate across markets (when municipality fixed effects are omitted) and across time, and thus to variation in employment opportunities and wages. As we show below, the instrument is negatively correlated with the endogenous variable, average hours worked, and highly significant statistically.

The key identifying assumption is that variation in the female unemployment rate across municipalities and within municipalities over time does not directly affect children's subsequent GPAs, controlling for our rich set of child and household characteristics, other than through the effect on female labor supply. Bernal (2008) makes a similar assumption. One concern is that municipalities with high unemployment rates may have low-quality schools, and thus low student GPAs, due to reduced tax revenues and reduced education funding or due to unobserved characteristics of parents and children who live in such locations. This is not likely to be as great a concern in Denmark as it would be in the United States in that, although local tax revenues are an important financing source for education, at a national level, Denmark provides large federal

[6] For women who live in different municipalities over this time period, we use the relevant unemployment rate for each municipality-year.

transfers from rich to poor localities. Furthermore, the female unemployment rate has a smaller impact on local finances than the male unemployment rate, which we do not use directly in the estimation. Despite the high female labor supply, Denmark has one the most gender-segregated labor markets in the world (Agustin 2011), with women concentrated in relatively low wage day care and teaching. Therefore, we expect the male labor market to exert greater influence on local budgets and school quality than does the female labor market.

Nevertheless, in some specifications we include a full set of municipality exposure variables to account for time-invariant municipality-specific factors that affect student outcomes. In these specifications the maternal employment coefficients are identified by changes over time in a municipality's female, education-specific unemployment rates.

Our third method of addressing the endogeneity of maternal employment is to use maternal fixed effects to control for differences between households in their children's abilities. The maternal employment coefficient in this specification is identified by differences between siblings in a mother's work intensity. Recall that all women in our sample gave birth to two or more children between 1987 and 1992. There are a variety of reasons why mothers' work intensity may vary across siblings; it is possible that these same reasons are also correlated with children's GPA in adolescence. For example, mothers may reduce their work hours for a child with health problems (Neidell 2000; Ruhm 2004). We address this concern by including controls for a child's health status, such as whether he/she had a low birth weight or was hospitalized early in life for a chronic health condition. To the extent that unobserved child health variables are important, however, we would expect the maternal employment coefficients to be biased upward in the maternal fixed effects model.

Relative to the IV method, therefore, the maternal fixed effects models provide less robust evidence of a causal effect of maternal work hours on a child's subsequent educational performance. In some of the maternal fixed effects specifications we also perform supplementary analyses in which we instrument for maternal employment using the municipality- and education-specific unemployment rate, as discussed above.

Another potential concern is that the employment decisions for women who have two or more children in a five-year period may differ from those of women who have only one child, such that the results from the maternal fixed effects model are not generalizable. In Figure 2 we display the 15-year pattern of employment separately for women with a single child born in our sample period (at the top) and women with two children born in the sample period (at the bottom of Figure 2). The employment patterns are similar for both groups of women.

As mentioned, the employment coefficients in the maternal fixed effects regressions are identified by mothers whose employment patterns differ across their children born between 1987 and 1992. In Table 3A we depict mothers' employment patterns during the first three years of their children's lives for mothers' older child (rows) and younger child (columns), based on the continuous work hour variable. About one-third of the women worked an average of 30 hours or more in both their older and younger children's first three years, and 11.7 percent of the women worked fewer than 10 hours on average with both their children.[7] Women generally work slightly more in the early years of their older child's life than in the early years of their younger child's life. For example, 45.4 percent of women averaged 30+ hours per week in the first three years of their older child's life versus 43.5 percent for their younger child. Twenty-two percent

[7] Figure 2 understates the amount of variation because, for example, a woman who works 20 to 29 hours in year 1 and 30+ hours in years 2 and 3 with her older child and 30+ hours for all three years with her younger child will appear in the bottom right cell in Panel A of Table 2. That is, due to averaging work hours across multiple years, some women with variation in work hours appear on the diagonal.

of the women in Table 3A decreased their average hours between their older child's and younger child's early years, whereas 16.9 percent increased their average hours with the younger child. A total of 40% of mothers differed in their work hours across siblings' first three years of life. A similar pattern emerges in Table 3B, which shows variation across siblings in maternal work hours across the first 15 years of childhood. Here, more mothers work 30 or more hours per week with both siblings (44%), and fewer work 0-9 hours per week (6%). A total of 32% of mothers differed in their work hours across siblings' first 15 years of life.

