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Parental Sleep and Employment: Evidence from a British Cohort Study

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Abstract
We show that sleep deprivation exerts a strong negative effect on labour market performance. We exploit variations in child sleep quality to instrument for parental sleep quality. A one-hour reduction in sleep duration significantly decreases labour force participation, the number of hour's worked and household income. In addition, we find that low-skilled mothers are more likely to opt out of the labour market and work less hours than high-skilled mothers when exposed to sleep deprivation. We argue that sleep is a major determinant of employment outcomes that needs more attention in designing economic models of time allocation and employment policies.

Keywords: child sleep, sleep, maternal employment, working hours, job satisfaction, ALSPAC
JEL codes: J13; J22; I18; J28

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I. Introduction

Sleep is an essential human function associated with both physiological and cognitive development. Lack of sleep is responsible for human fatigue, and can undermine economic performance. Paradoxically, the extent to which sleep time is a productive activity or not, has received very limited attention in economics research so far. Sleep is often overlooked in economics models despite its obvious restorative effects on human health alongside its influence on brain plasticity and feelings of wellbeing (Siegel, 2005; Frank, 2006). The prefrontal cortex, which has proven to be critical for executive functioning is found to be vulnerable to a lack of sleep (Harrison and Stone, 2000). Sleep exerts an influence on emotional wellbeing and restful perceptions, and sleep deprivation more generally, even when moderate, is found to be detrimental to employment behaviours and can underpin the association between socio-economic status and both physical and mental health (Moore *et al.*, 2002). The number of hours the average person sleeps has declined over the past century, and we still ignore its effects on economic activity and economic performance.

There are a number of mechanisms through which sleep can influence economic activity. Sleep loss can increase the "allostatic load" and can lead to chronic diseases associated with hypertension, diabetes, depression and obesity, as well as with cancer, increased mortality and more generally a reduced quality of life (Barnes and Wagner, 2009; Caruso *et al.*, 2006; Scott and Judge, 2006). Sleep-deprived individuals are more likely to make impulsive decisions. Although sleep deprivation can have several triggers such as round-the-clock access to technology, time and work schedules alongside changes in light and noise, there is evidence of household derived sleep deprivation. Specifically, sleep deprivation resulting from children's sleep routines together with increasing parental involvement and parental sharing in child bearing duties makes child related sleep deprivation a potential source of variation in adult sleep.

A meta-analysis of existing research suggests that sleep deprivation strongly impairs cognitive or motor performance (Pilcher and Huffcutt, 1996; Killgore 2010). Hence, one would expect to find an effect of sleep deprivation, and more specifically sleep quality, on measures of economic performance, including individual's earnings, consistent with recent evidence (Gibson and Shrader, 2015). However, to estimate the impact of sleep deprivation on economic performance, we need a source of exogenous variation in sleep quality. In this

paper, we propose to exploit variations in child sleep quality as a possible source of exogenous variation of parental sleep. Our strategy relies on three hypotheses:

i. We can identify significant longitudinal variations in child sleep quality, which in turn affect parental sleep.

ii. Although having children is a matter of choice itself, the quality of children's sleep is to a large extent uncertain and hence orthogonal to parental sleep, and can be thought of as resulting from the 'luck of the genetic draw' as the genetic component of sleep is not higher than in other areas of child development (Barclay *et al.*, 2010).

iii. The effect of child sleep on parental employment and working-time decisions works through its effect on parental sleep quality.

Based on these three hypotheses, we draw upon an instrumental variable strategy using the variation in child sleep quality as an instrument for changes in parental sleep quality. We rely on a unique dataset for the United Kingdom (UK): *the Avon Longitudinal Study of Parents and Children* (ALSPAC). This is a cohort study which follows a sample of 14,000 families from a child's birth to age 25. More specifically, it contains records of mothers since pregnancy and, crucially for our paper, has the advantage of including a rich and validated set of measures of both parental and child sleep alongside a set of other variables to be employed as controls and employment outcomes. Given that it has been designed by public health researchers, it contains very precise information on the child's quality of sleep, including whether the child wakes up at night, sleep time and day sleep, as well as child sleeping routines and environmental triggers of sleep quality. We can then relate these measures to objective and subjective measures of parental sleep quality, including average sleep duration, and whether the mother/father feels she had enough sleep. Another advantage is that the data provides us with information on both maternal and paternal employment characteristics, including employment status, the number of hours worked, job satisfaction and income for parents on a longitudinal basis. The latter are the key variables we use as economic outcomes in our empirical exercise. Furthermore, it contains maternal coordination capacity.

As a first step towards defining and evaluating the suitability of our empirical strategy, we visually examine reduced form associations between children's sleep and

employment outcomes. Figures 1 and 2 display the association between two employment outcomes (both the probability of mother's employment and her household income) on the number of times the child wakes up at night for a sample of 10,000 children (see below for data details). In both cases, the Figures show a strong negative relationship. The resulting message is that mothers who have children suffering from sleep disorders are significantly less likely to work and to have low income than mothers with children with normal sleep routines.

Our preferred explanation is that this relationship reflects the effect of child sleep quality affecting employment outcomes by altering maternal sleep quality. To test our explanation, we condition mother's employment decisions on mother's sleep duration, and instrument the latter by child sleep duration and the number of times the child wakes up at night alongside a number of other controls. Since our focus is on sleep disruption, we use the number of times the child wakes up at night as the main proxy for child sleep quality. There is a strong (first stage) relationship between the number of times the child wakes up at night and the mother's sleep duration. We find that a one-unit increase in the number of times a child wakes up at night leads to a reduction in the mother's average duration of sleep by 30 minutes per night. Controlling for child fixed effects, we also document that lower quality of child sleep reduces the probability of both maternal and parental sleep duration, although the effect on maternal sleep is more than twice that on paternal sleep.

Our main finding confirms that the relationship between sleep and employment outcomes works through the channels we consider: (i) child sleep quality is a major driver of parental sleep quality; and (ii) parental sleep quality is strongly correlated with parental employment and working-time decisions. Our two-stage least squares estimates of the effect of parental sleep on economic performance are substantial. We find that improving the mother's average nightly sleep duration by one hour increases employment by 4 percentage points, the number of hours worked by 7 percent, household income by 10-11 percent and job satisfaction by 0.01 points.

The exclusion restriction implied by our instrumental variable regression is that, conditional on regression controls, the quality of child sleep exerts no direct effect on parental employment and working-time decisions, other than its effect through parental sleep deprivation. The major concern with this exclusion restriction is that the quality of child sleep

could be correlated with omitted factors, which may have a direct effect on parental economic performance. In this case, our two-stage least squares estimates may be attributing the effect of these omitted factors of employment decisions to sleep quality. To address this issue, we further investigate whether parental sleep quality has a comparable effect on economic performance, once we control for a number of variables potentially correlated with child sleep quality and economic outcomes. We find that none of these overturn our results: the estimates appear to change remarkably little when we include controls for parenting style, how a mother is organised, the presence of a new partner, the presence of a new child, whether the child shares the bed or the bedroom with someone else, and the type of childcare used. Furthermore, the results are also robust to the inclusion of controls for environmental triggers of sleep quality (e.g. noise). These results suggest that the exclusion restriction required for our instrument-variables estimates is reasonable.

The general message of this analysis is that sleep is a major determinant of employment outcomes that needs attention in designing employment policies. The estimated effect of sleep in our study can be attributed to changes in child sleep quality. To our knowledge, this is the first paper that finds a link between child sleep quality and parental economic performance. The current economics literature on sleep is at its infancy. Drawing in the tradition of Becker (1965) and Grossman (1972) on allocation of time and demand for health respectively, a seminal work by Biddle and Hamermesh (1990) developed an optimal model of time allocation including sleep. They use a cross section of time use survey data and estimate that a one-hour increase in paid work reduces sleep by 10 minutes, and more generally they reveal the effect of opportunity cost of sleep on wages. Hamermesh *et al* (2008) examine how cues such as TV programs and sunlight affect sleep and coordination. Other economic influences on sleep include the effect of income and education: one would expect that they influence the opportunity costs of sleep, but especially sleep efficiency. Indeed, more affluent individuals appear to take longer to get to sleep, but are more efficient in their sleep (Gardner *et al.*, 2010). Similarly, Kamstra *et al*, (2000) find an influence of sleep on financial market performance. However, income differences in sleep problems no longer appear significant when health and other characteristics are adjusted. Szalatonai (2006) examines the effect of income on sleep in South Africa and Brochu *et al.* (2012) use data from Canada to estimate the impact of changes in wages on sleep time. Using time use data, Bonke (2012) attempts to identify circadian rhythms to examine it impact on productivity. Two other papers using American Time Use survey data find an effect of sleep

on wages and employment. Antillon *et al* (2014) examine the effect of unemployment on sleep, and find evidence of sleep to be countercyclical. However, unlike Antillon *et al* (2014), Ásgeirsdóttir and Ólafsson (2015) find a relationship between sleep duration and employment. Gibson and Shrader (2015) estimate the short-term effect of a reduction of one-hour sleep on wages to be 1.5 percent and the long-term effect to be 5 percent. Ásgeirsdóttir and Ólafsson (2015) find an inverse relationship between wages and sleep, where a 1 percent increase in wages is associated with a 9 second reduction in sleep duration. Nevertheless, this literature does not develop the link between child sleep quality and parental sleep quality.

Our paper is also related to the literature on the relationship between socio-economic characteristics and household derived sleep deprivation. Arber et *al.* (2009) find that women report more sleeping problems compared to men. Children from lower socio-economic groups also tend to have less efficient sleep than wealthier children, which can partially explain the gap in academic performance. Moore et *al.* (2012) find that sleep quality can mediate in the association of socio-economic status and both physical and mental health. Partnered individuals exhibit better sleep quality (Gardner *et al.,* 2010) and the social situation at work is strongly linked to disturbed sleep and impaired awakening (Mezick *et al.*, 2008).

