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ABSTRACT

The Effect of Parental and Grandparental Supervision Time Investment on Children's Early-Age Development

This article explores the impact of grandparents' supervision time input relative to the effect of parents' childcare provision on children's cognitive, social and behavioral development at an early age. We identify the effects of interest through panel data estimation methods. The findings provide evidence of complementarity between parental and grandparental involvement in the child-rearing process. Specifically, grandparental care has a stronger effect than parental intervention on the vocabulary skills of the child. However, parents' time input in the child has a larger impact than does the supervision time investment of grandparents on the socio-behavioral development and the picture similarities measure of cognitive ability of children between 3 and 6 years old.

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1. Introduction

Cognitive, social and behavioral development at an early age has an effect on later educational attainment, health, behavioral and socio-economic outcomes of children. These different aspects of the maturity process can be influenced by all caregivers who supervise the child. Therefore it is interesting to explore the relative importance of grandparents, other childcare providers and parents in the enhancement of early childhood outcomes for the following reasons. Grandparents can influence the early development of children through intergenerational transfer of experience, wisdom, knowledge and skills. They can help parents in the child-rearing process and might have more time, vigor and willingness to spend quality in addition to supervision time with the child. Grandparents can also directly affect early educational attainment of the child through helping him/ her learn letters and numbers, do homework, and develop practical skills which the child is likely to use later in life. However, this does not necessarily imply that grandparental care is sufficient for adequate child development. This paper addresses the question of whether grandparents and parents can be thought of as substitutes or complements in the development process of children, and quantifies the relative effect of parental and grandparental supervision time on child outcomes.

Previous literature focused on either the impact of grandparental provision of child care on grandparents, or the effect of grandparental resources, mainly material and financial, on the educational outcome of the grandchild. However, existing articles on the effect of downward transfers (i.e., transfers from grandparents to children) on child behavior and educational achievement are limited and inconclusive. We contribute to the existing literature by exploring the importance of raising grandchildren on their early-age development. We extend a previously developed model of skills and knowledge accumulation to take into account the supervision time

investment in the child not only by parents but also by grandparents. We employ Scottish data in FE panel data regression analysis and seemingly unrelated regressions (SUR) in order to identify the effect of the number of hours of childcare provision by grandparents relative to that of parents on three measures of child development at an early age.

Our findings are indicative of a significant difference between the effect of grandparental childcare provision and parental time investment in the child on the social and behavioral outcomes of children under 6, as well as on their cognitive attainment. While parents' supervision time has a larger impact on children's social and behavioral development than an additional hour spent with grandparents, the grandparents' effect on children's vocabulary enhancement is larger than that of the parents. Transferring 10 hours a week from the parents to the grandparents improves children's cognitive ability by 2.2%. These results are consistent with the findings of the psychology literature that not only parents but also other relatives and people children socialize with determine children's development at an early age (Harriss 2009).

Our findings imply a beneficial role of grandparents, and provide a strong argument in favor of policy considerations aimed to promote grandparental involvement in the child-rearing process in the first few years of life. Such policies include national insurance credit grants, financial allowances and paid leave, such as the ones recently implemented in the UK, Germany, Portugal and other European countries. In the context of Scotland and other countries in which childcare is not sufficient in some areas or cost-prohibitive country-wide, parents have to be aware of the consequences of employing a grandparent as a substitute for childcare or themselves.

The remainder of this paper is organized as follows. Section 2 summarizes the existing literature. Section 3 presents the empirical models, and explicates the identification strategies.

Section 4 describes the data used in the empirical analysis of the paper. Section 5 presents the findings of this study. Finally, Section 6 discusses the policy implications, and Section 7 concludes the paper.

2. Literature Review

This section summarizes the existing literature related to grandparenthood and the effect of investing in children on their outcomes.

2.1. Literature on the Effect of Grandparenthood

A number of articles, such as Jendrek (1993) and Arpino et al. (2014), considered how providing care to grandchildren affects the elder generation. Specifically, they examined the effect of grandparenting on the cognitive score of grandmothers. They found that providing care to a grandchild had a positive impact on the verbal fluency of the grandparent but did not have a significant impact on three other measures of cognitive development: numeracy, immediate recalls, and delayed recalls. Jendrek (1993) utilized the results from an interview of grandparents who have taken care of their grandchildren every day in order to investigate whether taking care of a grandchild changes grandparent's lifestyle, friendships, relationship with the family and with the spouse. The article was purely descriptive, and the effect on children was not included in the analysis. Another study, conducted by Bowers et al. (1999) contributed to the literature by showing a correlation between caregiving and grandmothers' life satisfaction, stress and feeling of a burden. The results showed that behavioral problems of the grandchild made a grandmother feel a larger burden, and decreased her satisfaction from taking care of a grandchild.

