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Non-cognitive development in infancy: the influence of maternal employment and the mediating role of childcare

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NON-COGNITIVE DEVELOPMENT IN INFANCY: THE INFLUENCE OF MATERNAL EMPLOYMENT AND THE MEDIATING ROLE OF CHILDCARE[1]

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ABSTRACT: This paper examines the relationship between maternal employment during infancy and the non-cognitive development of pre-school children. Non-cognitive skills such as self-control, emotional regulation, empathy and patience are at least as important as cognitive skills for personal development and later labour market success.

Drawing on recent advances in the economics literature on the theory of skill formation, this study uses data on Irish pre-school children (Growing Up in Ireland, Infant Cohort) to examine the influence of maternal employment in infancy on children's non-cognitive skills. Propensity score matching addresses the issue of potential selection bias and mediation analysis is used to investigate possible mechanisms for the effect of maternal employment, in particular the role of childcare, parental stress, quality of parent-child attachment and income.

Using the score derived from the Strengths and Difficulties Questionnaire (SDQ) to identify a problematic behavioural score at 3 years, no significant effects are found for maternal employment at 9 months. However, when heterogeneity is investigated, effects are identified for children from less advantaged backgrounds, as measured by maternal education, with full-time maternal employment at 9 months having a significant and detrimental effect on non-cognitive development at 3 years old. This effect is primarily mediated by childcare choices, such that children in informal childcare at 9 months, particularly unpaid grandparental arrangements, are more likely to have behavioural difficulties at 3 years. While parent-child attachment plays a modest role, income and parental stress do not explain the effect of maternal employment on child socio-emotional scores. When selection on observables is used to assess bias arising from selection on unobservables, maternal employment estimates are determined to be a lower bound.

As no adverse effects are found for children from more advantaged backgrounds, policies that support less advantaged families during this sensitive period, such as adequate paid maternity leave and access to quality affordable childcare, should be considered in order to address this inequality.

Key words: non-cognitive skills, socio-emotional, maternal employment, childcare.

JEL Classification: D10, D60, J13, J16, J22

INTRODUCTION

1.1 Maternal employment and non-cognitive development

Female labour force participation among childbearing aged women has risen sharply in most OECD countries, with average participation rates increasing from 54 percent in 1980 to 71 percent in 2010 (OECD Statistics on Employment). Research that contributes to an understanding of the impact of this phenomenon on child wellbeing is important both to facilitate parental investment decisions and to ensure policies are implemented in a manner which protects and promotes child development. An increase in the provision of childcare services has been both a response to and a driver of this increased female labour force participation (Thévenon, 2013), therefore an examination of the role of childcare choices on children's skills is critical to a comprehensive analysis of the effects of maternal employment.

This study focuses on the influence of maternal employment on the development of non-cognitive skills in early childhood. Non-cognitive skills are correlated with measures of intelligence and are at least as important as cognitive skills for personal development and later labour market success (Brunello and Schlotter, 2011). The Five – Factor Model offers a definition of these traits: agreeableness, conscientiousness, emotional stability, extraversion and autonomy (Nyhus and Pons, 2005). Inadequate development of these skills during the sensitive period of early childhood may manifest as behavioural problems, which in turn may signal difficulties later in life. For example, early aggression has been shown to predict criminality and violence in adulthood (Nagin & Tremblay, 1999), and social maladjustment in childhood is a strong predictor of educational attainment and career advancement (Silles, 2010). Therefore, while an understanding of the factors that influence the development of non-cognitive skills is crucial to supporting healthy development, it also has the potential to inform policy decisions over many domains including education, health and justice.

1.2 The Technology of Skill Formation

Building on evidence developed within the field of epigenetics and studies of a number of early intervention programmes (in particular Abecedarian, Perry Preschool and

Chicago Child-Parent Centre interventions), Cunha and Heckman (2007) have developed a body of work which highlights the role of early environmental conditions in the evolution of cognitive and non-cognitive skills. Their theory of the technology of skill formation states that capabilities, both cognitive and non-cognitive, are produced by investments, the environment, and genes. The capability formation process comprises a number of related developmental stages, each of which corresponds to a period in the child's lifecycle. Stages are linked such that inputs in one period produce outputs, which represent changes in capabilities, at the next period. Sensitive periods are stages that are more effective in producing certain capabilities, while critical periods are stages that alone are effective in producing a capability. Capabilities are self-reinforcing and cross-fertilising, defined as "self-productivity". Capabilities produced at one stage of the lifecycle increases the productivity of investment at later stages, and levels of investment in capabilities at different ages bolster each other, a process labelled as "dynamic-complementarity".

Early childhood has been identified as a sensitive period for skill development (Kautz et al., 2014). Given the brain is most flexible early in life (Centre on the Developing Child at Harvard University, 2007), this early plasticity means it is more effective to influence the developing brain architecture during infancy than in later life. Consequently, early investment is most productive as capabilities, cognitive and non-cognitive, can be improved and bolster each other (dynamic-complementarity), and early skill development lays the foundation for further development (self-productivity). Maternal employment in the early years may allow for greater investment in a child, particularly if maternal employment results in a substantial increase in financial resources. However, greater financial investment may come at a cost in terms of a reduction in the investment of maternal time with the child. A critical ingredient at this stage of the developmental process is the "serve and return" relationship between children and their parents and other caregivers, referring to the back and forth non-verbal interactions between an infant and caregiver (Centre on the Developing Child at Harvard University, 2007). Therefore, the impact of the constraint on maternal time may depend on the nature of replacement childcare, in particular the quality of the relationship between the carer and the child and their understanding of the needs of the child. Other factors such as the quality of the mother-child relationship, family

resources and parental skill levels may also play a role in determining the effect of maternal employment. Grossman (1972), in his seminal work, states that greater education should make an individual more efficient at producing health. Cutler & Lleras-Muney (2006) suggest education can affect both behaviour and decision-making. Therefore, maternal education should play an influential role in the production of children's skills and child outcomes may differ based on the level of maternal education. Similarly, non-parental childcare, parental behaviour and family resources could reasonably be expected to mediate the effect of maternal employment on child development.

1.3 The Irish Context

This study uses data on Irish pre-school children to examine the relationship between maternal employment when a child is 9 months old and non-cognitive skills at age 3. While female labour force participation in Ireland is slightly below the OECD average, the increase in participation over the past 25 years surpasses the OECD average. In 1983, 40 percent of Irish women worked outside the home, with this figure rising to 67 percent in 2007 (Russell et al., 2009). A rise in the cost of living over this period, in particular the cost of housing, has meant that parental employment decisions in the early years are influenced by financial commitments and the challenge of sourcing affordable childcare. Institutional support in Ireland for parents combining parenthood with employment is limited (Barry and Sherlock, 2008), and childcare costs are among the highest in the OECD (OECD, 2011), while parental leave is unpaid. Government expenditure on pre-school care and education stands at 0.4% of GDP, well below the UNICEF target of 1% (UNICEF, 2008), and much of this spending is in the form of universal cash payments to parents, not linked to means or employment status. Most centre-based childcare is provided by the private sector and is typically expensive and of inconsistent quality (Barry and Sherlock, 2008). In addition, regulation is focused on basic health and safety rather than the quality of the staff or curriculum provided (Johnston Molly et al., 2014). The limited availability of subsidised childcare[2] for low-

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[2] With effect from January 2010, a free pre-school year was introduced, providing all children with one year of early care and education prior to the commencement of school. The provision consists of 3 hours per day, 5 days a week over a 38-week year or 2 hours and 15 minutes per day, 5 days a week over a 50-

income families has resulted in an inequality in access to quality formal centre-based care and a reliance on informal, often unpaid, childcare arrangements. While maternity leave entitlements have improved, restrictions on this entitlement coupled with the problem of accessing affordable quality childcare has led to an inequality in the early years' experience of children in Ireland during this sensitive period that is likely to impact skill development.

1.4 Literature

A key challenge within the literature on the influence of maternal employment and childcare on child outcomes is the ability to establish a causal relationship. If mothers who work and/or use non-parental childcare differ from those that do not in ways that may influence the non-cognitive development of the child, then the estimated effects may be biased by these unobserved traits. Similarly, reverse causality, such that a child's development may influence a mother's decision to work and/or her choice of childcare, may also bias the estimates. Therefore, studies that address such potential endogeneity are likely to produce more robust results.

Relying on a rich set of control variables to address potential unobserved selection bias and controlling for childcare type and intensity, del Carmen Huerta et al. (2011) use ordinary least squares (OLS) and logit estimators to examine data from five OECD countries (the UK, Australia, Canada, United States and Denmark). Assessing the impact of the timing of a mother's return to employment on both cognitive and behavioural development, the authors find a small effect for British children only, such that children of mothers in the UK who returned to work within 6 months of the child's birth are more likely to experience behavioural problems. Formal childcare and pre-school participation is associated with poorer behavioural outcomes in some countries, yet the associations are small but long-lasting. The authors state that formal childcare participation and parenting activities often have a greater influence on child outcomes than maternal employment, yet results often depend on the age of the child on first

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week year or a variation involving 3 or 4 days a week depending on what the parents choose. However, the children in this study are not as yet old enough to avail of this care.

entering childcare, the extent of usage, the type of childcare, and country of residence, with country-specific institutional factors likely to play a role.

Exploiting the quasi-experimental opportunity provided by the introduction of a subsidised childcare programme in Quebec, Baker et al. (2005) use a difference-in-difference estimator to investigate the impact of this policy and find that subsidised childcare resulted in poorer outcomes for children aged 0 to 4 in terms of behaviour and health. A later paper by Baker et al. (2015) finds that these negative effects persist into the early school years, from the age of 5 to 9 years, and find a significant worsening in self-reported health and life satisfaction among teens exposed to this childcare programme. This study also finds an increase in criminal behaviour among this cohort, relative to their peers in other Canadian provinces, with these negative effects impacting boys only. (Kottelenberg & Lehrer (2014) use both difference-in-difference and change-in-change (Athey and Imbens, 2006) estimators to investigate whether the negative findings of Baker et al. (2005) vary by the age of entry into childcare. They find that early enrolment has a negative impact on motor-social developmental scores, parental report of child health, and behavioural outcomes, with the exception of hyperactivity and inattention scores, which have a negative relationship for entry at age 4, though not at an earlier age. This study suggests that the timing of both entry to and use of childcare matters.