Finally, our work is most closely related to previous attempts to capture the causal link between sleep quality and economic performance. Only one paper deals with the endogeneity of sleep quality by using instrumental variables approach as we do here. Gibson and Shrader (2015) instrument for sleep quality by using the short and long-term sunset time. The problem with this study is that they rely on location-level variations. Their estimates, therefore, should not be interpreted as individual effects. They potentially include spillovers across people who live in the same location. The advantage of our approach is that we exploit *individual variations* in sleep quality, due to changes in child sleep duration and the number of times a child wakes up at night. Unlike previous sleep studies, we rely on micro-longitudinal data, and we do not employ cross-sectional time-use surveys. The existing literature has focused on between-person findings. However, between-person findings do not provide any information on whether individuals' economic performance fluctuates as a function of variation in sleep quality. By way of contrast, micro-longitudinal data can capture the effects of exogenous variations in sleep quality and economic performance.

The rest of this paper has the following structure. The next section presents the data. Section III reports OLS regressions of parental economic performance on our measures of parental sleep quality. Section IV describes our key instrument for parental sleep quality, the

child sleep quality and presents our main results. Section V investigates the robustness checks of our results, and Section VI concludes.

II. The ALSPAC Data

We use a unique dataset, the ALSPAC data, which has followed more than 14,000 families from child birth to age 25. This is a near-census English cohort study, which was primarily designed to investigate environment, genetic, and socio-economic influences on health and development over the life course.[1] The study recruited 14,541 pregnant women residing in the Avon area of the UK with expected delivery dates between April 1, 1991 and December 31, 1992.[2] This corresponds to roughly 70% of the eligible pregnancies in the area. The sample is broadly representative of the national population of mothers with children less than 12 months old, although higher socio-economic status groups as well as people of white ethnicity are over-represented compared to the national population (Boyd *et al*, 2012). The study includes rich information on the parents' characteristics and family background as well as indicators of child wellbeing and cognitive skills. In particular, the dataset provides precise information on parental and child sleep quality over time. In addition, it contains various variables on employment, working-time decisions, income and job satisfaction, for our purposes.

Table 1 provides the descriptive statistics for the key variables of interest distinguishing employment related and sleep related variables. The sample is restricted to families with children under the age of 12 (for which we have information on child sleep quality). This gives us a sample size of 10,000 families. After age 12, the survey questions on child sleep quality are no longer available. There are large variations in child average duration of sleep and the probability that the child wakes up at night in our sample. The standard deviation is 1.26 for a child's average duration of sleep and 0.5 for the probability that the child wakes up

[1]Please note that the study website contains details for all the data that is available through a full searchable data dictionary: http://www.bris.ac.uk/alspac/reseachers/data-access/data-dictionary/

[2] 14,541 is the initial number of pregnancies for which the mother enrolled in the ALSPAC study and had either returned at least one questionnaire or attended a "Children in Focus" clinic by 19/07/99. Of these initial pregnancies, there was a total of 14,676 fetuses, resulting in 14,062 live births and 13,988 children who were alive at 1 year of age.

at night. In rows 3 and 4, we also document the number of times a child wakes up at night and whether the child has a regular sleeping routine as alternative measures of child sleep quality. One might prefer these measures since they explicitly refer to sleep disruption. On the other hand, they may be noisier measures of child sleep quality than the probability that the child wakes up at night. Table A1 in the Appendix also examines the correlation between the different measures of child sleep quality used in this paper. Overall we find consistent correlations whereby waking up reduce sleep duration and having a sleep routine increases it.

We use several variables to capture parental sleep quality. Our main variable, reported in the fifth row, is an average of mother's sleep duration. On average, mothers sleep about 7 hours per night. We use the average value for our main specifications. However, one might also want to consider different categories: whether the mother sleeps less than 6 hours, between 6 and 7 hours or more than 7 hours per night. These categories are appropriate for our purposes since the focus here is on differences in economic performance originating from sleep deprivation. We want to know if the mother has enough sleep in order to be productive and not only how many hours the mother sleeps. The next row gives an alternative relevant measure, which is whether the mother/father feels she has enough sleep (from 0 to 1). We expect our notion of getting enough sleep to correspond to the number of hours slept, but the threshold may differ across individuals. Therefore, it is interesting to consider both self-reported and objective measures of sleep quality.

The next six rows report measures of parents' employment outcomes, which we use for measuring economic performance. The first is a measure of employment status (whether the mother/father works) and the second is a measure of part-time versus full-time jobs. In our sample, 63 percent of the mother's work and 83 percent of the father's work. 22 percent of the mother's work part-time. Interestingly, this information is also available at 8 weeks of pregnancy. This allows us to control for any endogeneity issue related to the probability to work, which is partly related to other factors than child sleep patterns. In addition, we are comparing individuals for whom having children is a choice. Hence, we expect individuals in our sample to be more comparable to the extent that they are all parents. In the following rows, we give the mean and the standard deviation of the number of hours worked as an alternative measure of work productivity. The second-to-last row gives information on the logarithm of household income. The final row gives a measure of job satisfaction, reported on a 0-1 scale, which is our measure of wellbeing at work. In our sample, 66 percent of the mother's report being satisfied at work.

III. Maternal Sleep and Economic Performance: Reduced Form

The first empirical exercise we perform attempts to investigate the reduced form effects of parental sleep on a number of employment outcomes including labour market participation, working-time decisions, income and job satisfaction drawing on ordinary least squares. The empirical specification we estimate in the first instance is represented in the following equation:

$$(1) \quad Y_{it} = \alpha + \beta PS_{it} + X_{it}\gamma + \mu_i + \varepsilon_i$$

where Y_{it} is employment status, or the number of hours worked, household income, and job satisfaction of parent of child i, PS_{it} is the parent quality of sleep, X_{it} is a vector of other covariates, and μ_i is a family/child fixed-effect.[3] The coefficient of interest throughout the paper is β, the effect of parental sleep quality on economic performance.

Table 2 reports the results of equation (1) with and without family fixed-effect for the three different measures of sleep quality (displayed in three different panels). Column (1) shows that in our sample, there is a robust and significant relationship between our different measures of mother sleep quality and the mother's employment probability, which suggests that maternal sleep (sleep deprivation) increases (decreases) labour market participation. Measures of sleep deprivation is found to be more sensitive to the inclusion of individual fixed effects. Indeed, column (2) reports that the effect of maternal sleep (sleep deprivation) on employment is slightly increased once we control for family fixed-effects. To get a sense of the magnitude of the effect of sleep quality on the probability to work, the estimate in column (1), Panel A, 0.01, indicates that a one-hour increase in mother sleep duration increases employment by 1 percentage point. We also find that in column (1), Panel B, sleeping less than 6 hours per night decreases the probability to work by a little more than 5 percentage points. Part-time work is more prevalent among women with children and many women working part-time choose part time work because it provides them the flexibility to manage their work and their family life. Working mothers, in particular, give up leisure and

[3] Note that we cannot include sibling fixed effects as only one child per family is observed in the ALSPAC data.

sleep, compared to mothers not in the labour force, to meet the demands of childcare and jobs.

To test the effect of mother's sleep quality on the number of hours worked, we run similar regressions for equation (1) with the logarithm of hours worked as dependent variable. Although the coefficient on mother's average sleep duration is not significant (column 3), which is consistent with the idea of a counterbalancing effect (working mothers give up sleep to manage their work and their family life), when family fixed-effects are included, the coefficient is now positive and significant, indicating that an expansion of maternal sleep quality increases her number of hours worked.

We then repeat our same basic regressions using the log of household income as the dependent variable. The coefficients on mother's sleep quality are statistically significant. The estimate in column (5), 0.04, indicates that a one-hour increase in mother's sleep duration increases household income by 4 percent (1 percent in time series). This is consistent and in line with estimates from previous studies (Gibson and Shrader, 2015). Finally, in columns (7) and (8), we look at the effect of mother's sleep quality on mother's satisfaction with job (which we expect to pick up potential work-life balance effects of sleep deprivation that are not necessarily reflected in participation, hours worked and income effects). Again, the effects are statistically significant. The estimate in column (7), 0.01, indicates that a one-hour increase in mother's sleep duration increases her job satisfaction by 1 percent.

Overall, the results in Table 2 are consistent with the existence of a relationship between mother's quality of sleep and mother's employment outcomes including employment, working-time decisions, income and job satisfaction. However, there are a number of reasons for not interpreting this relationship as causal. First, working mothers sleep less than non-working mothers which could raise a reverse causality question. Such reverse causality problem would create attenuation bias, and hence bias the OLS estimates downwards. Arguably, there are a number of other potentially omitted determinants of employment and working-time decisions (e.g., time efficiency, ability among others) that could correlate with sleep patterns. In addition, given that the measures of mother's sleep quality are reported by the mother herself, she might have a natural bias in reporting that she has enough sleep when she is satisfied with her job. That matter in practice can introduce a positive bias in the OLS estimates. We argue that such biases could be corrected if we have an instrument for mother's sleep quality. Such an instrument should be theoretically and empirically valid, and hence we should be able to observe it as a major determinant of

mother's sleep quality. At the same time, it should not have a direct effect on mother's employment, working-time decisions, income and job satisfaction, except through maternal sleep. We argue that variation in child sleep quality during the first 12 years of life is a plausible instrument.

IV. Child Sleep Quality

A. Descriptive Statistics

In this subsection, we briefly describe the measures and estimates of both quantity and quality of child sleep in our sample. The standard measure we rely on refers to the average duration of child sleep. Figure 3 shows that on average, children between 0 and 24 months sleep on average a little more than 11 hours. This figure decreases over time and by age 8, children sleep about 10 hours every 24 hours.

As expected, we also find in Figure 4 that over time children are more likely to adjust to a sleeping routine and by age 8, 96% of children already have a sleeping routine. However, sleep routine does not always imply no maternal sleep disruption. To examine this, our data contains information on the probability that a child wakes up at night and the number of times the child wakes up at night. Arguably, this is a better estimate of sleep disruption, because parents have to wake up and take care of the child during these awakening episodes. Indeed, Figure 5 reports the probability of wake-up times at night by child age. We find a spike in sleep deprivation between 2-5 years of age which is in line with findings of a recent review of observational studies (Galland *et al*, 2012).

Variations in sleep quality are found to be highly uncertain and determined by the so-called "luck of the genetic draw". A review of previous literature on sleep quality in adults (using twin studies) reveals a moderate contribution of genes (approximately 30%) for sleep duration and little effect of shared environmental factors (Tafti *et al*., 2005). In children, there

have been very few studies of sleep and results appear relatively inconsistent. Some studies find that heritability explains the greater proportion of the variance in day/night sleep ratio at 6 months (e.g. Touchette *et al.*, 2013), while other studies show a strong contribution of shared environmental factors for both night time sleep duration and daytime sleep with a moderate contribution of genes (Dionne *et al.*, 2011). Finally, other twin studies conclude that the genetic contributions to sleep patterns and sleep disruption of pre-adolescents and adolescents are close to those found in adults (Gehrman *et al.*, 2011; Moore *et al.*, 2011).