Vendell et al. (2003) studied the factors, such as mother's age, ethnicity, employment status and others, which influence the likelihood of observing four types of grandparental childcare:

extended full-time, extended part-time, sporadic and no routine care. The results indicated that all types of care were more likely when the grandparent lives in the household. The probability of sporadic care was higher when the mother was younger and worked non-standard hours, while the chance of full-time care relative to extended part-time care was higher for mothers who worked full-time.

Our study is different from the above-mentioned ones in that we are interested in the comparison of the importance of grandparental involvement relative to that of parents for the development outcomes of the child.

2.2. Literature on the Effect of Investing in Children on Their Outcomes

Prior literature also considered the effect of grandparents' financial resources, human capital, social status and acquaintances, rather than time investment, on grandchildren. Some of these papers confirmed the existence of an effect on child outcomes (e.g., Zeng and Xie 2014) while others did not (e.g., Bol et al. 2016; Erola et al. 2007). For example, Bol et al. (2016) studied the effect of grandparents' education, occupational status and culture on the educational outcome of the grandchild. Pedersen et al. (2015) investigated the effect of grandparents' economic, cultural, and social capital resources on grandchildren's choice of secondary education (academic, vocational, or none). They showed that cultural capital possessed by grandparents had a positive effect on the probability that the grandchild would choose academic education, but economic and social resources of the grandparents did not influence educational choice (Pedersen et al. 2015). Further, evidence from the Netherlands was indicative of the lack of a significant impact of grandparent's resources on the educational success of grandchildren.

In contrast, this article investigates the effect of time investment in the child by the parents and grandparents rather than the impact of financial support or social status. We also test the

hypothesis that there is a difference in the effect of time input in child development, provided by grandparents relative to parents. The differential effect has been extracted from a model similar to the ones developed by Blau et al. (1992), Duncan et al. (2003), Bernal (2008) and Bernal and Keane (2010, 2011). However, while they investigated the effect of child care and the time parents supervise their children on child development, we also incorporate grandparents' supervision time in this article.

Specifically, Blau et al. (1992) studied the effect of maternal employment on child's cognitive development. Their findings indicated that maternal employment of 100% a week was associated with a decline in the standardized cognitive ability score of the child by 5.8 points in the first year, but had a positive effect of 4.2 points in the following three years. These results imply absence of a net effect on child's development in the first few years of life.[1]

Duncan et al. (2003) examined the effect of childcare quality on academic and cognitive skills of children and found a positive impact. Bernal (2008) developed a structural model of the decision of married mothers about whether to use child care or not and whether to work part-time, full-time, or not work, and then, examined the effect of the combination of the two decisions on the cognitive outcome of the child. He evaluated the effect of maternal employment, day care child inputs and household income on the reading and mathematical skills of children between 3 and 6. His empirical findings suggested that an increase in full-time employment of the mother by 1 year lowers the scores of the child by 1%, and utilization of child care for a year more reduces the child cognition test score by 0.8%. Thus, if a mother is employed full-time and uses child care for an extra year, the ability test score of her child decreases by 1.8%.

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[1] The authors provide 2 possible explanations of the impact after the first year: mother's employment is associated first, with higher household income, and second, with more contacts of the child with children and adults as a result of non-maternal care, which may affect the cognitive development of the child.

Bernal and Keane (2010) extended Bernal's work (2008) to single mothers, and obtained similar results, with the latter effect of interest being 2.7% instead of 1.8%. They investigated the effect of maternal time, alternative childcare and goods inputs on child cognitive achievement at ages 4-6 in the case of single mothers, and created a model of the employment and child care decisions of a mother in order to deal with potential selection bias.

Finally, Bernal and Keane (2011) estimated the effect of single-mother time input on child cognitive development. Using welfare reforms, including TANF, the Earned Income Tax Credit (EITC), subsidies provided by the Childcare Development Fund, and Child support enforcement for single mothers, as instruments for childcare use, they found that an additional year of child care lowered test scores of children by 2.1%.