VI. Results

We now turn to results of analyses linking maternal work hours to child GPA at age 15. Coefficient estimates from the ordinary least squares regressions are reported in Table 4. In the first four columns we examine the association between maternal employment in a child's first three years and the child's GPA at age 15; in the remaining columns we examine the association between maternal employment in a child's first 15 years and the child's GPA at age 15. First we report regression results that include a set of variables measuring the percentage of the child's first three years that a woman spent working between 10 and 19, 20 to 29 hours, and 30 or more hours per week relative to the omitted category (percentage of years working fewer than 10 hours per week, including nonwork). This specification allows for a non-linear effect of work hours on children's outcomes. When we only include birth-year and birth-month fixed effects in column one, the coefficients measuring the percentage of the child's first three years that a woman spent working between 10 and 19, 20 to 29 hours, and 30 or more hours per week are all positive and significant relative to the omitted category (percentage of years working fewer than 10 hours per week). The coefficients on the three employment variables increase monotonically as average hours increase.

In the second column of Table 4 we include the full set of control variables previously described. The results indicate that working 10-19 hours per week while a child is under four years of age is associated with a 0.18-point increase in child GPA at age 15, compared to working less than 10 hours per week. The coefficients on the percentage of time working 20-29 hours and 30 or more hours per week have a similar magnitude. The inclusion of the control variables in column two has substantially decreased the employment coefficients. The magnitude of the association between work hours and GPA is relatively small. The mean GPA in the sample is 8.27, suggesting that the child of a woman who worked 10-19 hours per week while the child was under the age of four would be predicted to have a GPA 2.1 percent higher than an otherwise similar child whose mother worked less than 10 hours per week. In Appendix 1 we report coefficient estimates for the full set of control variables that are not reported in Table 4.

In the third column of Table 4, we include a measure of the mother's income one year prior to the year of birth. Although the coefficient on this variable is positive and significant, including it does not change the coefficients on maternal work hours. In unreported regressions we replace this variable with a measure of a mothers' average income during the child's first three years (or first 15 years), and the results are qualitatively similar to those reported in column three.[8] In column four we include a linear hours worked variable in order to facilitate comparisons to the IV specifications discussed below[9].

[8] Results are available from the authors by request.

[9] We also performed analyses including a continuous measure of the average number of hours per week mother worked while her child was under the age of four, as well as a quadratic hours-worked term. The coefficient on a mother's average hours worked per week was positive, significantly different from zero, and indicates that an additional hour worked per week between ages zero and three is associated with a 0.0065-point increase in a child's GPA in adolescence. The predicted magnitude of working 15 hours per week is about 50 percent smaller compared to the specification in column two.

In the final four columns of Table 4 we present results from a similar set of regressions that includes a mother's employment history over the child's first 15 years of life rather the first three years. The coefficients on maternal work hours remain positive and significant, and the magnitudes are larger than when examining maternal employment only in the first three years, suggesting that the effect of maternal employment accumulates for many years over a child's life, rather than being focused only on a child's first few years.

In column six of Table 4, which includes a full set of control variables, the results show that the percentage of time a mother worked 10-19, 20-29, and 30+ hours per week over the child's lifetime are associated with a 0.50, 0.43 and a 0.32-point increase in the child's GPA at age 15, respectively, compared to working less than 10 hours per week. In both columns 6 and 7, child GPA at age 15 is significantly higher when mothers work 10-19 hours per week compared to when she works 30 or more hours per week. A child of a woman who worked between 10 and 19 hours per week is predicted to have a 6.0 percent higher GPA relative to the child of a woman who worked fewer than 10 hours per week. As in the first set of regressions, the maternal employment coefficients are considerably smaller when we include detailed characteristics of the child and mother. And as with the 3-year employment analysis, including a mother's pre-birth income does not substantially change the magnitude of the maternal employment coefficients, nor does including a woman's average income received while the child is under the age of 16 (results not shown). In the final column we include a continuous average hours-worked variable.

We next present results in Table 5 from the two-stage least squares models in which we instrument for a woman's work hours with the female, education-specific unemployment rate in

her municipality during the first three or 15 years of her child's life.[10] The full set of control variables is included in all of the Table 5 specifications. The local unemployment rate is assumed to affect a child's GPA solely through its impact on a woman's labor supply decisions. In each of the six first-stage regressions, the coefficient on the local unemployment rate is negative as expected and significant, and the F-statistics are very large. A one-percentage point increase in the female, education-specific unemployment rate in a woman's locality is associated with a decrease of about 0.05 hours worked per week.

The second-stage maternal employment coefficients are positive, significant, and in the first three columns, are about three times larger than the coefficients from the comparable OLS specifications reported in Table 4. In the first column of Table 5, each additional hour per week of maternal employment during the first three years of a child's life is associated with a 0.015-point increase in a child's 9th grade GPA. The child of a woman who worked an average of 15 hours per week while the child was under the age of four is predicted to have a GPA that is 0.22 points (or 2.6 percent) higher than an otherwise similar child whose mother did not work at all. Adding a mother's pre-birth income in the second column of Table 5 has little effect on the maternal employment coefficient.