Overall substantial individual variation remains at all ages (Inglowstein *et al*, 2003; Acebo *et al.*, 2005) and most of the variations are unexplained. These considerations, together with the data we have on sleep quality, lead us to believe that child sleep patterns are a plausible instrument for parental sleep: child sleep patterns affect parental sleep duration, but are orthogonal to parents' economic performance.

B. Sleep Quality and Economic Performance: Instrumental Regressions

Determinants of Parental Sleep Quality

Equation (1) documents the relationship between parental sleep quality and economic outcomes. However, as mentioned before, there are reasons to believe that the association is not causal, which would result in estimates being biased. Hence, we define an instrumental variable strategy to address the problem, which exploits child duration of sleep and the number of times the child wakes up at night as instruments for maternal quality of sleep. Child sleep is found in several studies to be associated with maternal sleep. Specifically night time awakenings can be detrimental. They diminish both sleep duration and cause fragmentation, which impacts on mood and attention (Kahn et al, 2014). Specifically, we estimate the effect of child sleep on maternal sleep as follows:

$$(2) \qquad PS_{it} = \delta + \mu\, CS_{it} + Z_{it}\, \lambda + \rho_i + u_i$$

where PS_{it} is the measure of parental sleep quality of child i. CS_{it} is our measure of child sleep quality. Z_{it} is a vector of covariates that affect all variables and ρ_i are family fixed-effects. The identification strategy is to use CS_{it} (i.e. child sleep duration and the number of times the child wakes up at night) as instruments for PS_{it}. The exclusion restriction of this instrumental approach is that CS_{it} is uncorrelated with ε_i – that is, child sleep quality has no

effect on parental employment and working-time decisions other than through its impact on parents' sleep quality. We argued above that this exclusion restriction is reasonable.

Figure 6 describes the relationship between child sleep quality and parents' sleep quality. We use the number of times a child wakes up at night and mother's average duration of sleep as instruments. Consistent with our hypothesis, there is a strong relationship between the number of times a child wakes up at night and the mother's average duration of sleep. This indicates that mothers who have a child with good sleeping routines and who seldom wakes up at night, sleep longer on average than mothers who have a child with sleeping problems. We find that the association is more heterogeneous after the first wake up given that the reason and duration of each night time wake-up becomes more varied after the first awakening (e.g., sickness, nightmares, sleep problems, toileting, etc).

In Table 3, we report the estimates of the relationship between child and maternal sleep and examine whether the association works through the channels considered. More specifically, we report OLS regressions of equations (2). These specifications will be the first stages for our main two-stage least squares estimates (2SLS). Columns (1) and (3) use mother's hours slept as the dependent variable and show that there is a strong correlation between a child's duration of sleep and the mother's average duration of sleep. For example, a one-hour increase in the child's duration of sleep increases the mother's hours slept by 0.07 (12 minutes). A one-unit increase in the number of times a child wakes up at night decreases the mother's hours slept by 0.20 (30 minutes) and increases the probability of sleeping less than 6 hours per night by 4 percentage points. Columns (2) and (4) add the family fixed effects, which reduce the estimates by 2.5. The magnitude of the estimates indicates that a one-unit increase in the number of times a child wakes up at night decreases the mother's hours slept by 0.08 (13 minutes) and increases the probability of sleeping less than 6 hours per night by 1 percentage point. Both average mother's duration of sleep and dummies for mother's duration of sleep, are quantitative measures of sleep quality, and do not provide information about whether the mother feels restful. In columns (5) and (6), we propose an alternative approach and use a qualitative measure of mother's sleep – that is, whether the

mother feels she is getting enough sleep. This has little effect on the estimates and indicates that when a child sleeps longer, the mother is more likely to feel that she is getting enough sleep. Similarly, when a child wakes up at night, the mother is more likely to feel that she is not getting enough sleep.

Parental Sleep Quality and Economic Outcomes; IV regressions

Equations (1) and (2) are estimated jointly as 2SLS model in Table 4. Parental sleep quality is treated as endogenous and modelled as in equation (2). The exclusion restriction is that there is no correlation between the instrument and the error term in equation (1).

Panel A of Table 4 reports 2SLS estimates of the coefficient of interest, β from equation (1), in which mother's average sleep duration is treated as endogenous and Panel B and C give the corresponding equations in which the probability that the mother sleeps less than 6 hours, and whether the mother is getting enough sleep are treated as endogenous. F-tests (Cragg-Donald Statistics) reject the hypothesis of weak instruments for all regressions. The corresponding 2SLS estimates indicate that one extra hour of sleep increases employment by 4 percentage points (12 percentage points with family fixed effect), the number of hours worked by 7 percent (38 percent with family fixed effects), and increases household income by 11 percent (5 percent with family fixed effects). We find no effect on job satisfaction unlike in the OLS estimates.

Similarly, sleeping less than six hours produces consistent estimates.[4] Finally, our qualitative measure of sleep satisfaction, consistently with prior results, increases labour market participation by 26 percentage points, the number of hours of work by 23 percent, and income by 10 percent but consistently does not affect job satisfaction. These estimates are larger than the OLS estimates reported in Table 2. Hence the OLS estimates were downward biased. This suggests that reverse causality that creates attenuation bias is likely to be very important in all these relationships.

[4]Note the existence of non-linearity effects. The effects of sleep quality are larger at the lowest level of hours slept.

Does the 2SLS estimate make quantitative sense? Does it imply that parental sleep quality variations can explain a significant fraction of economic performance changes over time? Let's consider two mothers, one who sleeps 6 hours per night and another who sleeps 7 hours per night. Our 2SLS estimate, 0.04, implies that the one hour difference in sleep duration between these two mothers should translate into a 4 percentage point difference in the probability to work. Similarly, it should translate into a 7 percent difference in the number of hours worked, an 11 percent difference in household income and 1 percentage point difference in job satisfaction. In practice, the presence of measurement error complicates this interpretation. Therefore, the estimates are upper bounds. In any case, the estimates imply a not implausibility large effect of sleep deprivation on economic performance. In the rest of the paper, we investigate the robustness of these results.

V. Robustness Checks

Additional controls

Given that the identification of the causal effect of sleep quality on employment outcomes can be blurred by a number of other effects we consider the inclusion of determinants which we classify as environmental factors influencing child sleep, parenting style, household composition and father's characteristics. Overall, we find that our results change remarkably little with the inclusion of these variables.

Table A2 in the Appendix investigates the effects of different covariates potentially influencing the child's quality of sleep. Consistent with the literature, sleep duration declines with age (Mindell *et al*, 2015), and boys sleep less and wake up more frequently. As expected, sickness is a major determinant of child sleep patterns. Some maternal characteristics are important: children of younger and low-skilled mothers sleep less, while children with mothers who slept fine during the pregnancy, sleep more. We already account for this in the main specification.

In addition, noise in the house and sharing a room increase the number and the probability of waking up as well as decrease the probability of sleeping routine. The quality of the sleep environment also matters because it is directly correlated with parental sleep quality. In Panel A of Table 5, we add three variables to control for this: (i) whether noise is a problem, (ii) where the child shares a bed/bedroom, and (iii) the number of years lived in

Avon. This has little effect on our 2SLS estimates. For example, the estimate of the effect of sleep duration on employment is 0.04 (s.e. = 0.014) without controlling for environmental triggers and again 0.04 (s.e. = 0.014) with environmental triggers. Therefore, it appears that parental sleep quality is affected by child sleep quality, but the effect is not driven by environmental factors, such as noise and sleep environment quality.

Parenting style is also argued to be important for sleep quality (Mindell *et al.*, 2013). Table A2 shows for instance that bed time and wake up times as well as day sleep significantly influence child sleep. In Panel B, we control for the following variables: (i) whether the child is still breastfed after 15 months, (ii) has never been breastfed, (iii) the number of hours spent in child care (commercial carer and nursery), (iv) time the child goes to bed, (v) time the child wakes up, (vi) whether there is any sleep during day time, and (vii) whether the mother is an organised person. Our estimates of the effect of sleep duration on economic performance are slightly affected.

Another argument is that the presence of other children can be a key determinant of child sleep quality, parental sleep quality and parental economic performance. To control for this, in Panel C, we add (i) the number of children in the household, (ii) whether the child is the first child, (iii) the number of older siblings, (iv) the number of younger siblings, (v) whether the mother is pregnant, (vi) whether there is a new parent in the household. Again, these controls have very little effect on our main estimates.

Finally, in Panel D, we investigate whether our instrument could be capturing any effect related to father's characteristics. One might argue that child sleep quality would affect mother's sleep quality differently according to father's behaviour. Controlling for (i) the father's educational level, (ii) social class, (iii) whether the father works during the mother's pregnancy, (iv) the father's age at pregnancy, (v) health and (vi) whether the father is getting enough sleep, barely change our results. The coefficient of employment is again 4 percentage points. The coefficient of the number of hours worked is now estimated to be somewhat higher, 11 percent instead of 7 percent in Table 4. Further, the effect on income is 10 percent, instead of 11 percent.

Overall, the main deviation for our previous 2SLS estimates is that when including environmental triggers, parenting style, household composition and father's characteristics all together (Panel E), the effect of sleep on the probability to work and the number of hours worked is estimated to be slightly higher, while the effect of sleep on income is estimated to be a bit smaller. (Yet the difference between the two coefficients (for income) is not statistically different). Nonetheless, it appears that the results are consistent with sleep being

a significant determinant of economic performance, with little effect from environmental triggers, parenting style, household composition and father's characteristics. Irrespective of the inclusion of such estimates, we also find no significant effect on job satisfaction.

Alternative instrument

Given that previous estimates are highly dependent on how child sleep quality is measured, namely the child's sleep duration and the number of times the child wakes up a night, we can investigate the validity of our approach by using an alternative instrument, namely whether the child has a sleep routine. This approach is useful since it is a direct test of whether our previous estimates are affected by measurement errors. Table 6 reports the results. The first stages reveal strong relationships between child sleeping routine and mother's sleep quality, although the magnitude of the F-tests are smaller than before. In addition, compared to Table 4, we find that the 2SLS estimates are consistent, although the use of this new instrument does lead to larger coefficients than before. This can result from lower precision of the new instrument: the child's sleeping routine, which is reported by the mother using a dummy variable. Overall, this gives us additional confidence that child sleep quality can be used as an instrument to estimate the effect of parental sleep on economic performance.