2.3. Contribution

As shown in the previous subsections, evidence from previous literature is mixed. Furthermore, none of the prior papers emphasized the effect of grandparental caregiving.

This article delves more deeply in both the predictors of success and the outcomes of the child. It contributes to the literature in several ways. First, instead of looking at the effect of material and connection support provided by grandparents, as it has been done in most previous papers, we explain the impact of the amount of supervision time grandparents devote to grandchildren, in addition to the effect of parental supervision time investment and non-family-based child care. In other words, the focus is on non-material support influencing child outcomes through transmission of experience, multi-generational and potentially multi-cultural exposure to ideas, assistance in daily tasks and attention.

Second, unlike previous papers which restrict attention to either educational or cognitive attainment, we verify whether grandparental intervention can explain some of the variability in both cognitive achievement, and social and behavioral development of the child relative to the effect of parents. This is different from most of the papers whose dependent variable captures cognition or life satisfaction of grandparents.

Third, to the best of our knowledge, there is no previous paper whose analysis has been based on Scottish data. Focusing on this particular country is important due to the high childcare costs there, as well as the unavailability of formal care in some areas.

Finally, most studies, with the exception of Black et al. (2005), were based on data obtained from interviews with few observational subjects. In addition, most studies except for Bernal (2008) and Keane and Bernal (2010, 2011), used cross-sectional data which did not allow making a distinction between past and present effects. We address this shortcoming by using a longitudinal dataset, following more than 5000 children for 6 years. This allows us to distinguish between time investment into the child in the current moment and time inputs in previous periods because skills and abilities are continuously acquired over time, and parental and grandparental involvement may have both an immediate and a delayed effect on the cognitive, social and behavioral formation of the child.

3. Methods

3.1. Model Specification

The goal of our analysis is to explore the determinants of a full set of child development outcomes, including measures of early-age cognitive, social and behavioral development. To

identify the causal effect of childcare provided by grandparents, we consider a model similar to the one developed by Bernal and Keane (2011). Our model is as follows:

$$lnScore_{it} = lnE_{it} + \boldsymbol{\alpha HF}_{it} + \alpha_i + \tau_t + \epsilon_{it} \qquad (1)$$

In this equation, $Score_{it}$ is a measure of child development. $\boldsymbol{HF}$ is a vector of covariates controlling for observed child's health, family and household characteristics at time period t. E_{it} captures child's acquisition of ability and skills through the process described in the following paragraph. α_i are child-specific fixed effects, or unobserved cross-sectional heterogeneity whose purpose is to control for unobserved skill endowment of the child. τ_t are time fixed effects, and ε_{it} is an unobserved, idiosyncratic error component capturing errors and transitory shocks. Subscripts i indicate that the variable is defined at children level, and subscripts t denote years.

Following Bernal and Keane (2011), the development of child's abilities is assumed to be a function of his inherent, initial endowment E_{i0} with which child i was born, and a set of inputs (parental and grandparental supervision time spent with the child, child care provided by non-parental and non-grandparental sources, and goods inputs), enhancing the innate E_{i0} over time. Intrinsic E_{i0} is correlated with a set of observable characteristics of the parents and observable characteristics of the child at birth, $\boldsymbol{X}_{io}$, including educational attainment of the parents and gender of the child, as well as a component ω_{i0}, capturing unobserved heterogeneity in the inherited endowment of the child, partly explained by unobserved ability endowment of the parents, and partly due to unexplained endowment of the child itself:

$$lnE_{i0} = \boldsymbol{X}'_{i0}\boldsymbol{\vartheta} + \omega_{i0} \qquad (2)$$

Then, similarly to Bernal and Keane (2011) and Leibowitz (1974), we assume that a production function of child development or acquisition of human capital is given by:

$$lnE_{it} = f(P_{i\tau}, Grp_{i\tau}, CC_{i\tau}, I_{i\tau}, E_{i0} | \tau : 0 < \tau \leq t) \qquad (3)$$

In (3), $P_{i\tau}, Grp_{i\tau}, CC_{i\tau}, I_{i\tau}$ are inputs in the development of child i. Specifically, P_{it} is a measure of parental supervision time inputs. I_{it} are goods inputs used in the production of child development. $Grp_{i\tau}$ is grandparental supervision time input into the child, and CC_{it} is child care supervision time input (excluding parental and grandparental time) t years after the birth of the child.