In column three we estimate an IV regression where we include a set of variables recording the proportion of a child's first three years or first 15 years that he/she spent in each municipality. If women (and their children) never moved, this would be equivalent to including a full set of municipality fixed effects, in which case the effect of maternal employment would be identified by within-municipality changes over time in the female- and education-specific unemployment rates. Including the municipality variables allows a child's performance in

[10] Because we lag the unemployment rate one year, we actually use the year prior to the child's birth plus the first two years, and so forth for the 15-year analysis.

school to be affected by municipality-specific factors, such as educational quality, and allows this effect to be proportional to the amount of time a child spent in each municipality. The maternal employment coefficient in column three is significantly different from zero and is slightly larger than the coefficients in the first two columns.

In the final three columns of Table 5 we report the IV results when analyzing women's employment histories over their children's first 15 years of life. As with the OLS results, the maternal employment coefficients are about two times larger in the 15-year versus the three-year time period. Based on the specification in column four of Table 5, the child of a woman who worked an average of 15 hours per week while the child was under the age of 16 would be predicted to have a GPA 0.51 points (6.2 percent) higher than an otherwise similar child whose mother did not work at all.

The estimated maternal employment coefficients in the IV models are larger than the OLS estimates. This may be because the IV model estimates a Local Average Treatment Effect (LATE), capturing the effect of maternal employment only for children of the "compliers" -- women whose labor supply decisions were affected by the female-, education-specific unemployment rate in their localities. This measured effect is not necessarily the same as the effect for women whose labor supply decisions were not affected by the local unemployment rate, perhaps because their job offers were not affected by incremental changes in labor demand, or because they had very high reservation wages. Additionally, in Table 2 we show that women who work 30 or more hours per week when their child is less than 16 years old are better educated, have healthier children at birth, and had a higher income before a child's birth than women who work fewer hours. If the former women and their children also have unobserved characteristics that improve a child's educational performance relative to the latter group of

women and their children, then one would expect the IV maternal employment coefficients to be smaller than the OLS coefficients, and perhaps even negative. The pattern that we actually observe indicates that selection appears to work in the opposite direction: conditional on the observed characteristics, women who work a relatively large number of hours appear to have unfavorable unobserved attributes with respect to their children's future educational performance. However, if the effect of maternal employment varies across families, differences between the OLS and IV coefficients would not necessarily address the presence or direction of selection bias. That is, with heterogeneous treatment effects, the coefficients may differ due to differences in the populations for which the effect is estimated.

We report coefficient estimates from the maternal fixed effects regressions in Table 6. The full set of control variables for children and time-varying variables for mothers are included in all of the Table 6 specifications. In the first two columns, the coefficients on the percentage of time a woman spent working between 10-19 hours per week when her child was under the age of four are positive and significant, whereas the coefficients on the percentage of time working 20-29 and 30 or more hours per week are insignificant. The magnitude of the association is about one-third that of the OLS estimate from Table 4: the child of a woman working 10-19 hours per week while the child was under the age of four would be predicted to have a GPA 0.7 percent higher than another child in the same family where the mother worked less than 10 hours per week. The maternal employment coefficient is insignificant in column three when we use a continuous measure of the average number of hours per week a mother worked while her child was under the age of four.[11]

[11] In analyses not shown, we instrumented for a woman's work hours with the gender, education-specific unemployment rate in her municipality. In this specification, the coefficient is identified by variations in the labor market conditions a woman faces between adjacent births and the employment coefficient is insignificant. In these

In the remaining columns of Table 6 we report the maternal fixed effects results when analyzing women's employment histories over their children's first 15 years of life. The coefficients on both the percentage of time a woman spent working 10 to 19 and 20 to 29 hours per week are positive and significant, whereas the coefficient for 30 or more hours is not significantly different from zero. The magnitude of the first two coefficients are about 50 percent smaller than in the comparable OLS specifications, as reported in column seven of Table 4. As before, the maternal employment coefficients are insignificant in column six of Table 6 when we use a continuous measure of the average number of hours per week a mother worked while her child was under the age of 16.[12]

In Table 7 we report coefficient estimates on the maternal employment variable when we stratify the sample by education, examining whether a woman has less than a high school degree (low education) or a high school degree or more (high education). Results are reported separately for the OLS, IV, and maternal fixed effects models.[13] The maternal employment coefficients in the maternal fixed effects models when using a continuous hours worked variable are generally insignificant when stratifying by education, just as they are for the sample as a whole. In the OLS models, the maternal employment coefficients when stratifying by education are similar in magnitude to the full-sample coefficients. In the IV models, however, the maternal employment coefficients are larger for more educated mothers.