Instrumental variable (IV) techniques can prove effective in isolating selection bias, however the challenge of finding a suitable instrument means that IV techniques are rarely applied in this field. One study uses access to kindergarden based on the level of state spending on pre-kindergarden programmes as an instrument. Magnuson et al. (2007) apply an IV estimator to US data and find that formal childcare prior to kindergarten results in greater behavioural problems on entering school. In a second study using an IV approach, Gupta and Simonsen (2010) use variation in the level of guaranteed access to the provision of municipally provided preschool in Denmark as an instrument to assess the impact of childcare at age 3 on outcomes at age 7. While no effect is found for the sample as a whole, this study does identify some heterogeneous effects, such that family day care usage, referring to care by a childminder in their own home, compared with home care by a parent is associated with higher difficulties scores

for boys with mothers with low levels of education. No such effect is found for formal childcare. As Baker et al. (2005), Kottelenberg & Lehrer (2014) and Magnuson et al. (2007) all use North American data, institutional factors may explain the differing impact in European settings.

Evidence from other disciplines support the conclusion that childcare in the first 12 months is associated with more behavioural problems such as externalising problems (Jacob, 2009; Belsky, 2001; NICHD ECCRN, 2003). Comparing informal care with formal care at 9 months, Hansen and Hawkes (2009) find that children cared for by grandparents have higher difficulty scores. However, psychologists Lombardi & Colley (2014) utilise propensity score weights and find no association between later behavioural problems and maternal employment prior to 9 months. This study also investigates whether maternal time, stress and wages play a mediating role between maternal employment and child outcomes and find no evidence in support of this.

1.5 The contribution of this study

This study contributes to research on the impact of maternal employment and childcare in a number of areas. Firstly, much of this body of research emanates from North America. However, with country specific factors such as maternity leave entitlements, supports for working parents, and the extent and quality of childcare services, likely to exert an influence on child development, research from countries with different social systems makes a valuable contribution. Secondly, much of the economics literature has focused on the influence of maternal employment and childcare on the development of cognitive skills. Yet, following the seminal work of Heckman et al., (2007), attention has now been drawn to non-cognitive skills. This study adds to this emerging, but as yet, relatively modest body of literature. Thirdly, many of the studies in this field utilise data on children born over 20 years ago (e.g. Gregg et al., 2005; Baker et al., 2005; Lefebvre et al., 2000; Gupta et al., 2010), while the present study utilises data from the infant cohort of the Growing Up in Ireland (GUI) study, which gathers data on children born between 1 December 2007 and 30 June 2008. The nature of maternal employment and childcare has evolved substantially over the last few decades, thus the GUI data reflects current circumstances. Fourthly, this study adopts methodological strategies that

underpin the robustness and validity of the findings. Propensity score matching reduces potential selection bias by yielding a cohort that is balanced in respect of measured covariates. Mediation analysis helps to understand the factors that may channel the effects of maternal employment on non-cognitive skills. The calculation of a ratio that determines how large the selection on unobservables would need to be in order to attribute the effect of maternal employment to selection bias (Altonji, Elder & Taber, 2005a) allows the reader to interpret the robustness of the results to this threat.

3. DATA AND METHODOLOGY

3.1 Growing Up In Ireland

This study uses data from the Infant Cohort of the Growing Up in Ireland (GUI) study. The 11,134 participant children were selected randomly from the 41,185 children born between 1 December 2007 and 30 June 2008 as per the Child Benefit Register. This study uses data on participants who responded to both wave 1 (sample size of 11,134), when the child was 9 months, and wave 2 (sample size of 9,793), when the child was 3 years of age. Population weights are used, where appropriate, to account for between wave attrition (See Williams et al. , 2013 for more details).

3.2 Non-Cognitive Skills – Strengths & Difficulties Score (SDQ)

Non-cognitive skills are measured using the score derived from the Strengths and Difficulties Questionnaire ("SDQ score") at age 3. This questionnaire is a parent completed instrument, widely used to assess child socio-emotional behaviour (Goodman, 1997). The questionnaire comprises of 25 items, covering five domains of behaviour: hyperactivity, emotional symptoms, conduct problems, peer problems and pro-social behaviour. Each item has a choice of one of three response categories – "not true" (0), "somewhat true" (1) and "certainly true" (2). A total difficulties score is calculated from the addition of the scores for the first 4 domains i.e. excluding pro-social behaviour. A score of 17 or greater is defined by Goodman (1997) as abnormal or "problematic", while a score of 14 to 16 is classified as "borderline". In this study, 4.4% of children can be described as problematic, while a further 7.1**%** fall within the

borderline category. For the purpose of this analysis a child with a score of 14 or greater is seen to be at risk, and is described as having a high SDQ score.

3.3 Maternal Employment

Utilising self-reported work status when the child is 9 months old, maternal work status[3] is categorised as home-duties (39%), part-time employment (21%), full-time employment (27%), and mothers on leave but planning to return to work (13%). Binary variables are constructed from these classifications for both the mediation analysis and propensity score matching. Additional maternal employment covariates treated as baseline covariates for estimation purposes include a binary indicator of unemployment at 9 months, whether the mother worked prior to this birth and the average hours worked pre-birth. Maternal employment status at 3 years, categorised as at home, part-time, full-time and maternity leave, is also controlled for.

3.4 Choice of Baseline Covariates

Baseline control variables split by maternal employment status at 9 months are detailed in both Table 1 and Appendix 1 (more detailed), and include child and birth characteristics, maternal characteristics and family characteristics. This latter category includes the work status of the father at 9 months and 3 years and the father's education level. However, due to the extent of missing data on fathers, indicator categories are utilised to signify missing data, ensuring the sample size is not compromised. However, as a robustness check, multiple imputation is also utilised to impute missing data.

Baseline covariates also include variables identified as potential mediators measured at 9 months, with the exception of childcare and income variables, due to multi-collinearity concerns.

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[3]Maternal Employment: Home-duties (3,693), which includes those unemployed (292) and on long term illness (59); part-time (1,946), includes those on state training schemes (42); full-time (2,582), includes full-time students (142); and with the fourth category relating to mothers on leave but planning to return to work (1,252).

3.5 Potential Mediators

There are a number of mechanisms through which the influence of maternal employment on child development may be manifested and mediation analysis is used to assess the role of these potential mediators as measured both at 9 months and 3 years. All potential mediators are selected due to their prominence in the literature on child development.

3.5.1 Childcare

Non-parental childcare replaces maternal care with that of another caregiver, and may also expose a child to a new environment. This is important as evidence suggests that early environmental conditions directly affect the expression of genes that control the development of the brain and the nervous system (Weaver et al., 2004). The absence of appropriate sensitive interactions can result in deficits in the brain's architecture, which in turn leads to disparities in learning and behaviour. More specifically, the quality of the care relationships a child is exposed to, be they maternal, paternal or non-parental, can directly influence the child's response to stress, as expressed by the epigenomic state of a gene (Weaver et al., 2004).

40 percent of 9 month olds in this study are in some form of childcare, the majority (94%) of whom have a mother who is employed. Yet, 31 percent of children with working mothers are cared for at home by a parent. As there is no measure of childcare quality in the data, childcare type is used as a proxy for quality, where the reference category is children cared for at home by a parent or in childcare for 8 hours or less per week (60%). The second category includes "Informal" care and comprises of children cared for by a childminder, relative other than a grandparent, or friend in either the child's or carer's home (15%); the third category refers to children cared for by a grandparent (14%), with the final category referring to children cared for in a centre-based setting, which is labelled "Formal" care (11%). A further variable indicates whether or not the childcare is paid, and may also serve as a proxy for quality. Finally, the number of hours in childcare is also controlled for. While childcare variables at 9

months are key explanatory variables in this study, all childcare variables at 3 years old are also controlled for[4].

3.5.2 Quality of Attachment Score/Parent-child relationship

Parent-child attachment is another channel through which maternal employment may influence a child's development. The purpose of attachment is to make a child feel safe, secure and protected (Benoit, 2004), and low levels of attachment in early childhood can result in long term problems. For example, children raised in institutional care have been found to exhibit low levels of attachment security to their primary caregiver (Almas et al., 2012), experience more social problems later in life (Erol et al. 2010), and report no specific friendships (Roy et al., 2004). While a child's experience in institutional care does not compare with the experience of non-parental childcare, these findings clearly illustrate that secure attachment is fundamental to the healthy development of a child.

The 'Quality of Attachment' subscale used in the GUI study is a construct of 9 of the 19 items from the full Maternal Postnatal Attachment Scale (Condon & Corkindale, 1998). When the child is 9 months, mothers are asked about their feelings towards their infant and about themselves as parents. Response categories for each question varies between three and five but all are re-scored to range between one and five before calculating a total score. At 3 years of age, the Pianta CPR-S is used, a fifteen-item measure that reflects both positive and negative aspects of the parent-child relationship. It produces a *Positive Aspects* subscale and a *Conflicts* subscale. All scales are utilised in the mediation analysis to determine if the effect of maternal employment is channelled through the parent-child relationship.

3.5.3 Income

Recent research has highlighted the role of family income in the formation and evolution of children's non-cognitive skills (Fletcher and Wolfe, 2012). Becker and Lewis (1973) show that greater family resources typically lead to a greater investment

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[4] Mediation analysis is initially carried out using a binary indicator for any form of non-parental childcare for more than 8 hours per week. Further analysis is then carried out using a detailed categorical variable for childcare by type, further categorised by paid/unpaid in order to identify heterogeneity in effects.

in children, increasing the marginal cost of children. Higher income may lead to fewer children and a higher standard of living for the family, with access to better health services, education, nutrition, and recreational activities. Maternal employment increases the financial resources within a family and therefore may lead to greater levels of investment in a child, which in turn may facilitate the development of non-cognitive skills. Therefore, the mediation analysis investigates the role of family income in channelling the effects of maternal employment. In the absence of data on maternal earnings, equivalised family income in quintiles at both 9 months and 3 years of age is investigated as a possible mediator. This relates to the income of the household from all sources, including employment and social welfare payments, adjusted for the number of people in the household. As income is endogenous to working, these variables are utilised only in the mediation analysis in order to avoid the issue of multicollinearity.