Probit estimates

Another concern with our previous 2SLS estimates is the use of linear probability models to estimate the effect of sleep on employment for instance. We can investigate the validity of our approach by using probit instrumental regressions, instead of OLS to capture the effect of sleep on the probability to work and job satisfaction (0-1). Table 7 indicates that our previous estimates are robust to the use of probit regressions. The coefficients remain positive and statistically significant on the probability to work. Further, the effect of sleep on job satisfaction is again not significant.

Father's Sleep Quality and Economic Outcomes

So far we have not considered the effect of child sleep quality on father's sleep and economic performance. It might be interesting to look at whether there is any heterogeneous effect of sleep on economic performance considering father's outcomes as well. Table 8 reports both OLS and 2SLS estimates for the effect of father's sleep on the father's employment and the related first stages. Information on the father's hours worked and job satisfaction are not available in the ALSPAC data.

Importantly, the OLS estimates do not suggest evidence of an effect of father's sleep quality on employment. As with the mother, we find that child sleep duration (number of times the child wakes up) increases (reduces) the probability of the father getting enough sleep. Yet, the effect on paternal sleep is half the effect on maternal sleep, when comparing with Table 2. This is consistent with idea that fathers are less affected when a child wakes up at night.

Note, however, that IV estimates do suggest evidence of an effect of father sleep on the employment, instrumenting father's sleep by child's sleep. Further, the effect sizes appear to be stronger than those of the mother. Yet such estimates may be biased by measurement errors where father's quality of sleep is less precisely measured and child sleep quality is less correlated with father's sleep quality. The magnitude of the F-tests, still significant, are much smaller.

Heterogeneous Effects

Figures A1, A2, A3 and A4 in the Appendix show some evidence of heterogeneous effects of parental sleep on employment outcomes based (i) on children's age, (ii) whether the child is the first or not, (iii) mother's educational level and (iv) mother's ability to organise herself. Figure A1 suggests that the effect on labour market participation, the number of hours worked and job satisfaction seem to be steeper for older children, whilst the

effect on income is independent of child age. Figure A2 indicates no heterogeneity on income and labour market participation based on the child being the first, whilst first children seem to have an effect on the association between sleep and hours worked and job satisfaction. Finally, Figures A3 and A4 reveal heterogeneous effects among low-skilled and high-skilled mothers, and organised and less organised mothers: the effect of sleep on the probability to work and the number of hours of work is stronger for low-skilled mothers, while the effect is almost zero for high-skilled mothers and mothers who report leading an organised life. By way of contrast, there is no heterogeneity on income and job satisfaction based on the mother's educational level.

VI. Concluding Remarks

Many economists and social scientists have studied how people allocate time. However, they have largely ignored the time spent sleeping and its impact on economic activity. In this paper, we have argued that differences in time spent sleeping give rise to significant differences in economic outcomes. We have taken advantage of a unique dataset that contains rich data on sleep quality for both parents and their children. The data has allowed us to draw upon a credible instrumental variable approach where changes in maternal sleep are instrumented by changes in child sleep.

We have shown that: (1) child sleep patterns have substantial effects on parents' sleep. (2) Using child sleep as a source of variation, sleep duration significantly influences the probability of maternal labour market participation, alongside the number of hours worked and the resulting household income. However, we did not find an effect on job satisfaction. (3) The average effects mask substantial heterogeneity: fathers are somewhat less affected by child sleep problems; similarly, the probability of high-skilled mothers working is not affected when children wake up at night. Low-skilled mothers instead experience a large decrease in employment and the number of hours worked when facing sleep deprivation.

The results suggest that sleep quality should be a significant variable to consider in the design of employment policies. Our upper bound estimates indicate that one hour difference in sleep duration increases employment by 4 percent, the number of hours worked by 7 percent, household income by 11 percent and job satisfaction by 1 percent. If labour market productivity depends on sleep, it might appear counterproductive to expand working time beyond a certain threshold.