VII. Conclusions

In this paper we estimate the causal effect of maternal employment on children's educational outcomes using three different methods. Using detailed data from the Danish

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analyses, the first-stage F-statistic (4.9) is substantially smaller than in the Table 5 regressions, indicating that the instrument is weaker when including maternal fixed effects.

[12] The first-stage F-statistic is 33.0.

[13] The sample size for the entire sample exceeds the sum of the sample sizes of the low-education and high-education sub-samples because we omit women who are missing education information.

administrative registers on over 130,000 children born between 1987 and 1992, we examine the association between a child's grade point average in ninth grade and his/her mother's employment status and work hours during the first three years of the child's life, and separately during the first 15 years of the child's life.

Overall, several patterns emerge. The OLS, IV, and maternal fixed effects models produce a consistent set of results indicating that maternal employment is associated with an increase in children's grades. These effects are strongest for women working 10-19 hours per week. In the IV specification, for example, the child of a woman who worked between 10 and 19 hours per week while her child was under the age of four is predicted to have a GPA that is 2.6 percent higher than an otherwise similar child whose mother did not work at all.

The analysis also indicates that the positive coefficient on maternal employment does not appear to be driven by increased maternal earnings. This result is consistent with many U.S. studies and suggests that rather than being attributable to the additional resources mothers' bring into the household, maternal employment influences children's cognitive development through other channels. Although our data set is not well-suited to test the possible mechanisms, possible explanations include increased access to social support among employed mothers, improved mental well-being among mothers who work, and access to high-quality child care. Future work is needed to better understand the mechanisms that may link maternal employment to improved child outcomes.

The magnitude of the effect of maternal employment differs across the three models, with the maternal fixed effects model producing the smallest and the IV model the largest estimates. A key point, however, is that in none of the three models presented here do we find evidence of a negative association between maternal employment and children's grades. These results stand in

contrast to a series of recent studies that use data from the U.S., Europe, and Canada and report no association or a small, negative association between maternal employment and children's cognitive development.

The beneficial effect of maternal employment is larger when examining a mother's full 15-year work history versus employment in a child's first three years only. This stands in contrast to other work in the U.S. context, which has found that employment in the earliest years of life are more strongly (and negatively) associated with child cognitive outcomes than later employment (Ruhm 2008; Baum 2003; Brooks-Gunn, Han and Waldfogel 2002; Hill, Waldfogel, Brooks-Gunn, and Han 2005). Our results, in contrast, suggest a cumulative association between maternal employment and child GPA, such that it is the accumulation of maternal employment experiences over childhood that matters most (and in a positive direction) for children's success in school.

In the OLS and maternal fixed effects models, the beneficial effect of maternal employment was larger for women working 10-19 hours per week than 20-29 or 30+ hours per week. This is similar to several studies using U.S. data, which find that children's cognitive outcomes are highest when mothers work part-time (Brooks-Gunn, Han and Waldfogel 2002; Ruhm 2008; Hill, Waldfogel, Brooks-Gunn, and Han 2005) typically defined as around 25 hours per week.

We also find evidence that the beneficial impact of maternal employment on children's educational outcomes is stronger among more advantaged households. This differs from a previous study using Swedish data, which find that maternity leave (or non-employment in the earliest years) is associated with improved outcomes only for children of higher-educated mothers (Liu and Skans 2010) and U.S. results showing that the detrimental effects of maternal

employment concentrated among children of more educated mothers (Ruhm 2008). One explanation for this might have to do with the quality of care that children experience when their mothers work. As noted above, the U.S. invests much less in child care quality than does Denmark. It is possible that, for more advantaged U.S. mothers, time at work means that a child substitutes time in enriching home environments for time in lower-quality child care (see Ruhm 2008). Denmark, in contrast, invests a great deal in child care; perhaps there time spent in day care may not differ from the quality of time spent at home for more educated mothers, meaning that other factors may come into play to explain the greater benefits of maternal work for children of more educated mothers. This could include the quality of jobs held by more educated mothers; previous work has shown benefits for children when mothers are employed in more cognitively demanding jobs (Johnson, Kalil and Dunifon 2012). Perhaps more educated mothers, whose jobs may be most enriching, reap the psychological, social or other benefits of employment in ways that benefit their children.

This paper has some limitations that should be noted. As discussed above, we are not able to shed light on the channels through which maternal employment improves children's school outcomes. While the Danish register data has several advantages, particularly its large sample size, it does not contain information on family processes and other factors that may account for the associations we observe. Additionally, we are forced to infer women's work hours from their tax payments. As noted above, comparisons between our assumptions and direct assessments of women's work hours from survey data increase our confidence in these inferences; however, a possibility remains that, for some women, work hours are mis-measured.