3.5.4 Stress

Balancing the dual role of mother and employee may prove stressful for many employed mothers (Chatterji et al., 2011). Parental stress has been associated with adverse outcomes for children including insecure attachment and behavioural problems (Crnic and Low, 2002). Therefore, stress may act as a mediator for the effects of maternal employment on non-cognitive skill development. However, McBride (1990) suggests each of these roles provides a context for social interaction and feedback valued by women, which may offset the potential stresses of increased time and energy demands. The GUI study utilises the Parental Stress Scale, assessed when the child is 9 months, which is a self-reported scale measuring positive and negative aspects of parenthood. It comprises a Total Parental Stress Score as well as four subscales: Parental Rewards (6 items); Parental Stressors (6 items); Lack of Control (3 items); and Parental Satisfaction (3 items). At three-years the *Parental Stressors* subscale was also included. This study focuses on the responses at 9 months and 3 years as provided by the mother.

3.6. Methodology

Using the baseline covariates, Ordinary Least Squares (OLS) and Probit regression analysis are used to examine the impact of maternal employment on the SDQ score and likelihood of the study child having a high SDQ score (>=14) and propensity score

matching is utilised to address selection bias. Results are divided into sub-groups based on low (42%) and high (58% - minimum of post-secondary school qualification) maternal education. Mediation analysis is then applied, assessing each of the potential mediators individually, to understand how any identified effects are channelled.

As maternal employment and child outcomes may be influenced by endogeneity, propensity scare matching (PSM) helps to reduce any potential bias. PSM has the advantage of being intuitively easy to understand, while making no assumption on the functional form of the relationship between the outcome and covariates (Dehejia and Wahba, 1999). Those who receive a treatment i.e. maternal employment, are matched with those that do not receive a treatment but have a similar probability of being treated based on observable characteristics. As this approach does not address selection on unobservables, causal estimates may not be produced using PSM. However if selection is on observables only or, in the case where unobservable characteristics influence the selection into maternal employment, the balancing on observables also balances on these unobservables.

Variables that are not affected by participation in the treatment (Caliendo and Kopeinig, 2005) are used in the estimation of the propensity score. These variables are then evaluated to assess the quality of the matching process, with a maximum standardised difference between the two groups of 5% often deemed acceptable[5]. Once the propensity score is calculated, radius matching with a caliper (distance) of 0.01 is used to match the treated with the control group[6]. Each treated observation is matched with all counterfactuals within the caliper, with each counterfactual observation within the caliper weighted equally. An untreated observation may be matched with more than one treated observation and, while all treated observations within the area of common support are matched, this may not be the case for all observations in the control group. Appendix 2 details the selection of matching estimator and the results of tests of the

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[5] The standardised difference is the absolute difference in sample means divided by an estimate of the pooled standard deviation of the variable. Variables with a difference substantially greater than 5% are excluded from the final estimation of the propensity score

[6] With the exception of nearest neighbour without replacement, results are robust to the choice of matching estimator and caliper.

level of bias after each estimation. Once matched, the final estimation includes controls for all baseline covariates.

Mediation analysis is utilised to understand the channels through which the effects of maternal employment at 9 months on the probability of a high SDQ score at 3 years may operate. A variable functions as a mediator to the extent that it accounts for the relationship between a predictor and a dependent variable (Baron and Kenny, 1986). For example, choice of childcare may explain the effect, either partially or entirely, of maternal employment on the SDQ score. Multicollinearity of maternal employment and childcare may be a concern when both variables are included in a regression and result in a reduction in the power of the test for significance. Therefore, Baron and Kenny (1986) advise that it is important to examine both the significance and the absolute size of these coefficients. This study utilises the Sobel-Goodman Test (Sobel, 1983), a calculation that examines whether a mediator carries the influence of an independent variable to a dependent variable and also provides an approximate significance test for the indirect effect of the independent variable on the dependent variable via the mediator[7].

4. RESULTS

4.1 Descriptive Statistics

Descriptive statistics by maternal work status at 9 months are presented in Table 1[8]. The mean SDQ score and the probability of a high SDQ score is lowest for children of mothers working full-time and those on leave, indicating less socio-emotional and behavioural problems among these children. However, there are a number of key differences between these groups that must be accounted for in order to ascertain the true effect of maternal employment.

Full-time working mothers have the highest level of educational attainment, are more likely to be from a household classified as professional/managerial, have fewer children,

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[7] See Appendix 3 for full description of Mediation Analysis.
[8] A more detailed table is presented in Appendix 1.

are older when they have their first child, have a lower incidence of depression and have the highest average equivalised household income, which may be expected as income is endogenous to working. Mothers on home-duties have the highest rate of smoking, single parenthood and chronic illness. They are also most likely to have lived in a family that had difficulty making ends meet when they were aged 16.

TABLE 1 - DESCRIPTIVE STATISTICS SPLIT BY MOTHER'S EMPLOYMENT STATUS AT 9 MONTHS						
		ALL	HOME	PART-TIME	FULL-TIME	ON LEAVE
	N	9751	3802	1994	2650	1272
	%		39%	20%	27%	13%
SDQ score		7.79	8.31	7.71	7.35	7.24
SDQ score >=14		12%	14%	11%	9%	9%
Potential Mediators						
Child Care at 9 months						
At home with Mother		60%	95%	30%	18%	87%
Informal		15%	2%	28%	29%	6%
Grandparent		14%	2%	28%	26%	4%
Formal		11%	2%	15%	27%	4%
Childcare paid at 9 months		31%	3%	50%	68%	9%
Childcare hours at 9 months		10.61	0.70	14.00	26.41	2.26
Child Care at 3 years						
At home with Mother		49%	72%	39%	27%	40%
Informal		15%	5%	20%	24%	18%
Grandparent		9%	3%	14%	14%	9%
Formal		27%	20%	28%	35%	33%
Childcare hours at 3 years		12.9	5.5	13.4	21.9	15.6
Childcare paid at 3 years		45%	24%	52%	65%	54%
Equivalised Household Income at 9 months		21,839	16,309	22,215	27,491	25,624
Equivalised Household Income at 3 years		18,334	14,408	18,644	22,121	21,522
Maternal Quality of Attachment 9 months		42.55	42.78	42.55	42.17	42.68
Parent child relationship at 3 years - Positive score		33.80	33.72	33.81	33.88	33.86
Parent child relationship at 3 years - Conflict score		15.60	15.96	15.57	15.17	15.16
Maternal stress at 9 months		12.35	12.72	12.19	12.31	12.13
Maternal stress at 3 years		14.61	14.98	14.33	14.30	14.57
Baseline Covariates (see Appendix 1 for full list)						
Workstatus at 3 years						
At Home		42%	77%	20%	13%	31%
Part-time		28%	14%	59%	23%	34%
Full-time		23%	6%	15%	54%	23%
Maternity leave		6%	2%	7%	10%	11%
Non-Irish Ethnicity		19%	26%	14%	15%	12%
Age at first pregnancy		27.2	25.6	27.4	28.2	29.3
Age when study child is 9 months		31.9	31.3	32.2	31.8	33.5
Maternal Education						
Up to leaving Certificate		43%	60%	41%	28%	29%
Degree Level		38%	30%	41%	44%	44%
Postgraduate		19%	10%	18%	28%	27%
Chronic illness (Mother)		11%	15%	9%	8%	12%
Mother ever depressed		16%	20%	14%	13%	14%
Mother worked before pregnancy		78%	52%	99%	97%	88%
No. of siblings at 9 months		0.99	1.28	0.96	0.63	0.90
Household Class						
Never worked		10%	23%	1%	4%	0%
Unskilled & Semi-skilled		9%	15%	8%	5%	5%
Skilled & Non-manual		30%	32%	35%	24%	27%
Professional/Managerial		51%	30%	56%	68%	68%
Partner		89%	83%	14%	94%	94%

4.2 Regression Analysis [9]

Table 2 reports the results from both OLS regressions estimating the impact on the SDQ score of maternal employment and probit regressions estimating the probability of a child having a high SDQ score (>=14), with a high score indicating an increased probability of behavioural problems. While none of the employment categories are significant at the aggregate level, when split by low and high maternal education, full-time maternal employment has a negative and statistically significant effect on SDQ scores for children with mothers with higher levels of education suggesting that children from these families have less problems. A similar significant effect is found for children of mothers who are employed but have yet to return to employment. In contrast, children of mothers with low levels of education that work full-time at 9 months, have a 5% increased likelihood of a high SDQ score.

TABLE 2 - OLS AND PROBIT (MARGINAL EFFECTS) RESULTS SPLIT BY EDUCATION

		TOTAL SDQ SCORE (OLS)			PROBABILITY OF SDQ SCORE >=14 (PROBIT)		
		ALL	LOW MATERNAL EDUCATION	HIGH MATERNAL EDUCATION	ALL	LOW MATERNAL EDUCATION	HIGH MATERNAL EDUCATION
N		8,858	3,695	5,163	8,858	3,695	5,163
Maternal Workstatus at 9 months (versus at home)							
Part-time Employment		0.135	0.338	-0.212	0.015	0.039	-0.008
		[0.186]	[0.296]	[0.220]	[0.013]	[0.025]	[0.012]
Full-time Employment		-0.031	0.356	**-0.465****	0.015	**0.051***	-0.008
		[0.187]	[0.318]	[0.221]	[0.013]	[0.027]	[0.012]
On Leave		-0.053	0.391	**-0.520****	-0.001	0.006	-0.012
		[0.190]	[0.328]	[0.218]	[0.014]	[0.026]	[0.012]
Note: All baseline controls included							

[9]The full regression analysis is detailed in Appendix 4. Multiple imputation was carried out with equivalised income, parental stress, quality of attachment, maternal depression, maternal drinking and drug taking while pregnant initially imputed. A further imputation was then carried out, adding Father's education and workstatus to the variables imputed. Neither specification altered the size of the maternal employment coefficients, though part-time employment at 9 months for the low education subsample is significant at the 10% level under the latter specification.