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VII. Figures

FIGURE 1: REDUCED-FORM RELATIONSHIP BETWEEN MOTHER'S PROBABILITY TO WORK AND THE NUMBER OF TIMES CHILD WAKES UP AT NIGHT

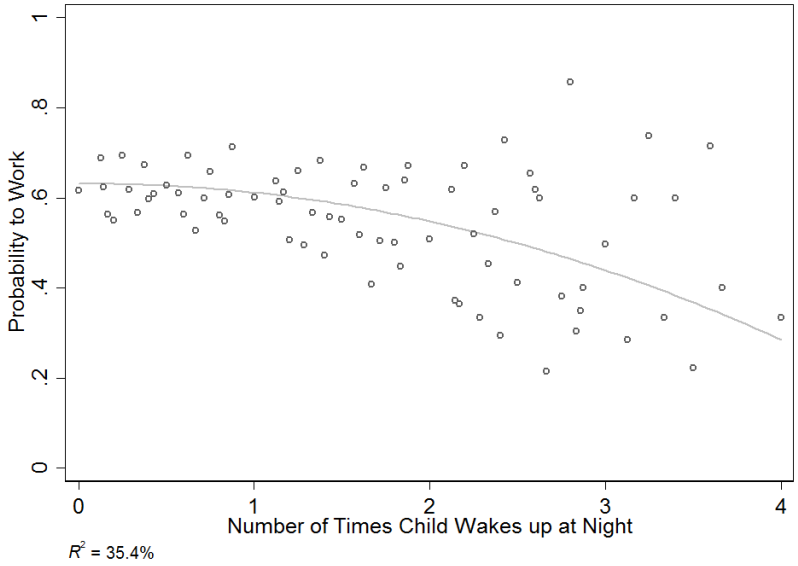


FIGURE 2: REDUCED-FORM RELATIONSHIP BETWEEN HOUSEHOLD INCOME AND THE NUMBER OF TIMES CHILD WAKES UP AT NIGHT

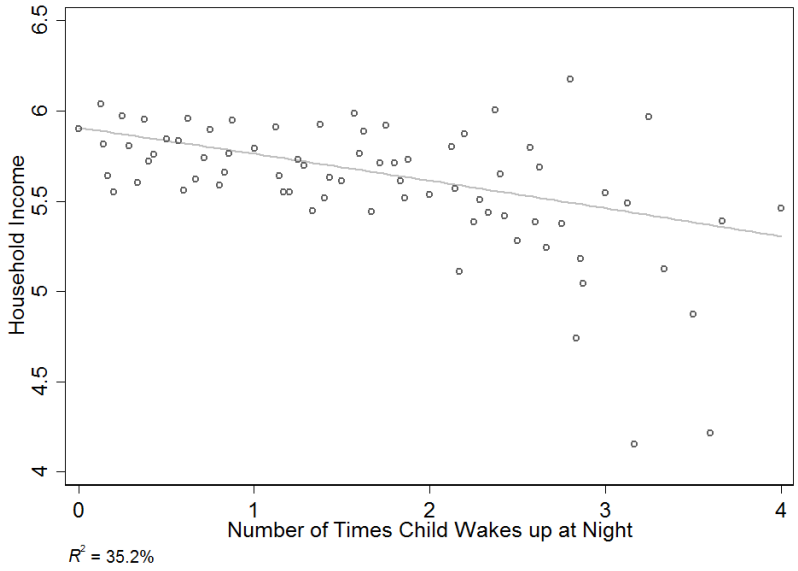


FIGURE 3: CHILD SLEEP DURATION BY AGE

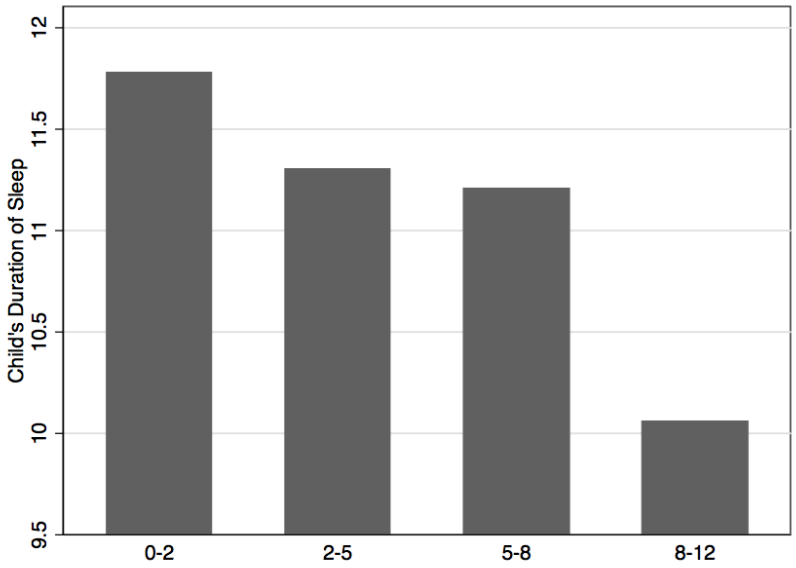


FIGURE 4: PROBABILITY THAT CHILD HAS A SLEEPING ROUTINE, BY AGE

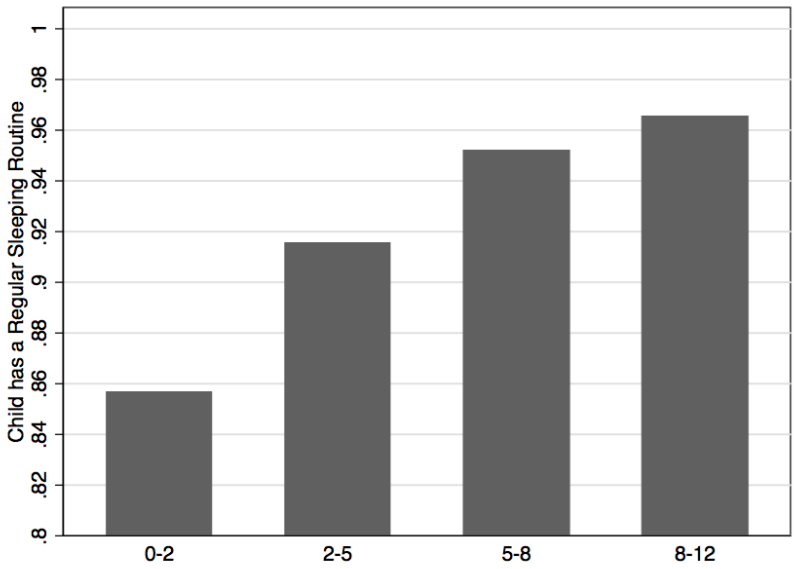


FIGURE 5: PROBABILITY THAT CHILD WAKES UP AT NIGHT, BY AGE

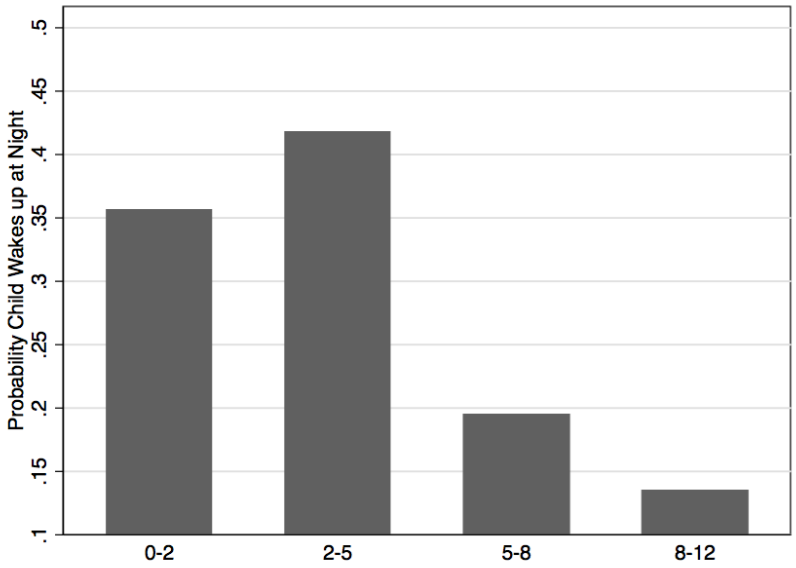
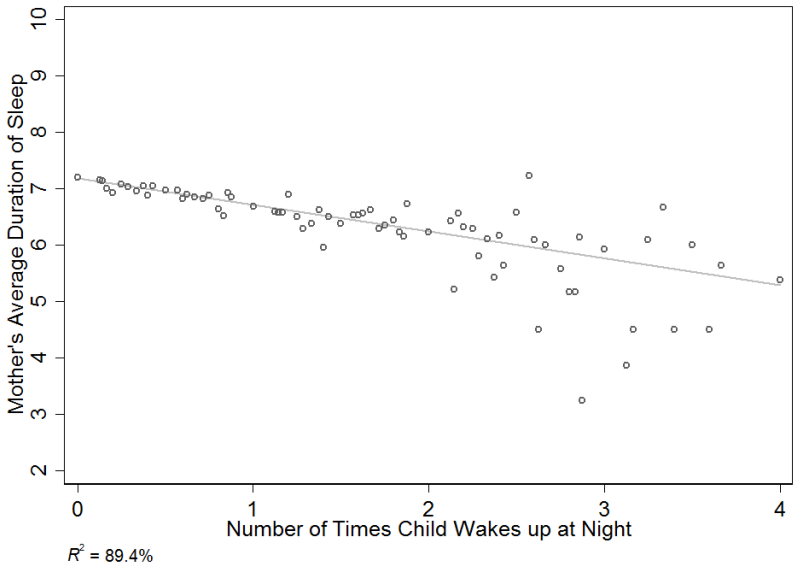


FIGURE 6: FIRST STAGE RELATIONSHIP BETWEEN NUMBER OF TIME CHILD WAKES UP AT NIGHT AND MOTHER'S SLEEP DURATION



VIII. Tables

TABLE 1 – DESCRIPTIVE STATISTICS

	Mean	(Standard. Dev)	Min	Max
Sleep related variables				
Child duration of sleep : hours	11.18	(1.26)	1	18
Child wakes up at night: Yes/No	0.32	(0.47)	0	1
Frequency child wakes up at night	0.48	(0.84)	0	4
Child has a regular sleeping routine	0.91	(0.28)	0	1
Mother duration of sleep : hours	6.97	(1.32)	0	9
Mother sleeps less than 6 hours	0.11	(0.31)	0	1
Mother sleeps between 6 and 7 hours	0.54	(0.50)	0	1
Mother is getting enough sleep	0.59	(0.49)	0	1
Father is getting enough sleep	0.62	(0.49)	0	1
Employment related variables				
Mother works	0.63	(0.48)	0	1
Father works	0.84	(0.36)	0	1
Mother works part-time	0.22	(0.41)	0	1
Mother's hours worked per week (ln)	2.91	(0.65)	0	4
Household income (ln)	5.86	(0.67)	4	7
Mother is satisfied with job	0.66	(0.48)	0	1

Notes: This table provides the list, arithmetic mean and standard deviation alongside extreme values of all left and hand side variable of interest excluding controls. This includes child duration, frequency of child sleep interruptions, whether a sleep routines are established, maternal sleep in hours and as a binary variable if its exceed six hours or between 6 and 7 hours and finally we include a measure of maternal and paternal fatigue (whether parents are getting enough sleep). Next, we list the main employment variables such as maternal and paternal labour market participation, whether the mother works part time and the number of hours of work, household income and job satisfaction.

TABLE 2 – OLS REGRESSIONS

	Probability to work		Log(Hours worked)		Log(Income)		Satisfied with job	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A :								
Sleep (hours)	0.01***	0.01***	0.001	0.04***	0.04***	0.01***	0.01***	0.01***
	(0.002)	(0.001)	(0.007)	(0.004)	(0.003)	(0.001)	(0.003)	(0.001)
R-squared	0.111	0.530	0.155	0.624	0.279	0.801	0.024	0.590
Panel B :								
Sleep less than	-0.05***	-0.06***	-0.11***	-0.17***	-0.15***	-0.02***	-0.03***	-0.016***
6 hrs	(0.009)	(0.005)	(0.028)	(0.014)	(0.014)	(0.005)	(0.012)	(0.006)
R-squared	0.112	0.530	0.156	0.624	0.278	0.801	0.024	0.590
Panel C :								
Enough sleep	0.01***	0.03***	0.00	0.07***	0.06***	0.02***	0.07***	0.02***
	(0.005)	(0.003)	(0.017)	(0.009)	(0.008)	(0.003)	(0.007)	(0.004)
R-squared	0.113	0.530	0.158	0.626	0.279	0.804	0.029	0.591
Observations	120405	120405	114932	114932	114932	114932	86049	86049
Individual controls	YES	YES	YES	YES	YES	YES	YES	YES
Individual FE	NO	YES	NO	YES	NO	YES	NO	YES
Number of individuals		10,504		10,476		10,476		8,769

Notes: All regressions are OLS. Standard errors are in parentheses. Regressions also include controls for whether the mother is separated, mother's age at pregnancy, mother's BMI, mother's educational level, mother's social network index, mother's social class, mother's sleep quality during pregnancy and whether the mother is working at 8 weeks of pregnancy. In columns (1), (2), (3), (4), (7) and (8) we also control for the logarithm of household income. In columns (5), (6), (7) and (8) we control for mother's hours worked. Sleep (hours) is the mother's average duration of sleep per night. Sleep less than 6 hours is a dummy with (1) indicating that the mother sleeps less than 6 hours per night. Enough sleep is equal to (1) if the mother feels she is getting enough sleep. See Table 1 for more detailed variable definitions.

TABLE 3 – DETERMINANTS OF MOTHER'S SLEEP QUALITY

	Mother's sleep duration		Mother sleeps less than 6 hours		Mother has enough sleep	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A :						
Child's sleep duration	0.07***		-0.01***		0.02***	
	(11.4)		(7.6)		(8.8)	
Nb of times child wakes up at night	-0.20***	-0.08***	0.04***	0.01***	-0.08***	-0.04***
	(19.1)	(19.3)	(13.1)	(14.2)	(21.5)	(24.4)
R-squared	0.054	0.658	0.037	0.603	0.042	0.623
Panel B :						
Child has a regular sleeping routine	0.33***	0.08***	-0.08***	-0.02***	0.13***	0.05***
	(10.0)	(7.4)	(9.2)	(6.8)	(13.0)	(12.8)
R-squared	0.041	0.657	0.030	0.603	0.031	0.622
Observations	133651	133870	133651	133870	142559	142851
Mother controls	YES	YES	YES	YES	YES	YES
Child controls	YES	YES	YES	YES	YES	YES
Family FE	NO	YES	NO	YES	NO	YES
Number of mother/child obs		11,334		11,334		11,980

Notes: All regressions are OLS. T-statistics are in parentheses. Regressions include controls for whether the mother is separated, mother's age at pregnancy, mother's BMI, mother's educational level, mother's social network index, mother's social class, mother's sleep quality during pregnancy, whether the mother is working at 8 weeks of pregnancy, child's gender, child's birth weight, whether the child has been in a special unit at birth, child's age and child's health. In columns (2), (4), (6) and (8), we also control for individual fixed effects.