Taken together, however, this paper presents evidence of a positive causal linkage between maternal work hours and the GPA of Danish teens. These associations are strongest

when mothers work part-time, and among more advantaged mothers, and are not accounted for by mothers' earnings. In some ways, these findings diverge from the larger body of work linking maternal employment to child outcomes, most of which finds neutral, or small negative associations between maternal work hours and child cognitive development. It is not clear whether our divergent findings are due to the unique situation faced by working mothers in Denmark, which may be more supportive of maternal employment and therefore promote improved child well-being, or whether our findings differ from other studies for sampling or other methodological reasons. Of the previous econometric work in this area, only one (Rasmussen 2010) used Danish data; that study focused only on maternal employment in the earliest weeks of life, while the current study examined a much longer time window. More work is needed to better understand how and why the influence of maternal employment on children may differ in cross-national contexts. However, the current study provides strong evidence, across multiple models, that, for Danish women, maternal employment is associated with improved outcomes for children.

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Figure 1: Maternal Employment during a Child's 1st 15 Years of Life

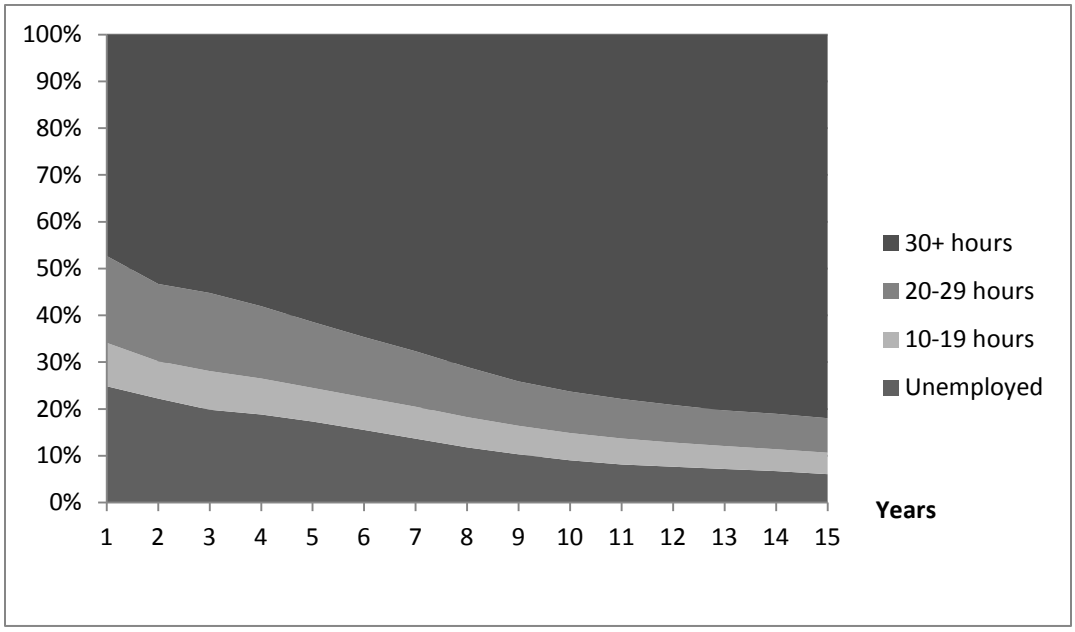
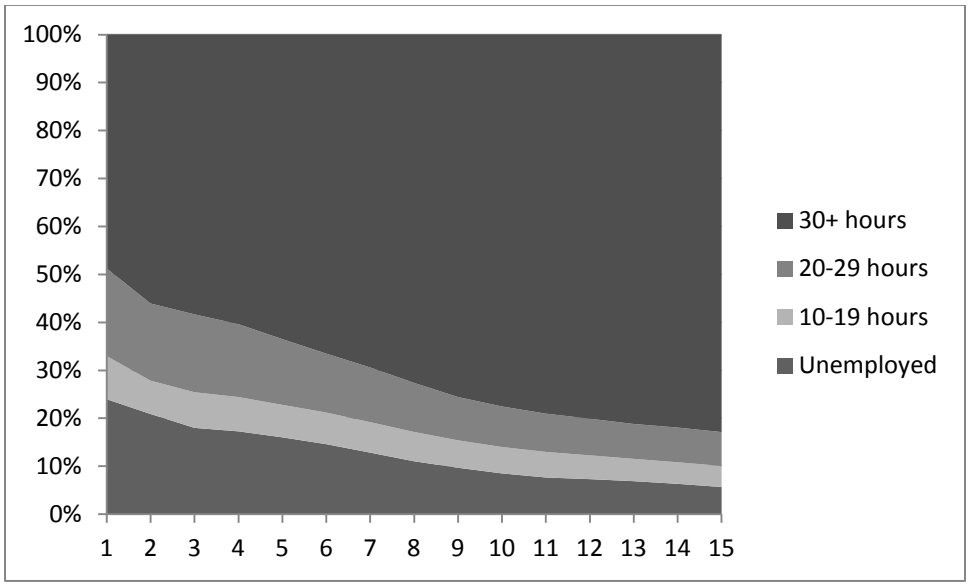