4.3 Propensity Score Matching

Propensity score matching (PSM) estimation is applied to the low and high maternal education subsamples. Table 3 displays the results for each category of both PSM and marginal effects probit models for 3 binary treatment models – full-time employment versus mother at home, part-time employment versus mother at home and full-time employment versus mother working part-time.

TABLE 3 - PROPENSITY SCORE MATCHING - PROBABILITY OF HIGH SDQ SCORE (>=14)												
	LOW MATERNAL EDUCATION						HIGH MATERNAL EDUCATION					
	Probit (mfx)	PSM	Probit (mfx)	PSM	Probit (mfx)	PSM	Probit (mfx)	PSM	Probit (mfx)	PSM	Probit (mfx)	PSM
Fulltime v Home	0.060** [0.029]	0.040* [0.021]					-0.005 [0.013]	-0.011 [0.014]				
Parttime v Home			0.051* [0.027]	0.017 [0.021]					-0.008 [0.014]	-0.014 [0.014]		
Full v Part					0.016 [0.024]	0.03 [0.020]					-0.003 [0.011]	0 [0.011]
Covariates:												
Full set of baseline controls included in analysis plus maternal and paternal employment at 3 years												

The outcome measure is the probability of having a high SDQ score, and is estimated within the matching logarithm using marginal effects probit. Results report the treatment effect on the treated when compared with the counterfactual control group. Consistent with earlier finding for binary SDQ, PSM does not result in any significant effects for children of mothers with higher levels of educational attainment. However, full-time maternal employment by mothers with low levels of educational attainment is associated with a higher risk of a child reporting a high SDQ score when compared to mothers at home[10] (PSM: 0.04, Probit (mfx): 0.06) and part-time maternal employment is significant only in the probit model (Probit 0.05). Full-time versus part-time employment by these mothers is not significant under either estimation.

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[10] Effect sizes are consistent under multiple imputation though full-time employment for the low maternal education subsample is not significant.

4.4 Mediation analysis

As maternal employment is significant for children of mothers with low levels of education only, mediation analysis is applied to this subsample, with results for potential mediators measured at 9 months detailed on Table 4. The marginal total effect is significant at the trend level for both childcare and quality of attachment, though neither the indirect or direct effect is significant for either. The Sobel-Goodman Test (Sobel, 1983), which examines whether a mediator carries the influence of an independent variable to a dependent variable, calculates that 51% of the total effect of full-time maternal employment on the probability of a high SDQ score was mediated by non-parental childcare at 9 months and a more modest mediation effect of 7% for quality of attachment.

FULL MEDIATION ANALYSIS - LOW MATERNAL EDUCATION

OUTCOME: PROBABILITY OF HIGH SDQ SCORE (>=14)		POTENTIAL MEDIATORS			
		Childcare	Income	Stress	Quality of Attachment
Fulltime v Home & Mediator	Path A	1.328***	0.48***	-0.247	-0.769***
		[0.038]	[0.060]	[0.369]	[0.142]
Mediator	Path B	0.014	-0.002	0.005	-0.004
		[0.011]	[0.008]	[0.001]	[0.003]
Fulltime v Home (no mediator)	Path C	0.0372*	0.041*	0.036*	0.040*
		[0.022]	[0.023]	[0.023]	[0.022]
Fulltime v Home (with mediator)	Path C'	0.018	0.042*	0.037*	0.037*
		[0.0269]	[0.024]	[0.022]	[0.022]
Sobel-Goodman: Percentage of total effect mediated		**51%**	-2%	-3%	7%

Covariates:

Full set of baseline controls included in analysis, plus maternal and paternal employment at 3 years.
Sample weights not applied to sgmediation analysis in STATA.

Measures of income and parental stress were not found to mediate the effect between maternal employment and a high SDQ score for this low education subsample. These findings are consistent with research from the US (Brooks-Gunn et al., 2010; Lombardi and Coley, 2014).

4.5 The Role of Childcare

To further investigate the mediating role of childcare for children of mothers with low levels of education, a categorical variable of paid/unpaid childcare by type of care is used to determine if the childcare effect is specific to a particular type of care. The results of this probit regression are detailed in Table 5, with unpaid grandparental care increasing the risk of a high SDQ score by 7 percent at 9 months.

TABLE 5 - CHILDCARE BY TYPE				
OUTCOME: PROBABILITY OF SDQ SCORE >=14 (MFX PROBIT)		ALL	LOW MATERNAL EDUCATION	HIGH MATERNAL EDUCATION
	N	8,852	3,692	5,160
Childcare at 9 months (base: At home with parent)				
Informal Unpaid		0.03	0.02	0.04
		[0.031]	[0.046]	[0.045]
Informal Paid		-0.03**	-0.02	**-0.03***
		[0.013]	[0.029]	[0.01]
Grandparent Unpaid		0.03	**0.07***	0
		[0.021]	[0.038]	[0.0167]
Grandparent Paid		0	0	0
		[0.018]	[0.035]	[0.016]
Centre Based Care		-0.02	0.01	**-0.02***
		[0.014]	[0.036]	[0.011]
Note: All baseline controls included plus maternal employment at 9 months and 3 years				

44.5 percent of children in childcare within this low maternal education category are cared for by a grandparent at 9 months, 57.5 percent of whom are unpaid. If paid childcare can be viewed as a proxy for quality, it would appear that unpaid grandparental care when a child is 9 months old is detrimental to the non-cognitive development of young children. This analysis also highlights that utilisation of paid informal and formal childcare by mothers with higher levels of education has a beneficial effect, reducing the probability of a high SDQ score by 3 and 2 per cent respectively.

4.6 Selection on Unobservables

Altonji, Elder and Taber (2005a) propose a theory that uses the degree of selection on observables as a measure of the degree of selection on unobservables, and provide a

method to quantitatively assess the degree of omitted variable bias. A measurement of the amount of selection on observables is used in the calculation of a ratio that determines how large the selection on unobservables would need to be in order to attribute the entire effect of maternal employment to selection bias[11].

Applying this methodology to the current study, a negative bias for the effect of full-time maternal employment by less well educated mothers of 0.68 is estimated (Table 6). This implies that maternal employment is negatively related to ε_i as a result of the negative correlation between maternal employment and the observable determinants of behavioural problems. The coefficient on full-time maternal employment could therefore be viewed as a lower bound, such that maternal employment may increase the risk of a high SDQ score by at least the effect estimated in these results. Ruhm (2004) similarly concludes that, once a particularly comprehensive number of controls for non-random selection into maternal employment have been included, remaining omitted variable bias may lead to underestimates of the adverse effects of maternal employment.

TABLE 6					
Estimates of bias of the effects of Maternal Employment based on the Altonji et al. Methodology (Limited Probability Model)					
OUTCOME: Probability of High SDQ score at 3 years of age					
Treatment	Sample	OLS Estimate	Significance	Estimated Bias	Implied Ratio
		(1)	(2)	(3)	(4)
Full-time Employment v Home	All	0.03	No	-1.23	-0.02
Full-time Employment v Home	High Maternal Education only	-0.01	No	-0.59	0.02
Full-time Employment v Home	**Low Maternal Education only**	**0.05**	**10%**	**-0.68**	**-0.08**
Part-time Employment v Home	All	0.01	No	-0.69	-0.02
Part-time Employment v Home	High Maternal Education only	-0.01	No	-0.46	0.03
Part-time Employment v Home	Low Maternal Education only	0.04	No	-0.38	-0.09

Note 1: Beta: coefficient on binary treatment with full controls, child's SDQ as outcome measure, population weights applied and no imputation

Note 2: As estimated bias is negative, selection on unobservables would have to be of the opposite sign to selection on observables for true effect of maternal employment to be zero. Therefore, effect of maternal employment on increasing risk of a High SDQ score may be understated.

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[11] For a detailed description refer to Appendix 5

5. DISCUSSION

These results suggest that children of employed mothers from less advantaged backgrounds, as measured by maternal education, have an increased risk of socio-emotional problems in early childhood, as indicated by the elevated risk of a high SDQ score. Much of this effect is mediated by childcare, in particular the use of unpaid grandparental care at 9 months. Consistent with the theory of the technology of skill formation which states that capabilities are produced by investments, the environment, and genes (Cunha and Heckman, 2007), many of these families may be unable to invest in quality childcare, resulting in a sub-optimal environment for child development during this sensitive period.

While these findings are consistent much of the international literature (Jacob, 2009; Belsky, 2001; NICHD ECCRN, 2003; Gupta and Simonsen, 2010), they may be somewhat explained by the institutional context of employment and childcare in Ireland, in particular inequality in both maternity leave entitlements and access to childcare. While mothers in employment prior to the birth of a child are entitled to state sponsored maternity benefit for 26 weeks subject to certain conditions, some employers at their own discretion, particularly professional and large organisations, pay top-up payments to maintain salary levels throughout this period. However, these additional benefits are linked to high quality employment and are therefore largely available to better educated mothers, allowing them to maintain their financial resources through this period and to maximise the value of their maternity leave. These women are also likely to benefit from job protection while on leave. In addition, employed mothers are entitled to a further 16 weeks of unpaid leave on the expiration of their paid maternity leave, such that the majority of employed higher educated mothers return to work during or on the expiration of their unpaid leave. However, mothers with lower education levels may not be in a position financially to avail of this unpaid leave. Indeed, 26% of low educated working mothers return to work by the time their child is 5 months old compared with 17% of mothers with higher levels of education.