TABLE 4 – IV REGRESSIONS

	Probability to work		Log(Hours worked)		Log(Income)		Satisfied with job	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A :								
Sleep (hours)	0.04***	0.12***	0.07	0.38***	0.11***	0.05**	0.01	0.05
	(0.014)	(0.023)	(0.043)	(0.067)	(0.020)	(0.021)	(0.019)	(0.032)
Cragg-Donald Wald F-stat	239.1	320.0	232.3	296.2	239.9	293.0	150.4	165.1
Panel B :								
Sleep less than 6 hrs	-0.23***	-0.70***	-0.39*	-2.15***	-0.62***	-0.29**	-0.08	-0.27
	(0.078)	(0.137)	(0.240)	(0.406)	(0.113)	(0.123)	(0.107)	(0.168)
Cragg-Donald Wald F-stat	104.0	160.1	101.8	143.8	105.0	140.5	69.0	97.2
Panel C :								
Enough sleep	0.12***	0.26***	0.23*	0.73***	0.36***	0.10**	0.04	0.10
	(0.039)	(0.047)	(0.187)	(0.130)	(0.057)	(0.041)	(0.055)	(0.063)
Cragg-Donald Wald F-stat	280.9	511.6	275.1	501.9	281.4	499.0	173.9	266.9
Observations	120023	120051	114573	114578	114573	114578	85889	85722
Individual controls	YES	YES	YES	YES	YES	YES	YES	YES
Individual FE	NO	YES	NO	YES	NO	YES	NO	YES
Number of individuals		10,404		10,365		10,365		8,568

Notes: All regressions are OLS. Standard errors are in parentheses. Regressions report the two-stage least squares estimates, instrumenting for mother's sleep quality using child's sleep duration and the number of times child wakes up at night. The corresponding first stage is reported in Table 3. Regressions also include controls for whether the mother is separated, mother's age at pregnancy, mother's BMI, mother's educational level, mother's social network index, mother's social class, whether the mother is working at 8 weeks of pregnancy, child's gender, child's birth weight, whether the child has been in a special unit at birth, child's age and child's health. In columns (2), (4), (6) and (8), we also control for individual fixed effects. In columns (1), (2), (3), (4), (7) and (8) we also control for the logarithm of household income. In columns (5), (6), (7) and (8) we control for mother's hours worked. Sleep less than 6 hours is a dummy with (1) indicating that the mother sleeps less than 6 hours per night. Average sleep duration is in hours. Getting enough sleep is a dummy, with (1) indicating that the mother has the feeling of having enough sleep. See Table 1 for more detailed variable definitions.

TABLE 5 – ROBUSTNESS CHECKS FOR IV REGRESSIONS (ADDITIONAL CONTROLS)

	Probability to work		Log(Hours worked)		Log(Income)		Satisfied with job	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A :								
Sleep (hours)	0.04***	0.13***	0.07	0.41***	0.10***	0.04**	0.01	0.04
	(0.014)	(0.023)	(0.044)	(0.067)	(0.020)	(0.021)	(0.020)	(0.031)
Environment triggers	YES	YES	YES	YES	YES	YES	YES	YES
Cragg-Donald Wald F-stat	232.9	330.4	226.5	305.7	232.4	301.8	145.6	170.8
Panel B :								
Sleep (hours)	0.03**	0.12***	0.08*	0.43***	0.14***	0.04*	0.02	0.01
	(0.015)	(0.025)	(0.046)	(0.073)	(0.021)	(0.022)	(0.021)	(0.033)
Parenting style	YES	YES	YES	YES	YES	YES	YES	YES
Cragg-Donald Wald F-stat	206.2	274.0	199.0	235.5	206.2	248.9	123.1	153.0
Panel C :								
Sleep (hours)	0.02	0.15***	0.02	0.43***	0.12***	0.04**	0.03*	0.03
	(0.013)	(0.024)	(0.041)	(0.069)	(0.019)	(0.021)	(0.019)	(0.032)
Household composition	YES	YES	YES	YES	YES	YES	YES	YES
Cragg-Donald Wald F-stat	255.4	316.9	249.3	293.6	259.0	289.2	160.5	166.4
Panel D :								
Sleep (hours)	0.04***	0.12***	0.07	0.35***	0.09***	0.05**	0.01	0.05
	(0.014)	(0.023)	(0.044)	(0.067)	(0.019)	(0.021)	(0.020)	(0.032)
Father characteristics	YES	YES	YES	YES	YES	YES	YES	YES
Cragg-Donald Wald F-stat	908.0	317.0	865.9	293.1	888.3	290.3	550.7	164.2
Panel E :								
Sleep (hours)	0.04***	0.12***	0.11***	0.43***	0.10***	0.01	0.01	0.01
	(0.015)	(0.025)	(0.045)	(0.074)	(0.019)	(0.022)	(0.022)	(0.033)
Environment triggers	YES	YES	YES	YES	YES	YES	YES	YES
Parenting style	YES	YES	YES	YES	YES	YES	YES	YES
Household composition	YES	YES	YES	YES	YES	YES	YES	YES
Father characteristics	YES	YES	YES	YES	YES	YES	YES	YES
Cragg-Donald Wald F-stat	202.4	266.4	194.8	245.9	200.0	132.4	117.5	148.1
Observations	120023	120051	114573	114578	114573	114578	85889	85722
Individual controls	YES	YES	YES	YES	YES	YES	YES	YES
Individual FE	NO	YES	NO	YES	NO	YES	NO	YES
Number of individuals		10,404		10,365		10,365		8,568

Notes: All regressions are OLS. Standard errors are in parentheses. Regressions report the two-stage least squares estimates, instrumenting for mother's sleep quality using child's sleep duration and the number of times child wakes up at night.. Regressions also include the usual controls for mother and child characteristics. In columns (2), (4), (6) and (8), we also control for individual fixed effects. In columns (1), (2), (3), (4), (7) and (8) we also control for the logarithm of household income. In columns (5), (6), (7) and (8) we control for mother's hours worked. Environment triggers include information on noise, whether child shares bed/bedroom, and the number of years lived in Avon. Parenting style includes whether the child is still breastfed after 15 months, has never been breastfed, the number of hours spent in child care (commercial carer, nursery), time child goes to bed, time child wakes up, any sleep during day time and whether the mother is an organised person. Household composition includes the number of children in the household, whether chid is the first chid, the number of old sibling, young sibling, whether the mother is pregnant, whether there is a new parent in the household. Father characteristics include father's educational level, father's social class, whether father works during pregnancy, father's age at pregnancy, father's health and whether father is getting enough sleep during pregnancy.

TABLE 6 – ROBUSTNESS CHECKS FOR IV REGRESSIONS (ALTERNATIVE INSTRUMENT)

	Probability to work		Log(Hours worked)		Log(Income)		Satisfied with job	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A :								
Sleep (hours)	0.13***	0.26***	0.32***	0.73***	0.26***	0.16***	0.06**	0.04
	(0.036)	(0.062)	(0.110)	(0.181)	(0.050)	(0.054)	(0.043)	(0.056)
Cragg-Donald Wald F-stat	74.9	57.0	71.8	51.8	78.7	50.8	59.4	53.6
Panel B:								
Sleep less than 6 hrs	-0.56***	-1.29***	-1.34***	-3.76***	-1.12***	-0.82**	-0.26**	-0.26
	(0.151)	(0.326)	(0.467)	(1.023)	(0.223)	(0.297)	(0.195)	(0.403)
Cragg-Donald Wald F-stat	63.7	38.5	60.0	31.3	64.1	30.2	42.2	16.9
Panel C :								
Enough sleep	0.28***	0.44***	0.65***	1.14***	0.60***	0.25***	0.12**	0.06
	(0.076)	(0.095)	(0.229)	(0.257)	(0.105)	(0.080)	(0.097)	(0.110)
Cragg-Donald Wald F-stat	145.8	130.9	152.8	135.5	159.2	134.5	108.0	86.7
Observations	120023	120051	114573	114578	114573	114578	85889	85722
Individual controls	YES	YES	YES	YES	YES	YES	YES	YES
Individual FE	NO	YES	NO	YES	NO	YES	NO	YES
Number of individuals		10,404		10,365		10,365		8,568

Notes: All regressions are OLS. Standard errors are in parentheses. Regressions report the two-stage least squares estimates, instrumenting for mother's sleep quality using child's sleeping routine. The corresponding first stage is reported in Table 3. Regressions also include controls for whether the mother is separated, mother's age at pregnancy, mother's BMI, mother's educational level, mother's social network index, mother's social class, whether the mother is working at 8 weeks of pregnancy, child's gender, child's birth weight, whether the child has been in a special unit at birth, child's age and child's health. In columns (2), (4), (6) and (8), we also control for individual fixed effects. In columns (1), (2), (3), (4), (7) and (8) we also control for the logarithm of household income. In columns (5), (6), (7) and (8) we control for mother's hours worked. Sleep less than 6 hours is a dummy with (1) indicating that the mother sleeps less than 6 hours per night. Average sleep duration is in hours. Getting enough sleep is a dummy, with (1) indicating that the mother has the feeling of having enough sleep. See Table 1 for more detailed variable definitions.

TABLE 7 – ROBUSTNESS CHECKS FOR IV REGRESSIONS (PROBIT)

	Probability to work	Satisfied with job
	(1)	(2)
Panel A :		
Sleep (hours)	0.11***	0.04
	(0.022)	(0.028)
Panel B:		
Sleep less than 6 hrs	-0.59***	-0.20
	(0.119)	(0.153)
Panel C :		
Enough sleep	0.32***	0.10
	(0.060)	(0.079)
Observations	120023	85889
Individual controls	YES	YES
Individual FE	NO	NO

Notes: All regressions are instrumental probit. Standard errors are in parentheses. Regressions instrument for mother's sleep quality using child's sleep duration and the number of times child wakes up at night. Regressions also include controls for whether the mother is separated, mother's age at pregnancy, mother's BMI, mother's educational level, mother's social network index, mother's social class, whether the mother is working at 8 weeks of pregnancy, child's gender, child's birth weight, whether the child has been in a special unit at birth, child's age and child's health. We also control for the logarithm of household income. In column (2), we control for mother's hours worked. Sleep less than 6 hours is a dummy with (1) indicating that the mother sleeps less than 6 hours per night. Average sleep duration is in hours. Getting enough sleep is a dummy, with (1) indicating that the mother has the feeling of having enough sleep. See Table 1 for more detailed variable definitions.