Figure 2: Maternal Employment during a Child's 1st 15 Years of Life

Mothers with One Child



Mothers with More Than One Child

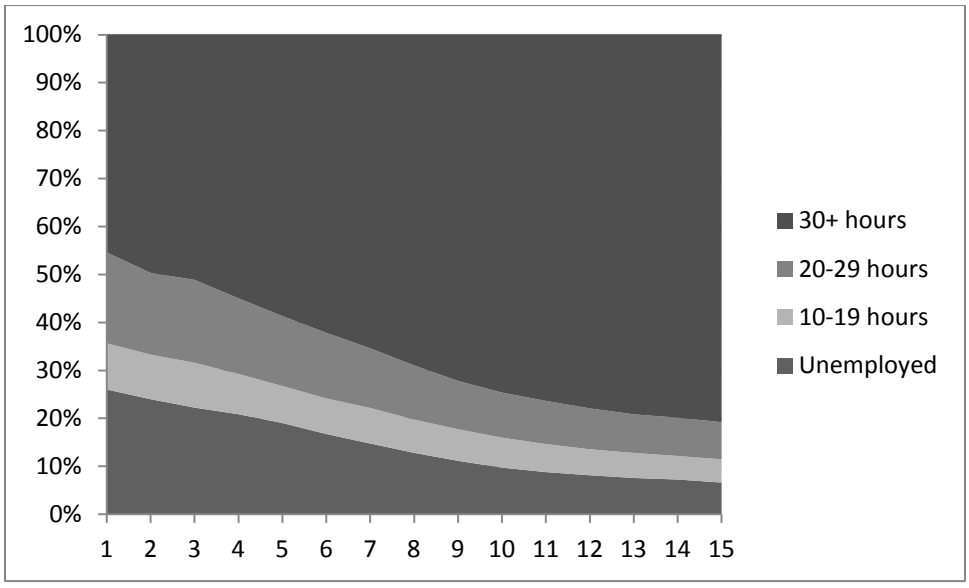


Table 1: Maternal Employment Patterns during a Child's 1st 15 Years of Life

Percentage of Women in the Sample

Years	0 to 9 hours	10 to 19 Hours	20 to 19 Hours	30+ Hours
0	53.3	57.6	40.0	15.1
1	11.4	23.2	23.8	4.17
2	9.58	10.5	15.8	3.65
3	7.44	4.68	9.49	3.54
4	5.61	2.09	5.14	3.54
5	4.13	0.90	2.66	3.65
6	3.01	0.46	1.35	3.85
7	2.11	0.22	0.69	4.29
8	1.39	0.12	0.41	4.56
9	0.92	0.08	0.24	5.04
10	0.56	0.05	0.14	5.43
11	0.31	0.02	0.10	5.66
12	0.15	0.02	0.06	6.10
13	0.08	0.01	0.04	6.87
14	0.03	0.01	0.02	8.47
15	0.01	0.01	0.01	16.1

Notes: this table reports the percentage of women in the sample by the number of years (out of 15) they spent in a particular work-hour category. For example, 53.3 percent of the women never worked less than 10 hours a week in any of the 15 years.

Table 2: Sample Statistics by Level of Maternal Employment

	Mother's average work hours per week the child's first three years				
	0-9 hours	**10-19 hours**	**20-29 hours**	**30+ hours**	**TOTAL**
Observations	23,192	16,710	25,280	54,128	119,310
Children					
Grade point average at age 15	7.89	8.07	8.30	8.48	8.27
Female	0.510	0.504	0.492	0.490	0.496
Born prematurely	0.062	0.052	0.055	0.045	0.051
Low birth weight (<2500 g)	0.063	0.051	0.052	0.043	0.050
Chronically ill	0.060	0.056	0.056	0.052	0.055
Child born in Denmark by non-native parents	0.107	0.046	0.015	0.005	0.033
Mothers					
Elementary school education	0.475	0.395	0.268	0.149	0.272
High school education	0.094	0.120	0.110	0.090	0.099
Vocational school	0.284	0.309	0.339	0.360	0.334
Short-term further education	0.023	0.026	0.035	0.044	0.035
Bachelor's degree	0.050	0.089	0.198	0.290	0.196
Master's degree or higher	0.016	0.023	0.030	0.060	0.040
Missing mothers education	0.058	0.038	0.021	0.008	0.025
Age when child was born	26.1	26.4	27.6	28.5	27.5
Mothers average income (0000)	7.39	7.47	8.24	9.45	8.51
Residing in Copenhagen	0.246	0.233	0.249	0.328	0.282
Residing in a city	0.563	0.566	0.564	0.523	0.546
Residing in a town	0.131	0.137	0.133	0.112	0.124
Residing in the outskirts	0.048	0.050	0.042	0.032	0.040
Missing geography	0.013	0.014	0.012	0.004	0.009