As noted by previous authors, it is not easy, if possible at all, to estimate (3) if the inputs and ω_{i0} have a different effect on E_{it} at different ages (Bernal and Keane 2011). Therefore, we make three assumptions, standard in the literature. First, we assume that cumulative rather than per period time inputs are pertinent to the framework of human capital production. The second assumption is that the ability component ω_{i0} is invariant over time. Finally, we assume a linear relationship between E_{it} and the inputs.

Given (2) and the simplifying assumptions, the behavioral and cognitive ability (development) production function in (3) can be expressed as:

$$lnE_{it} = lnE_{i0} + \pi_1 \frac{\sum_{\tau=1}^{t} P_{i\tau}}{t} + \pi_2 \frac{\sum_{\tau=1}^{t} Grp_{i\tau}}{t} + \pi_3 \frac{\sum_{\tau=1}^{t} CC_{i\tau}}{t} + \pi_4 lnI_{it} + u_{it} \qquad (4)$$

Here, u_{it} is an idiosyncratic error term, $u_{it} \sim N(0, \sigma_u^2)$. In the construction of this equation, by including cumulative terms capturing cumulative parental, grandparental, and external childcare over time we take into account the possibility that current possession of skills can be influenced by both past and present inputs in the development of the child. This is an important distinction and improvement of other papers which ignore historical attainment of skills because specifications which incorporate only present inputs impose the strong assumption that present outcomes are independent of past investments in the child.

We use annual household income as a proxy for the unobserved I_{it}. Data on caregivers' inputs, including grandparents, are available. We assume that parents are residual caregivers, and express parental supervision time P_{it} as follows:

$$P_{it} = T - Grp_{it} - CC_{it} \qquad (5)$$

In this equation, T is total time in a period, which is a week (168 hours) in our specification. The expression $T - Grp_{it} - CC_{it}$ can be interpreted as the number of hours in a week which a child certainly does not spend with either a grandparent, or an alternative child care provider.[2] Under the assumptions that there should always be an adult supervising children at an early age and that parents are the only residual caregivers, can we rewrite (4) as follows:

$$lnE_{it} = \boldsymbol{X}'_{i0}\boldsymbol{\vartheta} + \omega_{i0} + \pi_1 \frac{\sum_{\tau=1}^{t}(T - Grp_{it} - CC_{it})}{t} + \pi_2 \frac{\sum_{\tau=1}^{t}Grp_{i\tau}}{t} + \pi_3 \frac{\sum_{\tau=1}^{t}CC_{i\tau}}{t} + \pi_4 lnI_{it}$$

$$+ u_{it}$$

$$= \boldsymbol{X}'_{i0}\boldsymbol{\vartheta} + \omega_{i0} + \pi_1 T + (\pi_2 - \pi_1)\frac{\sum_{\tau=1}^{t}Grp_{i\tau}}{t} + (\pi_3 - \pi_1)\frac{\sum_{\tau=1}^{t}CC_{i\tau}}{t} + \pi_4 lnI_{it}$$

$$+ u_{it} = \beta_0 + \boldsymbol{X}'_{i0}\boldsymbol{\vartheta} + \beta_2 \frac{\sum_{\tau=1}^{t}Grp_{i\tau}}{t} + \beta_3 \frac{\sum_{\tau=1}^{t}CC_{i\tau}}{t} + \pi_4 lnI_{it} + u_{it} \qquad (6)^3$$

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[2] We assume that parents supervision time is given by the difference between the total number of hours in a week and grandparents' and other care providers' supervision time spent with a child. However, it is likely that a parent and a grandparent sometimes supervise a child simultaneously. In that case, the assumption that parents are residual caregivers may lead to underestimation of the time parents spend with a child because the amount of time of simultaneous care-giving has already been counted as time under grandparents' supervision. Therefore, the effect of grandparents on child outcomes will be over-estimated while the impact of parents' supervision on development of the child will be under-estimated.