Despite the rise in female employment in Ireland, policy initiatives have not supported equal access to affordable childcare. While some subsidised community childcare places

are available to those on very low incomes, formal childcare in Ireland is largely privatised and expensive (OECD, 2014). Families from lower SES backgrounds have more limited childcare options in the first year when compared with their better resourced well educated counterparts, and are more reliant on unpaid childcare, in particular care provided by grandparents. 22% of low educated mothers in the GUI study state that their choice of childcare is determined by financial constraints, compared to 12% of mothers with higher levels of education. Consequently, many children from such resource-constrained backgrounds do not benefit from the structured care of qualified professionals in formal settings. Childcare accessibility may also limit access to employment for many of these mothers, with 11% of mothers with low education levels stating that difficulty in arranging childcare has prevented them from looking for a job (5% for the high education category) and 8% state they have turned down or left a job due to such difficulties (also 5% for the high education category).

This paper is subject to some limitations due to data availability. Like most studies in this field, childcare quality is unmeasured and information on the work status of mothers is limited. Despite these limitations, this study makes a valuable contribution to the international literature for a number of key reasons. Firstly, mediation analysis improves the understanding of the relative roles of maternal employment and childcare, while also clearly illustrating that income and stress are not mechanisms through which the effects of maternal employment on non-cognitive development are mediated. This analysis also shows that the quality of the parent-child relationship plays a modest role as a mediator. The use of propensity score matching which estimates results consistent with the probit analysis, allows potential selection bias to be minimised. The application of the methodology to assess selection bias derived by Altonji et al. (2005) suggests that the results for maternal employment should be viewed as a lower bound estimate. Finally, as GUI data relates to children born in 2007/2008, these findings reflect current working and childcare experiences.

This research concludes that maternal employment and childcare choices during infancy have adverse implications for the non-cognitive development of children from less advantaged backgrounds, as measured by maternal education. However, there is no

evidence that maternal employment or childcare use by well-educated mothers has an adverse effect on children at this early stage of child development. Policies that narrow the gap for families from less advantaged backgrounds should be considered. However, Heckman et al. (2013) comment that non-cognitive improvements are critical to the long-run impact of childcare programmes on outcomes for children, so the provision of childcare services through either targeted or universal programmes must be of sufficient quality to ensure these skills are adequately developed.

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APPENDIX 1- DETAILED DESCRIPTIVES

DESCRIPTIVE STATISTICS SPLIT BY MOTHER'S EMPLOYMENT STATUS AT 9 MONTHS						
		ALL	HOME	PART-TIME	FULL-TIME	ON LEAVE
	N	9751	3802	1994	2650	1272
	%		39%	20%	27%	13%
SDQ score		7.79	8.31	7.71	7.35	7.24
SDQ score >=14		12%	14%	11%	9%	9%
Potential Mediators						
Child Care at 9 months						
At home with Mother		60%	95%	30%	18%	87%
Informal		15%	2%	28%	29%	6%
Grandparent		14%	2%	28%	26%	4%
Formal		11%	2%	15%	27%	4%
Childcare paid at 9 months		31%	3%	50%	68%	9%
Childcare hours at 9 months		10.61	0.70	14.00	26.41	2.26
Child Care at 3 years						
At home with Mother		49%	72%	39%	27%	40%
Informal		15%	5%	20%	24%	18%
Grandparent		9%	3%	14%	14%	9%
Formal		27%	20%	28%	35%	33%
Childcare hours at 3 years		12.9	5.5	13.4	21.9	15.6
Childcare paid at 3 years		45%	24%	52%	65%	54%
Equivalised Household Income at 9 months		21,839	16,309	22,215	27,491	25,624
Equivalised Household Income at 3 years		18,334	14,408	18,644	22,121	21,522
Maternal Quality of Attachment 9 months		42.55	42.78	42.55	42.17	42.68
Parent child relationship at 3 years - Positive score		33.80	33.72	33.81	33.88	33.86
Parent child relationship at 3 years - Conflict score		15.60	15.96	15.57	15.17	15.16
Maternal stress at 9 months		12.35	12.72	12.19	12.31	12.13
Maternal stress at 3 years		14.61	14.98	14.33	14.30	14.57
Workstatus at 3 years						
At Home		42%	77%	20%	13%	31%
Part-time		28%	14%	59%	23%	34%
Full-time		23%	6%	15%	54%	23%
Maternity leave		6%	2%	7%	10%	11%
Child & Birth Characteristics						
Study Child Female		49%	50%	49%	49%	49%
Study child is non-singleton		3%	4%	3%	2%	4%
Study child was preterm		6%	7%	5%	6%	9%
Caesarean Section		26%	24%	26%	27%	28%
Child in poor health at birth		3%	4%	2%	3%	4%
Child in poor health at 9 months		1%	1%	1%	1%	1%
Child temperament scores (9 months)						
fussy		14.83	15.25	14.80	14.39	14.51
unadaptable		8.97	9.37	8.85	8.53	8.86
dull		5.85	5.80	5.83	5.86	5.96
unpredictable		6.15	6.14	6.12	6.15	6.21

	ALL	HOME	PART-TIME	FULL-TIME	ON LEAVE
Maternal Characteristics					
Mother Unemployed at 9 months	3%	8%	0%	0%	0%
Non-Irish Ethnicity	19%	26%	14%	15%	12%
Age at first pregnancy	27.2	25.6	27.4	28.2	29.3
Age when study child is 9 months	31.9	31.3	32.2	31.8	33.5
Maternal Education					
Up to leaving Certificate	43%	60%	41%	28%	29%
Degree Level	38%	30%	41%	44%	44%
Postgraduate	19%	10%	18%	28%	27%
Chronic illness (Mother)	11%	15%	9%	8%	12%
Mother ever depressed	16%	20%	14%	13%	14%
Mother worked before pregnancy	78%	52%	99%	97%	88%
Mother's workhours before pregnancy	29.4	21.2	32.3	38.1	32.0
Maternal poverty (Age 16)	20%	23%	19%	18%	16%
Mother smoked while pregnant	16%	22%	15%	12%	12%
Mother drank alcohol while pregnant	21%	18%	22%	23%	25%
Mother took drugs while pregnant	2%	2%	2%	1%	1%
Family Characteristics					
No. of siblings at 9 months	0.99	1.28	0.96	0.63	0.90
Father's Workstatus at 9 months					
Working	72%	61%	75%	80%	80%
Unemployed	7%	10%	5%	6%	4%
Missing	21%	29%	19%	14%	16%
Father's Workstatus at 3 years					
Working	66%	55%	70%	76%	75%
Unemployed	11%	15%	9%	8%	7%
Missing	23%	30%	21%	17%	17%
Father's Education					
Up to leaving Certificate	40%	40%	42%	41%	34%
Degree Level	26%	21%	25%	30%	31%
Postgraduate	13%	10%	13%	15%	20%
Missing	21%	29%	19%	14%	16%
Household Class					
Never worked	10%	23%	1%	4%	0%
Unskilled & Semi-skilled	9%	15%	8%	5%	5%
Skilled & Non-manual	30%	32%	35%	24%	27%
Professional/Managerial	51%	30%	56%	68%	68%
Partner	89%	83%	14%	94%	94%
Local Authority Housing	8%	13%	6%	3%	3%
In receipt of Social Welfare	21%	33%	18%	9%	14%
Neighbourhood Deprivation					
Low	45%	43%	46%	49%	43%
Medium	48%	47%	49%	47%	52%
High	7%	10%	6%	4%	5%
Urban	43%	45%	40%	43%	47%
Marriage Quality Score	2.87	3.03	2.75	2.80	2.73
Has good support	72%	64%	78%	79%	74%
Family live nearby	64%	61%	70%	65%	62%
Living with Grandparents	3%	3%	4%	4%	2%
English/Irish household language	94%	90%	95%	96%	97%

APPENDIX 2 - PROPENSITY SCORE MATCHING

Choice of Matching Estimator, Selection of Variables for PSM estimation & Bias Reduction

Propensity score matching was used on three configurations of maternal employment, as detailed by Table 4. However, in order to ensure the most appropriate matching estimator is applied, a number of estimators were tested, using full-time maternal employment as the treatment and Mother at Home as the counterfactual.

Variables that are not affected by participation in the treatment (Caliendo and Kopeinig, 2005) are used in the estimation of the propensity score. These variables are then evaluated to assess the quality of the matching process before MI, with a maximum difference between the two groups of 5% deemed acceptable.

Propensity scores were estimated using a probit model and three types of matching methods were assessed. The radius-caliper method matches each treatment child to all children in the control group with an estimated propensity score within a particular caliper (distance). As this method matches treatment observations with controls within the specified caliper, is allows for usage of extra units when good matches are available, thus oversampling and avoiding the risk of bad matches. A possible problem with this method is that it's difficult to determine a priori what tolerance level is reasonable (Smith & Todd, 2005). For this reason 3 difference calipers were applied (0.01, 0.001, 0.1) and results from each were broadly consistent, though the bias reduction was smallest for the largest caliper.

The second method applied was nearest neighbour (NN) matching, with the treatment child matched with the child in the control group with the nearest estimated propensity score. This method was initially applied with no replacement, which produced the most limited reduction in bias, such that the method was deemed inappropriate. This method of matching is sensitive to the order in which matching occurs and while it may reduce variance, it does tend to lead to a higher bias. 3 formulations of nearest neighbour matching were then applied with replacement, firstly matching with replacement to the single nearest neighbour, then to the nearest 5 and 10 control observations using a

uniform weight. All 3 versions of NN matching with replacement produced satisfactory reductions in bias levels.

The final matching estimator, the kernel density estimator, matches each student to a weighted average of all observations in the comparison group, with each observation in the comparison group weighted inversely proportional to the difference between the observations estimated propensity score and the propensity score of the treatment child. While this methodology results in a lower variance as more information is used (Caliendo & Kopeinig, 2005), this can be at the expense of bad matches. 6 versions of the estimator are applied, the first simply applying the kernel distribution and the second the normal distribution, both giving satisfactory results. However, as the match should be within the area of common support, the remaining third version imposes this condition, as does the fourth, while also imposing a normal distribution, again giving similar results. Finally, 2 bandwidths are applied in the fifth and sixth version of 0.01 and 0.001 respectively, with results identical to the fourth estimation, such that there is no sensitivity to the imposition of the limit of a bandwidth.