Table 3A: Patterns of Maternal Employment in Child's 1st 3 Years of Life

Percentage of sample by mother's average weekly hours worked in child's first 3 years

		Younger Child				
		0 – 9 hours	10 – 19 hours	20 – 29 hours	30+ hours	Total
Older Child	0 – 9 hours	11.7	3.95	2.20	0.89	18.7
	10 – 19 hours	4.59	4.81	2.71	1.33	13.4
	20 – 29 hours	3.37	4.13	9.01	5.86	22.4
	30+ hours	0.89	1.87	7.21	35.5	45.4
	Total	20.6	14.8	21.1	43.5	100

Table 3B: Patterns of Maternal Employment in Child's 1st 15 Years of Life

Percentage of sample by mother's average weekly hours worked when child < 16 years old

		Younger Child				
		0 – 9 hours	10 – 19 hours	20 – 29 hours	30+ hours	Total
Older Child	0 – 9 hours	6.16	0.54	0.03	0.00	6.73
	10 – 19 hours	1.57	9.09	0.72	0.01	11.4
	20 – 29 hours	0.10	4.75	23.5	0.83	29.1
	30+ hours	0.03	0.05	8.22	44.4	52.7
	Total	7.86	14.4	32.4	45.3	100

Table 4: Ordinary Least Squares Coefficient Estimates

	Maternal Employment in Child's First 3 Years				Maternal Employment in Child's First 15 Years			
Model	1	2	3	4	5	6	7	8
Average hours worked per week (continues)				0.0051**				0.0120**
				(0.00031)				(0.00046)
Categorical work hours % of time working (<10 hours omitted):								
- 10 to 19 hours per week	0.3644**	0.1763**	0.1794**		0.7922**	0.4970**	0.4496**	
	(0.0233)	(0.0209)	(0.0209)		(0.0514)	(0.0467)	(0.0473)	
- 20 to 29 hours per week	0.4650**	0.1489**	0.1480**		0.8714**	0.4329**	0.3948**	
	(0.0168)	(0.0153)	(0.0153)		(0.0323)	(0.0304)	(0.0306)	
- 30+ hours per week	0.6415**	0.1708**	0.1666**		0.9197**	0.3247**	0.2995**	
	(0.0113)	(0.0109)	(0.0110)		(0.0139)	(0.0148)	(0.0151)	
Pre-birth maternal income (000)			0.00315**				-0.00135	
			(0.00130)				(0.00116)	
Observations	119,310	119,310	119,310	119,310	134,595	134,595	134,595	134,595
R^2	0.07	0.22	0.22	0.22	0.09	0.22	0.22	0.23
Full set of control variables	No	Yes	Yes	Yes	No	Yes	Yes	Yes

Notes: The dependent variable is a child's grade point average at age 15. Basic control variables include indicators for birth year and birth month. The full set of control variables also includes child's birth order, child's gender, mother's education, whether the mother immigrated to Denmark, an indicator for whether the child was born prematurely, whether the child was low birth weight (i.e., less than 2,500 grams), whether the child has a chronic health condition, and the mother's age when the child was born.
+ p<.10 *p<.05 ** p<.01

Table 5: Two-Stage Least Squares Coefficient Estimates

	Maternal Employment in Child's First 3 Years			Maternal Employment in Child's First 15 Years		
Model	1	2	3	4	5	6
Average hours per week worked by a mother	0.0145** (0.00168)	0.0153** (0.00187)	0.0171** (0.00320)	0.0342** (0.00278)	0.0365** (0.00307)	0.0476** (0.00499)
Pre-birth maternal income (000s)		-0.00677** (0.00207)			-0.01453** (0.00196)	
Municipality exposure variables	No	No	Yes	No	No	Yes
Observations	119,191	119,191	119,191	134,572	134,572	134,572
R^2	0.21	0.21	0.21	0.20	0.20	0.18
First stage						
Unemployment rate in municipality	-0.0552** (0.00100)	-0.0498** (0.00110)	-0.0449** (0.00148)	-0.0490** (0.00106)	-0.0446** (0.00108)	-0.0430** (0.00167)
R^2	0.21	0.24	0.22	0.32	0.33	0.32
F-statistic	3067	2064	921	2146	1709	666

Notes: the dependent variable is a child's grade point average at age 15. Control variables include indicators for birth year, birth month, child's birth order, child's gender, mother's education, whether the mother immigrated to Denmark, whether the mother lives in an urban or rural area an indicator for whether the child was born prematurely, whether the child was low birth weight (i.e., less than 2,500 grams), whether the child has a chronic health condition, and the mother's age when the child was born.