TABLE 8 – FATHER'S PROBABILITY TO WORK AND FATHER'S SLEEP QUALITY

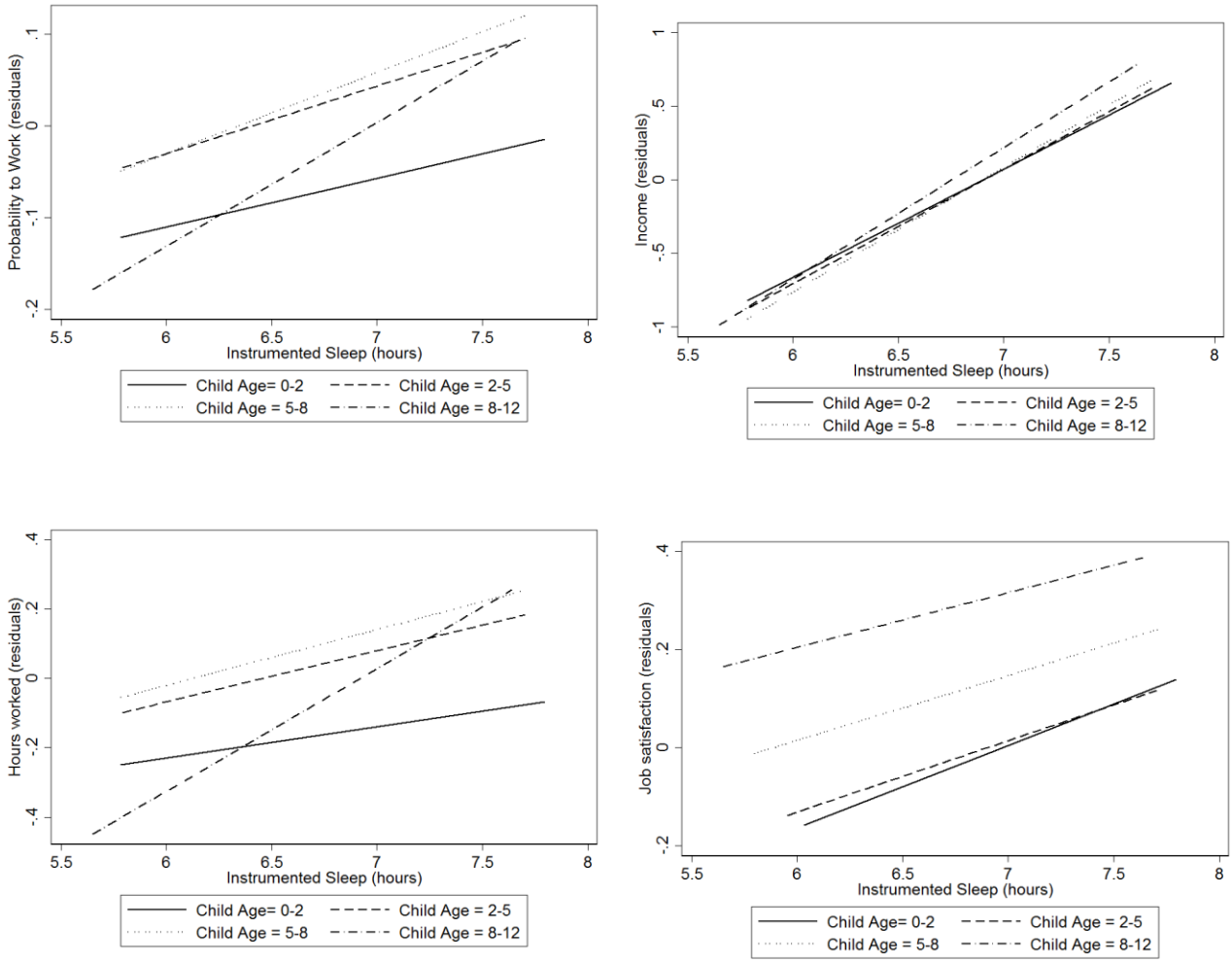
	Probability to work		Father is getting enough sleep		Probability to work	
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) IV	(6) IV
Getting enough sleep	0.00	0.00			0.58***	0.69***
	(0.005)	(0.003)			(0.129)	(0.137)
Child's sleep duration			0.01***			
			(0.003)			
Number of times child wakes			-0.03***	-0.01***		
Up at night			(0.004)	(0.001)		
Observations	85719	85719	100817	100817	89840	89840
R-squared	0.105	0.555	0.095	0.729	0.612	0.830
Individual controls	YES	YES	YES	YES	YES	YES
Individual FE	NO	YES	NO	YES	NO	YES
Number of father/child obs		7,587		8,570		7,839
Cragg-Donald Wald F-Stat					26.9	62.3

Notes: All regressions are OLS. Standard errors are in parentheses. Regressions include controls for father's educational level, father's age at pregnancy, father's social class, whether fathers work during pregnancy, father's health, whether father has enough sleep during pregnancy, child's gender, child's birth weight, whether the child has been in a special unit at birth, child's age and child's health. In columns (2), (4), (6), we also control for individual fixed effects. Regressions in columns (5) and (6) report the two-stage least squares estimates, instrumenting for father's sleep quality using child's sleep duration and the number of times child wakes up at night. The corresponding first stages are reported in columns (3) and (4).

IX. Appendix

FIGURE A1 – HETEROGENEOUS EFFECTS

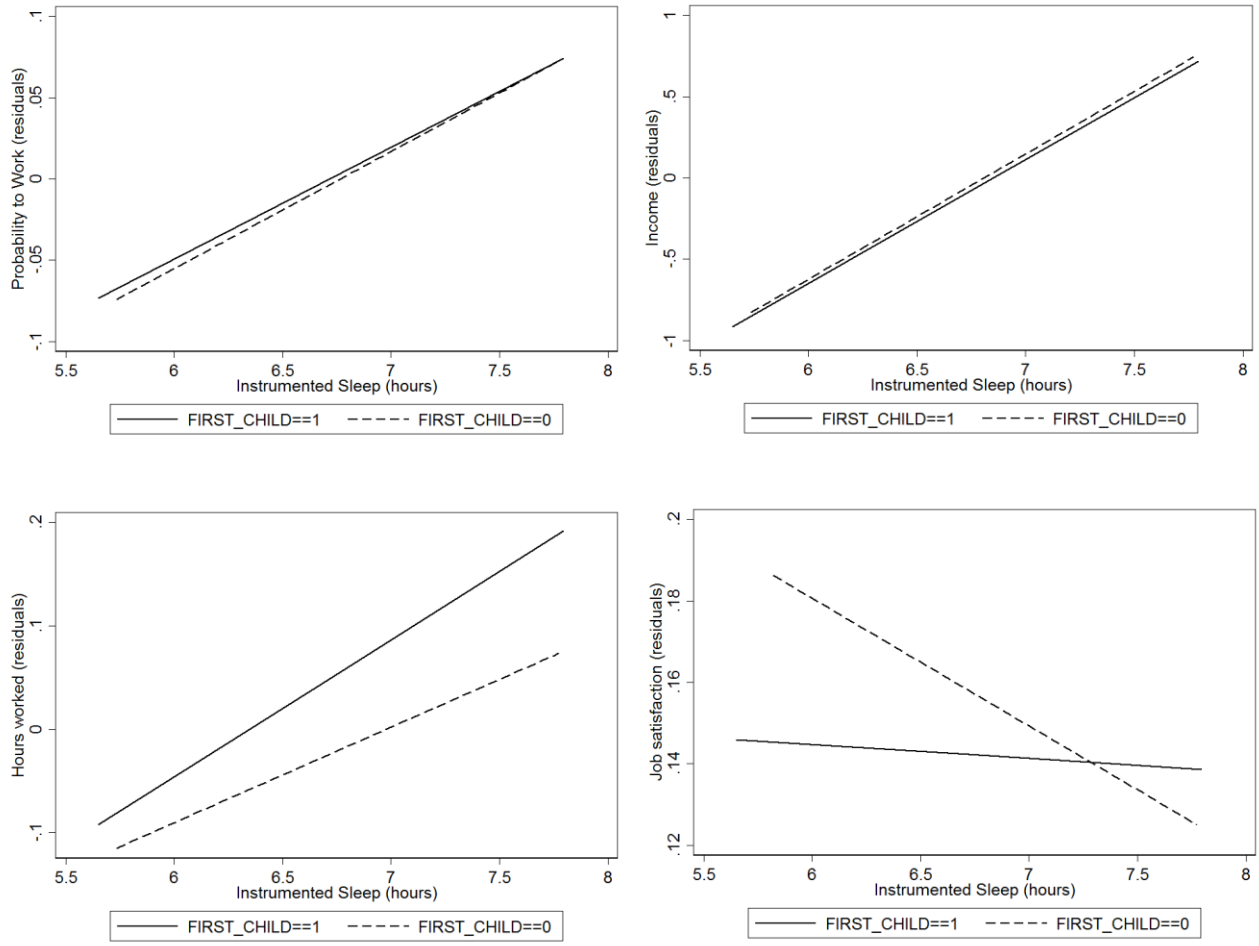
By child age



Notes: These figures show the dynamic relationships (in time series) between residualised outcomes (probability to work, hours worked, income and job satisfaction) and instrumented mother's duration of sleep by child age. The regressions include the same controls as in Table 4.

FIGURE A2 – HETEROGENEOUS EFFECTS

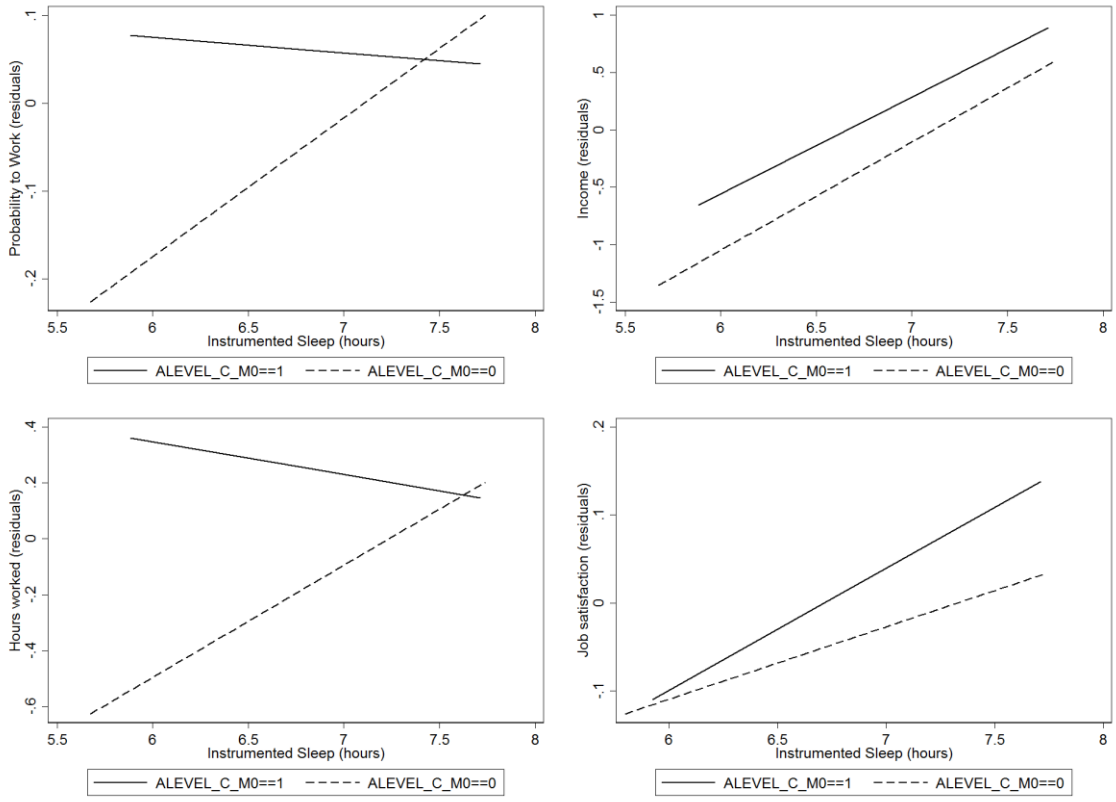
First child or not



Notes: These figures show the dynamic relationships (in time series) between residualised outcomes (probability to work, hours worked, income and job satisfaction) and instrumented mother's duration of sleep by child order. The regressions include the same controls as in Table 4.