Based on its comparability to most estimators and its success in reducing bias, radius-caliper matching with a calliper of 0.01 was selected to perform all matching. Equivalised family income and childcare are excluded from the estimation of the propensity score due to endogeneity concerns. Where appropriate, other variables were excluded from the propensity score estimation if they had a bias greater than 5%. All baseline covariates are included in the final post-matching estimation, including the relevant covariates at 3 years.

TABLE A3.1   PROPENSITY SCORE MATCHING - ASSESSMENT OF QUALITY OF ESTIMATORS

	UNMATCHED % BIAS	RADIUS CALIPER			NEAREST NEIGHBOUR				KERNAL					
						Replacement					Kernel Normal & Common Support	Normal & Common Support	Normal, Common Supoprt	Normal, Common Supoprt
		0.01	0.1	0.001	No replacement	1	5	10	Kernel	Normal			BW 0.01	BW 0.001
Maternal Ethnicity	-16.7	-2.2	-2.3	1.7	-8.8	-1.9	-1.3	-1.5	-1.7	-1.9	-1.7	-2	-2	-2
Maternal Chronic Illness	-25.1	0.1	-1.2	3.8	-6.7	4.5	-3.5	-2.7	-0.03	4.5	-0.3	4.6	4.6	4.6
Household Class	73.5	-1.2	5.2	-2.3	32.7	-10.2	-4	-2.4	0.1	-10.2	0.1	-10.4	-10.4	-10.4
No if siblings at 9 months	-64.9	5.8	0.2	5	-9	0.1	6.4	7.1	3.2	0.1	3.4	0.1	0.1	0.1
Gender (Female)	-2.3	2.1	-0.7	4.6	-4.9	2.6	2.8	1.6	-1.6	2.6	-0.9	5.6	5.6	5.6
Non-singleton	-10.0	-13	-2.9	-4.8	-4.9	-4.1	0.2	0.2	-2.2	-4.1	-2.3	-4.2	-4.2	-4.2
Pre-term	-0.3	-6.9	-7.5	-6.2	-2.2	-4.9	-5.4	-7.9	-6.3	-4.9	-8.5	-7.9	-7.9	-7.9
C Section	10.0	3.4	4.5	0.5	4.6	3	5.9	5.6	3.2	3	4.1	6.4	6.4	6.4
Child health at birth	-2.8	-1.6	-2.5	-4.4	-3	-6	-3.9	-2.4	-2.1	-6	-2.1	-6.1	-6.1	-6.1
Child health at 9 months	-7.1	-2.6	-4.2	1.5	1.7	1.7	-4	-5.9	-5.9	1.7	-6	1.7	1.7	1.7
Social Welfare	-58.7	-1.5	-4.4	-0.6	-19.1	-1.7	-0.5	-1.9	-2.4	-1.7	-2.4	-1.7	-1.7	-1.7
Area Deprevation	-24.5	-1.3	-1.9	-0.1	-7	0.2	-1.5	-3.2	-1.6	0.2	-0.8	-0.9	-0.9	-0.9
Urban	-3.7	-1.1	1.3	1.3	2.6	-2.9	-2.3	-1.5	0	-2.9	0.1	-0.9	-0.9	-0.9
Mother worked before birth	113.8	6.1	8.8	7.8	11.8	6.8	6.5	6.3	6.8	6.8	7	7	7	7
Mothers work hours before birth	49.8	-0.3	-0.9	6.6	11.9	1.3	-4	-7.4	-7.2	1.3	-7.2	1.2	1.2	1.2
Maternal Poverty age 16	-16.6	5.8	4.9	2.3	-1	6.1	6.3	3.5	6.1	6.1	6	5.9	5.9	5.9
Sufficient support	40.2	-0.3	1.6	1.4	14.2	1.7	-0.6	-0.9	-0.2	1.7	-0.2	1.7	1.7	1.7
Family nearby	15.1	7	7.5	-1.3	6.9	10.7	9.9	7.8	7.6	10.7	7.7	11.6	11.6	11.6
English/Irish household language	12.3	-0.6	0.5	-3.8	8.4	-1.8	-1.2	0.8	0.3	60	0.3	-1.9	-1.9	-1.9
Temperament														
Fussy	-19.6	2.1	0	3.5	-9.6	-2.4	0.1	1.6	1.8	-2.4	2	-0.6	-0.6	-0.6
Unadaptable	-21.0	-1.3	-3.6	1.4	-11.8	-5.2	-5.5	-1.9	-1.4	-5.2	-1.5	-3.1	-3.1	-3.1
Dull	3.8	2.7	0.5	4	1	1.1	6	3.4	2.9	1.1	0.9	-0.1	-0.1	-0.1
Unpredictable	7.3	-4.1	-1.9	-1.2	-3.4	-7	-3.5	-0.5	-0.6	-7	-1.1	-8.3	-8.3	-8.3
Mother smoked while pregnant	-21.4	3	0.3	2.6	-4.6	4.6	2	2.9	1.4	4.6	1.9	4	4	4
Mother drank while pregnant	3.5	3.6	5.1	4.3	0	-1.2	6.9	3.4	5.3	-1.2	4.8	-2.4	-2.4	-2.4
Mother took drugs while pregnant	-4.0	1.8	1.4	2.1	0	2.1	-1.5	1.3	1.5	2.1	0	2.2	2.2	2.2
MEAN BIAS		**2.7**	2.9	3	7.4	3.7	3.7	3.3	2.8	3.7	2.9	3.9	3.9	3.9

Note: Matching estimators assessed for full-time maternal employment v home - low maternal employment sub-sample only

A variable functions as a mediator to the extent that it accounts for the relationship between a predictor and a dependent variable (Baron and Kenny, 1986). For example, childcare may explain the effect, either partially or entirely, of maternal employment on the SDQ score. In order to function as a mediator, a mediator variable must meet 4 conditions, as detailed by Baron and Kenny (1986):

1. The independent variable (maternal employment) significantly affects the dependent variable (SDQ scores) in the absence of the mediator (childcare),

2. Variations in the level of the independent variable (maternal employment), significantly account for variations in the mediator (childcare) - Path a;

3. Variations in the mediator (childcare), significantly account for variations in the dependent variable (SDQ score) – Path b;

4. When the mediator (childcare) is controlled for, the previously significant relationship between the independent variable (maternal employment) and the dependent variable (SDQ score) is no longer significant – Path c. When this coefficient is reduced to zero, this is strong evidence for a single dominant mediator. Otherwise, there may be many mediators.

Multi-collinearity of maternal employment and childcare may be a concern when both variables are included in a regression, resulting on a reduction in the power of the test for significance. Therefore, Baron and Kenny (1986) advise that it is important to examine both the significance and the absolute size of these coefficients.

The Sobel-Goodman Test (Sobel, 1983) examines whether a mediator carries the influence of an independent variable to a dependent variable and provides an approximate significance test for the indirect effect of the independent variable on the dependent variable via the mediator:

$$\sqrt{b^2 s_a^2 + a^2 s_b^2}$$

The standard errors for path a and b are s_a and s_b[12].

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[12] The exact formula, given multivariate normality for the standard error, includes $\sqrt{s_a^2 s_b^2}$. However, this term is ordinarily small.

Variables that are not mediators may act as moderators, such that the effect of the independent variable may vary by subgroups as defined by these moderators (for example, education). However, some variables may act as confounders, influencing both the independent variable and the outcome. Therefore, all baseline covariates are controlled for in the mediation analysis.