* $p < 0.10$ **$p < 0.05$

Table 6: Maternal Fixed Effect Coefficient Estimates

	Child's First 3 Years			Child's First 15 Years		
Model	1	2	3	4	5	6
Continuous work hours			-0.00059			0.00041
Average hours per week			(0.00051)			(0.00170)
Categorical work hours						
Percentage of time working (< 10 hours omitted):						
- 10 to 19 hours per week	0.0559**	0.0577**		0.3164**	0.3218**	
	(0.0262)	(0.0263)		(0.1180)	(0.1181)	
- 20 to 29 hours per week	-0.0039	-0.0016		0.1945**	0.2012**	
	(0.0210)	(0.0211)		(0.0904)	(0.0907)	
- 30+ hours per week	-0.0217	-0.0191		-0.00221	0.0052	
	(0.0177)	(0.0177)		(0.0597)	(0.0604)	
Pre-birth maternal income (000)		0.00295*			0.00123	
		(0.00173)			(0.00154)	
Observations	119,309	119,309	119,309	134,594	134,594	134,594
R^2	0.11	0.11	0.11	0.11	0.11	0.11

Notes: the dependent variable is a child's grade point average at age 15. Control variables include municipality fixed effects, indicators for birth year, birth month, child's birth order, child's gender, mother's education, whether the mother immigrated to Denmark, whether the mother lives in an urban or rural area an indicator for whether the child was born prematurely, whether the child was low birth weight (i.e., less than 2,500 grams), whether the child has a chronic health condition, and the mother's age when the child was born.

* $p < 0.10$ **$p < 0.05$

Table 7: Maternal Employment Coefficient Estimates for Sub-Samples

	Child's First 3 Years			Child's First 15 Years		
	n	Coefficient	SE	N	Coefficient	SE
OLS						
- All women	119,310	0.0051**	(0.00031)	134,595	0.0120**	(0.00046)
- Low education	32,430	0.0065**	(0.00057)	36,121	0.0129**	(0.00077)
- High education	83,937	0.0058**	(0.00038)	88,746	0.0114**	(0.00063)
IV						
- All women	119,191	0.0153**	(0.00187)	134,572	0.0365**	(0.00307)
- Low education	32,425	0.0221**	(0.00259)	36,119	0 .0432**	(0.00347)
- High education	83,901	0.0702**	(0.00192)	88,746	0.1286**	(0.00347)
Maternal Fixed Effects						
- All women	119,309	-0.00059	(0.00051)	134,594	0.00041	(0.00170)
- Low education	32,430	0.00047	(0.00096)	36,121	0.00037	(0.00316)
- High education	90,889	-0.0012*	(0.00063)	88,746	-0.00205	(0.00220)

Notes: Each cell in the second and fifth columns reports the coefficient on the average hours per week a mother worked during her child's first three or 15 years of life from a separate regression. The dependent variable is a child's GPA in 9th grade (mean is 8.27). Low education is defined as less than high school; high education is defined as high school or more. The IV coefficients are from the model that does not include municipality fixed effects. When stratifying by gender of the child, we include women who had girls only and (separately) women who had boys only.

* $p < 0.10$ **$p < 0.05$

Appendix 1: OLS Coefficient Estimates on Full Set of Control Variables

Variables	Coefficient	SE
Birth-year indicators		
1987	-0.489	0.0109
1988	-0.500	0.0106
1989	-0.530	0.0098
1990	-0.561	0.0095
1991	-0.481	0.0098
1992 (omitted)		
Birth-month indicators		
January	-0.0185	0.0152
February	0.0052	0.0152
March	-0.0106	0.0147
April	-0.0036	0.0146
May	-0.0355	0.0147
June	-0.0473	0.0147
July	-0.0496	0.0147
August	-0.0645	0.0147
September	-0.0699	0.0149
October	-0.0650	0.0149
November	-0.0262	0.0152
December (omitted)		
Birth order	-0.170	0.0052
Female indicator	0.308	0.0059
Mothers' highest education prior to birth		
No education	-0.334	0.0097
High school	0.431	0.0119
Vocational school		
Short-term further edu.(omitted)	0.323	0.0178
bachelor degree	0.428	0.0097
Master degree or higher	0.752	0.0160
Missing education	-0.134	0.0302
Immigrant parents		
Child born outside Denmark	-0.463	0.1206
Child born in Denmark	-0.324	0.0269
Age of mother when she gave birth	0.044	0.0011
Child has a chronic health condition	-0.096	0.0134
Premature birth indicator	0.038	0.0175
Missing gestation	0.029	0.0435
Low-birth weight indicator (<2.500g)	-0.096	0.0179
Missing low birth weight	0.209	0.0530
Constant	7.49	0.03227

Notes: the dependent variable is a child's grade point average at age 15.