FIGURE A3 – HETEROGENEOUS EFFECTS

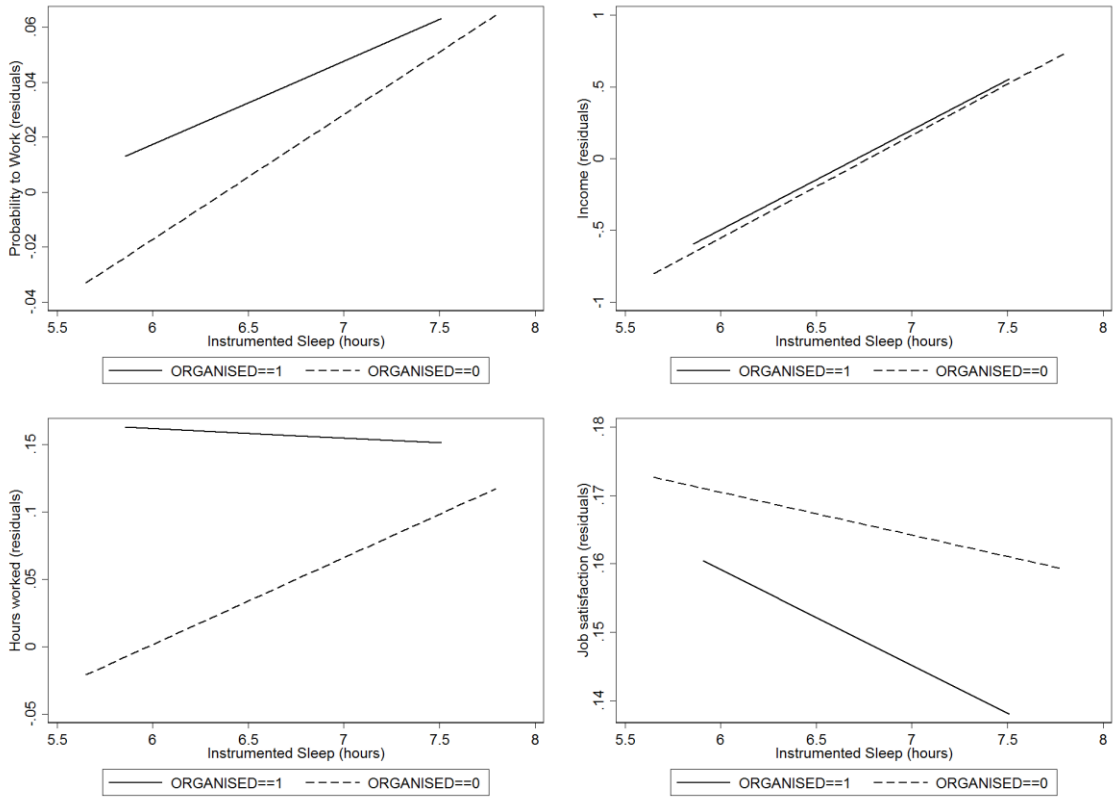
Mother has a A-level or not



Notes: These figures show the dynamic relationships (in time series) between residualised outcomes (probability to work, hours worked, income and job satisfaction) and instrumented mother's duration of sleep by child order. The regressions include the same controls as in Table 4.

FIGURE A4 – HETEROGENEOUS EFFECTS

Mother is organised



Notes: These figures show the dynamic relationships (in time series) between residualised outcomes (probability to work, hours worked, income and job satisfaction) and instrumented mother's duration of sleep by child order. The regressions include the same controls as in Table 4.

TABLE A1 – RAW CORRELATIONS BETWEEN CHILD QUALITY OF SLEEP VARIABLES

	Child sleep duration	Nb of times child wakes up at night	Probability child wakes up at night	Child has a regular sleeping routine
Child sleep duration	1.00			
Nb of times child wakes up at night	-0.05	1.00		
Probability child wakes up at night	-0.01	0.83	1.00	
Child has a regular sleeping routine	0.18	-0.30	-0.22	1.00

TABLE A2 – DETERMINANTS OF CHILD QUALITY OF SLEEP

	Child sleep duration		Nb of times child wakes up at night		Probability child wakes up at night		Child has a regular sleeping routine	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Child characteristics:								
Child age	-0.04***	-0.04***	-0.04***	-0.03***	-0.01***	-0.01***	0.02***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Child's gender: Male	-0.06***		0.02**		0.01		0.00	
	(0.01)		(0.001)		(0.00)		(0.00)	
Child: low birth	0.03		0.01		0.00		0.01	
weight	(0.02)		(0.02)		(0.01)		(0.01)	
Child: in special unit	-0.00		0.03		0.02		-0.00	
at birth	(0.02)		(0.02)		(0.01)		(0.01)	
Child's health	0.10***	0.06***	-0.32***	-0.12***	-0.18***	-0.07***	0.05***	0.02***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Mother characteristics:								
Mother's education	-0.03***		-0.03***		-0.01**		0.02**	
	(0.01)		(0.01)		(0.01)		(0.00)	
Mother's age at birth	-0.01***		0.00***		0.00***		-0.00***	
	(0.00)		(0.00)		(0.00)		(0.00)	
Mother's BMI	-0.00**		-0.00*		-0.00*		-0.00	
	(0.00)		(0.00)		(0.00)		(0.00)	
Mother's social	0.00***		-0.00*		-0.00*		0.00***	
network	(0.00)		(0.00)		(0.00)		(0.00)	
Mother's social class	-0.00		-0.01		-0.01*		0.00	
	(0.01)		(0.01)		(0.01)		(0.00)	
Mother is separated	0.07***	0.03***	0.04***	0.01	0.02**	0.01	-0.01***	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)

Mother sleeps ok	0.01*		-0.02***		-0.01**		0.01***	
during pregnancy	(0.01)		(0.01)		(0.00)		(0.00)	
Mother works	-0.01		-0.03***		-0.01*		0.00	
during pregnancy	(0.01)		(0.01)		(0.01)		(0.00)	
Father characteristics:								
Father's education	-0.01		-0.01		-0.00		0.01**	
	(0.01)		(0.01)		(0.01)		(0.01)	
Father's age at birth	-0.00		-0.00		-0.00		-0.00	
	(0.01)		(0.01)		(0.01)		(0.01)	
Father's health	0.06***	-0.02	-0.10***	-0.03**	-0.06***	-0.00	0.02***	0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Father's social class	-0.00		0.00		0.00**		-0.00**	
	(0.00)		(0.00)		(0.00)		(0.00)	
Father sleeps ok during pregnancy	-0.00		-0.05***		-0.03***		0.00	
	(0.01)		(0.01)		(0.01)		(0.00)	
Father works	0.01		-0.05***		-0.02**		0.02***	
during pregnancy	(0.01)		(0.02)		(0.01)		(0.01)	
Environment:								
Noise is not a pb	0.00	0.00	-0.03***	-0.01***	-0.01***	-0.00	0.01***	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Child shares bed	0.00	0.05***	0.16***	0.06***	0.07***	0.02***	-0.07***	-0.02***
or bedroom	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Length of time in	-0.00		0.00		0.00		-0.00**	
Avon	(0.00)		(0.00)		(0.00)		(0.00)	

Household compo:								
Number of children	0.01***	0.02***	-0.01	-0.00	-0.01***	0.00	-0.00*	0.00***
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
First child	-0.00		0.04***		0.02***		-0.01***	
	(0.01)		(0.01)		(0.01)		(0.00)	
Nb of old siblings	-0.00		0.01**		0.01***		-0.00**	
	(0.00)		(0.00)		(0.00)		(0.00)	
Nb of young siblings	0.01		-0.03***		-0.02***		0.00	
	(0.01)		(0.01)		(0.00)		(0.00)	
Mother is pregnant	0.04***	0.01	-0.02**	-0.01**	0.00	0.01	-0.00	-0.00
again	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
New parent in hhsold	0.04**	-0.06**	-0.03	-0.02	-0.02	-0.01	-0.01	0.00
	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Parenting style:								
Never breasfeed by	0.03***		-0.00		-0.00		-0.01*	
15 months	(0.01)		(0.01)		(0.01)		(0.00)	
Still breasfeed by	-0.05***		0.16***		0.08***		-0.03***	
15 months	(0.01)		(0.02)		(0.01)		(0.01)	
Use nursery	-0.00	-0.00	-0.00	0.00	-0.00	0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Use commercial	-0.00***	-0.00	-0.00***	-0.00	-0.00	0.00	0.00***	0.00***
carer	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Time child goes to	-0.91***	-0.75***	0.10***	0.05***	0.05***	0.02***	-0.08***	-0.05***
bed	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Time child wakes up	0.97***	0.80***	-0.13***	-0.08***	-0.06***	-0.04***	0.03***	0.03***
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Sleep during day	0.06***	0.02***	-0.03***	-0.01**	-0.01*	-0.00	0.00	0.00**
time	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Observations	132,381	132,381	132,243	132,243	132,243	132,243	132,540	132,540
R-squared	0.660	0.701	0.093	0.102	0.089	0.106	0.086	0.052
Fixed effects	NO	YES	NO	YES	NO	YES	NO	YES
Number of ID		12,904		12,799		12,799		12,863

Notes: All regressions are OLS. Standard errors are in parentheses. In columns (2), (4), (6) and (8), we also control for individual fixed effects.

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