APPENDIX 4 – FULL REGRESSIONS

OUTCOME:	BASE REGRESSION			PLUS CHILDCARE PAID			PLUS CHILDCARE 3 YEARS		
SDQ SCORE>=14	ALL	LOW	HIGH	ALL	LOW	HIGH	ALL	LOW	HIGH
Workstatus at 9 months (v. at home)									
Part-time	0.015	0.039	-0.008	0.016	0.027	0.001	0.015	0.030	-0.001
	[0.013]	[0.025]	[0.012]	[0.015]	[0.028]	[0.014]	[0.015]	[0.028]	[0.013]
Full-time	0.015	0.051*	-0.008	0.024	0.044	0.005	0.023	0.044	0.003
	[0.013]	[0.028]	[0.012]	[0.017]	[0.034]	[0.015]	[0.017]	[0.034]	[0.015]
Maternity leave	-0.001	0.006	-0.012	-0.002	0.005	-0.012	-0.002	0.004	-0.011
	[0.014]	[0.026]	[0.012]	[0.013]	[0.026]	[0.012]	[0.013]	[0.026]	[0.012]
Childcare (v. at home with mother)									
Informal				0.018	0.041	-0.006	0.011	0.027	-0.009
				[0.023]	[0.044]	[0.020]	[0.022]	[0.042]	[0.019]
Grandparent				0.029	0.048	0.010	0.037	0.065	0.010
				[0.022]	[0.042]	[0.019]	[0.023]	[0.044]	[0.019]
Formal				0.022	0.086	-0.013	0.025	0.073	-0.008
				[0.027]	[0.064]	[0.019]	[0.028]	[0.063]	[0.020]
Childcare hours at 9 months				0.000	0.000	0.000	0.000	0.000	0.000
				[0.001]	[0.001]	[0.000]	[0.00]	[0.001]	[0.001]
Childcare paid at 9 months				-0.031**	-0.046*	-0.017	-0.034**	-0.049**	-0.018
				[0.015]	[0.025]	[0.016]	[0.014]	[0.025]	[0.016]
Workstatus at 3 years (v. at home)									
Part-time	-0.022**	-0.035**	-0.007	-0.021**	-0.034*	-0.007	-0.022**	-0.038*	-0.006
	[0.010]	[0.018]	[0.010]	[0.010]	[0.018]	[0.010]	[0.011]	[0.020]	[0.011]
Full-time	-0.027**	-0.063***	-0.001	-0.026**	-0.064***	0.000	-0.026**	-0.070***	0.004
	[0.011]	[0.019]	[0.011]	[0.011]	[0.019]	[0.011]	[0.013]	[0.021]	[0.013]
Maternity leave	0.001	0.013	0.002	0.0024	0.017	0.003	0.002	0.017	0.003
	[0.017]	[0.040]	[0.016]	[0.018]	[0.041]	[0.016]	[0.017]	[0.041]	[0.015]
Childcare (v. at home with mother)									
Informal							0.033	0.046	0.019
							[0.028]	[0.052]	[0.026]
Grandparent							-0.017	-0.056*	0.009
							[0.019]	[0.031]	[0.021]
Formal							0.006	0.015	-0.001
							[0.023]	[0.041]	[0.022]
Childcare hours at 3 years							0.000	0.001	-0.001
							[0.001]	[0.001]	[0.000]
Childcare paid at 3 years							0.004	-0.002	0.003
							[0.018]	[0.031]	[0.018]
Unemployed Mum at 9 months	0.026	0.062	-0.014	0.028	0.063	-0.011	0.027	0.060	-0.013
	[0.024]	[0.041]	[0.018]	[0.024]	[0.042]	[0.018]	[0.024]	[0.041]	[0.018]
Maternal Stress at 9 months	0.003***	0.004***	0.002***	0.003***	0.004***	0.002***	0.003***	0.004***	0.002***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Quality of Attachment at 9 months	-0.001	0.002	-0.003**	-0.001	0.002	-0.004***	-0.001	0.002	-0.004
	[0.002]	[0.003]	[0.001]	[0.002]	[0.003]	[0.001]	[0.002]	[0.003]	[0.001]
Ethnicity	0.02	0.031	0.013	0.018	0.031	0.009	0.018	0.029	0.009
	[0.013]	[0.026]	[0.013]	[0.013]	[0.026]	[0.012]	[0.013]	[0.025]	[0.013]
Mothers age when first pregnant	,-0.002*	-0.002	-0.003**	-0.002*	-0.002	-0.003**	-0.002*	-0.002	-0.003**
	[0.001]	[0.002]	[0.001]	[0.001]	[0.002]	[0.001]	[0.001]	[0.002]	[0.001]
Mothers age when child 9 months	0.000	-0.001	-0.000	-0.033	-0.001	0.000	0.000	-0.001	0.000
	[0.001]	[0.002]	[0.001]	[0.001]	[0.002]	[0.001]	[0.001]	[0.002]	[0.001]
Maternal Education (v. up to leaving cert)									
Degree Level	-0.022**		0.005	-0.021**			-0.021**		
	[0.009]		[0.008]	[0.009]			[0.009]		
Postgraduate	-0.027**			-0.025**		-0.004	-0.026**		-0.003
	[0.0114]			[0.011]		[0.008]	[0.011]		[0.008]
Mother - Chronic illness	0.015	0.009	0.023*	0.015	0.008	0.023*	0.016	0.008	0.024*
	[0.012]	[0.020]	[0.014]	[0.012]	[0.020]	[0.014]	[0.012]	[0.020]	[0.014]
Mother ever depressed	0.079***	0.105***	0.062***	0.078***	0.103***	0.062***	0.079***	0.103***	0.069***
	[0.013]	[0.021]	[0.015]	[0.013]	[0.021]	[0.014]	[0.013]	[0.020]	[0.014]
No of siblings at 9 months	-0.015**	-0.013	-0.019***	-0.015**	-0.012	-0.018***	-0.015**	-0.012	-0.019***
	[0.006]	[0.010]	[0.005]	[0.006]	[0.010]	[0.005]	[0.006]	[0.010]	[0.005]

OUTCOME:	BASE REGRESSION			PLUS CHILDCARE PAID			PLUS CHILDCARE 3 YEARS		
SDQ SCORE>=14	ALL	LOW	HIGH	ALL	LOW	HIGH	ALL	LOW	HIGH
Father's Workstatus at 9 months (v. working)									
Unemployed	0.021	0.048*	-0.022	0.020	0.0479*	-0.0242*	0.020	0.0472*	-0.0242*
	[0.018]	[0.0285]	[0.014]	[0.018]	[0.0286]	[0.0129]	[0.0175]	[0.0282]	[0.0129]
Missing	-0.030	0.050	-0.237***	-0.027	0.054	-0.235***	-0.028	0.051	-0.234***
	[0.076]	[0.122]	[0.012]	[0.075]	[0.121]	[0.0113]	[0.0755]	[0.125]	[0.0113]
Father's Workstatus at 9 months (v. working)									
Unemployed	0.024	0.020	0.030	0.024	0.020	0.028	0.024	0.019	0.026
	[0.015]	[0.024]	[0.018]	[0.015]	[0.0234]	[0.0178]	[0.0149]	[0.0235]	[0.0178]
Missing	0.031**	0.0523**	0.009	0.032**	0.0528**	0.009	0.0308**	0.0491**	0.010
	[0.013]	[0.022]	[0.013]	[0.013]	[0.0222]	[0.0126]	[0.0129]	[0.0221]	[0.0126]
Paternal Education (v. up to leaving cert)									
Degree Level	0.002	-0.012	0.002	0.002	-0.013	0.003	0.002	-0.013	0.003
	[0.010]	[0.021]	[0.009]	[0.010]	[0.021]	[0.009]	[0.010]	[0.021]	[0.009]
Postgraduate	0.013	0.038	0.005	0.014	0.037	0.007	0.014	0.037	0.008
	[0.015]	[0.046]	[0.013]	[0.015]	[0.046]	[0.013]	[0.015]	[0.046]	[0.013]
Missing	0.034	-0.040	0.991***	0.029	-0.045	0.991***	0.031	-0.041	0.991***
	[0.101]	[0.103]	[0.001]	[0.096]	[0.100]	[0.001]	[0.098]	[0.104]	[0.001]
Household social class (v. never worked)									
Unskilled & Semi-skilled	0.012	0.021	0.007	0.008	0.017	0.003	0.007	0.016	0.003
	[0.022]	[0.032]	[0.032]	[0.021]	[0.031]	[0.030]	[0.021]	[0.031]	[0.030]
Skilled & Non-manual	-0.007	-0.002	-0.008	-0.010	-0.005	-0.011	-0.011	-0.008	-0.011
	[0.018]	[0.028]	[0.024]	[0.018]	[0.028]	[0.023]	[0.018]	[0.028]	[0.023]
Professional/Managerial	-0.038*	-0.040	-0.034	-0.042**	-0.043	-0.037	-0.043**	-0.045	-0.037
	[0.020]	[0.029]	[0.031]	[0.020]	[0.028]	[0.031]	[0.020]	[0.028]	[0.031]
Living with Partner	-0.034	-0.045	-0.013	-0.032	-0.043	-0.011	-0.031	-0.037	-0.012
	[0.026]	[0.041]	[0.028]	[0.026]	[0.040]	[0.027]	[0.025]	[0.039]	[0.028]
Study child Female	-0.032***	-0.046***	-0.020***	-0.032***	-0.047***	-0.020***	-0.031***	-0.044***	-0.020***
	[0.008]	[0.014]	[0.007]	[0.008]	[0.014]	[0.007]	[0.008]	[0.014]	[0.007]
Study child is non-singleton	0.024	0.018	0.027	0.024	0.018	0.027	0.026	0.022	0.028
	[0.025]	[0.043]	[0.026]	[0.025]	[0.043]	[0.025]	[0.025]	[0.043]	[0.025]
Study child was preterm	0.017	0.023	0.013	0.017	0.024	0.013	0.017	0.026	0.014
	[0.018]	[0.032]	[0.018]	[0.018]	[0.032]	[0.018]	[0.018]	[0.032]	[0.018]
Caesarean Section	0.008	0.014	0.002	0.008	0.014	0.002	0.008	0.014	0.002
	[0.009]	[0.017]	[0.008]	[0.009]	[0.017]	[0.008]	[0.009]	[0.017]	[0.008]
Child in poor health at birth	0.029	0.052	0.011	0.026	0.048	0.010	0.028	0.055	0.010
	[0.024]	[0.042]	[0.026]	[0.024]	[0.042]	[0.025]	[0.024]	[0.043]	[0.025]
Child in poor health at 9 months	-0.020	-0.022	-0.020	-0.020	-0.025	-0.017	-0.020	-0.029	-0.016
	[0.029]	[0.064]	[0.023]	[0.029]	[0.062]	[0.024]	[0.028]	[0.058]	[0.025]
Local Authority Housing	0.004	0.000	0.008	0.004	-0.002	0.009	0.003	-0.004	0.008
	[0.015]	[0.021]	[0.026]	[0.015]	[0.021]	[0.026]	[0.015]	[0.021]	[0.026]
In receipt of Social Welfare	0.001	-0.008	0.019	0.001	-0.007	0.018	0.001	-0.006	0.018
	[0.010]	[0.016]	[0.013]	[0.010]	[0.016]	[0.013]	[0.010]	[0.016]	[0.013]
Neighbourhood Deprivation (v. Low)									
Medium	0.011	0.016	0.004	0.010	0.015	0.004	0.010	0.014	0.004
	[0.008]	[0.015]	[0.008]	[0.008]	[0.015]	[0.008]	[0.008]	[0.015]	[0.008]
High	0.040**	0.058**	0.012	0.039**	0.058*	0.012	0.039**	0.055*	0.013
	[0.019]	[0.030]	[0.021]	[0.019]	[0.030]	[0.021]	[0.019]	[0.030]	[0.021]
Urban	-0.006	-0.005	-0.006	-0.007	-0.006	-0.006	-0.007	-0.010	-0.005
	[0.008]	[0.015]	[0.008]	[0.008]	[0.014]	[0.008]	[0.008]	[0.014]	[0.008]
Mother worked before pregnancy	0.012	0.001	0.037***	0.012	0.001	0.036***	0.012	0.001	0.036***
	[0.011]	[0.019]	[0.012]	[0.011]	[0.018]	[0.012]	[0.011]	[0.019]	[0.012]
Mother's workhours before pregnancy	0.000	0.000	-0.001	0.000	0.000	-0.001	0.000	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Maternal poverty (Age 16)	0.007	0.013	0.002	0.007	0.012	0.002	0.008	0.012	0.002
	[0.010]	[0.016]	[0.010]	[0.010]	[0.016]	[0.010]	[0.010]	[0.016]	[0.009]
Marriage Quality Score	-0.011***	-0.014**	-0.009***	-0.012***	-0.015**	-0.009***	-0.011***	-0.014**	-0.009***
	[0.004]	[0.007]	[0.003]	[0.004]	[0.007]	[0.003]	[0.004]	[0.007]	[0.003]
Has good support	-0.003	0.011	-0.010	-0.005	0.007	-0.013	-0.005	0.009	-0.012
	[0.009]	[0.016]	[0.009]	[0.009]	[0.016]	[0.010]	[0.009]	[0.016]	[0.010]

OUTCOME:		BASE REGRESSION			PLUS CHILDCARE PAID			PLUS CHILDCARE 3 YEARS	
SDQ SCORE>=14	ALL	LOW	HIGH	ALL	LOW	HIGH	ALL	LOW	HIGH
Family live nearby	0.006	0.022	-0.004	0.006	0.021	-0.004	0.006	0.021	-0.004
	[0.009]	[0.016]	[0.00826]	[0.00859]	[0.0157]	[0.00820]	[0.00857]	[0.0156]	[0.00818]
Living with Grandparents	-0.010	-0.029	0.010	-0.011	-0.030	0.008	-0.009	-0.027	0.008
	[0.024]	[0.035]	[0.0323]	[0.0239]	[0.0352]	[0.0308]	[0.0239]	[0.0352]	[0.0306]
English/Irish household language	-0.020	-0.028	-0.016	-0.019	-0.029	-0.015	-0.019	-0.026	-0.014
	[0.021]	[0.038]	[0.0218]	[0.0206]	[0.0376]	[0.0212]	[0.0205]	[0.0368]	[0.0212]
Child temperament scores (9 months)									
fussy	0.003***	0.004***	0.002***	0.003***	0.004***	0.002***	0.0034***	0.004***	0.002***
	[0.001]	[0.002]	[0.001]	[0.001]	[0.002]	[0.001]	[0.001]	[0.002]	[0.001]
unadaptable	0.000	-0.001	0.001	0.000	-0.001	0.001	0.000	-0.001	0.001
	[0.001]	[0.002]	[0.001]	[0.0011]	[0.002]	[0.001]	[0.001]	[0.0019]	[0.001]
dull	0.001	-0.003	0.003*	0.001	-0.003	0.003**	0.001	-0.003	0.003**
	[0.002]	[0.003]	[0.001]	[0.002]	[0.003]	[0.002]	[0.002]	[0.003]	[0.002]
unpredictable	0.006***	0.011***	0.001	0.006***	0.011***	0.001	0.006***	0.011***	0.001
	[0.001]	[0.003]	[0.001]	[0.001]	[0.003]	[0.002]	[0.001]	[0.003]	[0.002]
Mother smoked while pregnant	0.008	0.010	0.009	0.009	0.014	0.008	0.010	0.016	0.008
	[0.011]	[0.017]	[0.014]	[0.011]	[0.017]	[0.013]	[0.011]	[0.017]	[0.013]
Mother drank alcohol while pregnant	0.003	-0.021	0.019**	0.004	-0.021	0.021**	0.005	-0.021	0.021**
	[0.010]	[0.018]	[0.01]	[0.010]	[0.018]	[0.010]	[0.010]	[0.018]	[0.010]
Mother took drugs while pregnant	0.009	0.024	-0.013	0.008	0.023	-0.013	0.007	0.021	-0.014
	[0.031]	[0.051]	[0.027]	[0.030]	[0.051]	[0.027]	[0.030]	[0.050]	[0.027]
Observations	8,858	3,695	5,163	8,857	3,695	5,162	8,852	3,692	5,160
Robust standard errors in brackets	*** p<0.01, ** p<0.05, * p<0.1								

APPENDIX 5 – SELECTION BIAS

The Problem

In order to identify a causal effect of maternal employment when a child is 9 months on the probability of a child having a high SDQ score at 3 years of age, the coefficient on the regressor variable must not contain, either partly or entirely, the effect of relevant characteristics not identified and controlled for in the estimation. While sufficient controls should identify the effect of observables, it may prove more challenging to identify the existence of unobserved characteristics that impact the relationship between the explanatory variable and the outcome and, if appropriate, adjust the explanatory variable to exclude the influence of unobserved characteristics. In the absence of an appropriate instrumental variable for maternal employment, an estimation method developed by Altonji, Elder and Taber (2005) is used to assess selectivity bias.

Potential Solution - Altonji Methodology
Selection Bias

Adapting the approach taken in Altonji, Elder and Taber (2005) and taking maternal employment as our endogenous variable, the outcome (Y), representing the probability of the study child having a high SDQ score, is determined by:

$$Y^* = \alpha ME + W'ϯ \hspace{4cm} \text{Equation (1)}$$
$$= \alpha ME + Xϯ_x + e \hspace{3.5cm} \text{Equation (2)}$$

ME is a binary variable that represents 1 if the mother works and α is the causal effect of maternal employment on the risk of a high SDQ score. W represents a vector of observed and unobserved variables that determine Y^*, and ϯ is the causal effect of this vector of variables on the outcome. X is a vector of observable characteristics of W, and $ϯ_x$ is the causal effect of this sub-vector of W. The error component, e, is an index of the unobservable variables. As we cannot control for these unobservables, to the extent that they are correlated with both ME, the explanatory variable, and the outcome, Y^*, the estimation results may be biased.

Theoretical Foundation

Altonji et al. (2005) propose a theory that uses the degree of selection on observables as a measure of the extent of selection on unobservables, and provide a method to quantitatively assess the degree of omitted variable bias. A measurement of the amount of selection on observables is used in the calculation of a ratio that determines how large the selection on unobservables would need to be in order to attribute the entire effect of either maternal employment or childcare to selection bias.

This methodology relies on 3 key assumptions, which are required to derive Condition 1:

1. The variables in X, the observed variables, are chosen at random from the full set or variables W that determine Y;

2. The number of variables in both X and W are large, such that no one element dominates the distribution of ME or Y;

3. The regression of ME* on Y*- αME is equal to the regression of the part of ME* that is orthogonal to X on the corresponding part of Y* - αME. ME* is the latent variable that determines ME such that ME=1(ME*>0), where the indicator function 1(.) is 1 when ME*>0 and zero otherwise. ME* is therefore exogenous. The authors propose that this assumption is weaker than the standard OLS assumption of Cov (X, ɇ).

These assumptions allow the authors to set selection on the unobservables equal to selection on observables. What this means is that the part of Y* that is related to the observables and the part related to the unobservables have the same relationship with ME*. This is known as Condition 1.

Condition 2 says that the part of Y* that relates to the unobservables has no relationship with ME*. While this is a standard assumption in econometrics, it's unlikely to hold in practice, as many of the factors that influence Y* are correlated with maternal employment or X.

The authors, in the context of discussing the effect of attending a Catholic School (CH) on educational attainment and test scores, comment that the "random selection on

observables" assumption required as part of Condition 1 should not be taken literally. They suggest there are compelling reasons why the relationship between the unobservables and CH (or, in this case ME) is likely to be weaker than the relationship between the observables and CH. Applying their thoughts to this study, the reasons why this might be so are:

1. The selection of the covariates is not random, such that they have been selected in order to reduce bias. For example, maternal education and household class are both related to ME and child behavioural problems.

2. ε is also likely to contain a random element of child behavioural problems, perhaps traits of the child or mother that are not related to the decision of a mother to work.

3. Shocks that occur after 9 months are not included within the regressors. These shocks may influence the SDQ score of the child but not the decision to return to work when the child is 9 months.

The final condition, Condition 3, involves the authors identifying a set of bounds for α. The upper bound occurs with the assumption that Cov (ME*, ε)/Var (ε) = 0 and a lower bound that assumes

$$\frac{Cov\ (ME*,\varepsilon)}{Var\ (\varepsilon)} \quad = \quad \frac{Cov(ME*,X\dagger)}{Var\ (X\dagger)} \qquad \text{Equation (3)}$$

By arguing that for the decision of a mother to work, selection on unobservables is likely to be less strong than selection on observables. By estimating joint models of maternal employment and the outcome, the SDQ score of the child, subject to selection on unobservables and observables being equal, we achieve this lower bound estimate. Both OLS and Probit assume no selection on unobservables, and therefore provide an upper bound estimate.

Should the sign of the estimated effect of the unobservables on the outcome be negative, this would alter this logic, such that the bounds as outlined above would be reversed, with Cov (ME*, ε)/Var (ε) = 0 providing a lower bound estimate. This logic means that the unobservable factors that influence a mother's decision to work may have a

favourable impact on the child risk of a high SDQ score. Such factors may include a diligent well organised mother or an even tempered child.

Application of Altonji et al. Methodology

The first step of this estimation involves finding an estimate of $\dagger$ under the null hypothesis of no maternal employment effect:

$$Y_i = \alpha + X_i'\dagger + \mathrm{e}_i \qquad\qquad \text{Equation (4)}$$

This equation provides estimates of $\mathrm{Cov}(ME*, X\dagger)$, $Var\,(X\dagger)$ and $Var\,(\mathrm{e}_i)$, as indentified in Equation (3) above. Using these 3 estimates, an estimate of the implied bias, $\mathrm{Cov}\,(ME*, \mathrm{e})$, can be computed. A measure of the strength of this implied bias is determined from its ratio to the estimate of β, representing how strong selection on unobservables would have to be relative to selection on observables in order to attribute the entire estimated effect of maternal employment to selection bias (Elder & Jepsen, 2014).