[3] Alternatively, one may not take the average number of hours spent with the child (i.e. may not divide by the number of periods t) because in a production function, one might want to take into account the total amount of inputs (here, number of hours invested in the child). As the child grows older (i.e. as t increases), the number of hours would increase. However, if one chooses this alternative specification of the model, he/ she has to necessarily include a time trend to control for the unavoidable increase in the total number of hours spent with a child as t increases.

It is important that $\beta_2 \equiv \pi_2 - \pi_1$ in (6) captures the effect of time the child spends with grandparents *relative* to the effect of parental supervision time investment in the child on child development, and similarly, $\beta_3 \equiv \pi_3 - \pi_1$ shows the effect of time in external childcare *relative* to the effect of parental supervision time with the child on child development outcomes.

Given equations (1) and (6), we specify the final regression model of interest in the following form:

$$lnScore_{it} = \beta_0 + X'_{i0}\vartheta + \beta_2 \frac{\sum_{\tau=1}^{t} Grp_{i\tau}}{t} + \beta_3 \frac{\sum_{\tau=1}^{t} CC_{i\tau}}{t} + \pi_4 lnI_{it} + \alpha HF_{it} + \alpha_i + \tau_t$$
$$+ \varepsilon_{it} \quad (7)$$

We estimate different specifications of this model taking into account only individual FE, individual and time FE, and individual, time and regional effects[4]. Appendix A1 contains all variables used in the analysis and their descriptions.

As an alternative specification of the model, since acquisition of skills and ability is a continuing process and time investment into the child adds up over time, we distinguish between the effect of time investment in the past and in the present in order to examine the immediate effect of time investment distinctly from the one which affects child outcomes with a lag. We do so by separating previous periods from the current period, and rewrite (7) as:

$$lnScore_{it} = \beta_0 + X'_{i0}\vartheta + \beta_{2past} \frac{\sum_{\tau=1}^{t-1} Grp_{i\tau}}{t-1} + \beta_{2present} Grp_{it} + \beta_{3past} \frac{\sum_{\tau=1}^{t-1} CC_{i\tau}}{t-1}$$
$$+ \beta_{3present} CC_{it} + \pi_4 lnI_{it} + \alpha HF_{it} + \alpha_i + \tau_t + \varepsilon_{it} \quad (8)$$

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[4] To employ FE panel data method to identify the parameters in each of the regressions presented in the section, we assume cross-sectional heterogeneity, i.e. children differ in terms of their unobserved, time-invariant characteristics, and we also allow the latent effect or the unobserved, time-constant heterogeneity to be correlated with the covariates. We conduct a formal Hausman test to detect whether a FE model is the optimal estimation method.

The interpretation of the coefficients $\beta_{2past}, \beta_{2present}, \beta_{3past}$, and $\beta_{3present}$ in (8) is similar to that of β_2 and β_3 in (6), described earlier.

It is also worth mentioning that differentiating between past and present effects would make sense given that prior and current involvement into child's development are not highly correlated. In the context of Scotland, data suggest that the correlation coefficient between the sum of hours of all prior-period grandparental childcare provision and current number of hours of child care provided by the grandparents is 0.5257, while the correlation coefficient between the same variables but for external child care is even smaller, or 0.3832. Both correlation coefficients are suggestive of a reasonable motive to tease out past and current time input into the child skill development production function.

Finally, while we identify the effect of time spent under parents' or grandparents' supervision which is available in the dataset, we fail to capture the impact of "quality time" spent with the child which is unobserved. Thus we are able to quantify only the impact of supervision time investment on child scores. Because supervision time always has to add up to 168 hours per week, an additional hour under the supervision of one provider, e.g. a grandparent, is implicitly associated with a subtraction of one hour from the time another provider would otherwise spend with the child. Thus one cannot estimate the effect of the marginal hour holding everything else fixed.

3.2. Seemingly Unrelated Regressions

While using the panel feature of the dataset and applying fixed effects estimations enables us to establish causal relationships between the variables of interest and the outcome, examining each outcome, one at a time, independently of the others, may not be sufficient in the context of child development. The reason is that a given outcome or ability can be a major predictor of

another capability in the same or subsequent years. In other words, two measures of cognition for a given child are likely to be related although the outcomes of one child are not related to those of another. If different measures of cognitive development and/ or their values at different ages are correlated, and a formal Breusch-Pagan independence test provides evidence of such correlation, then the effects of interest should be explored through a system of equations, related stochastically through the correlation between the error terms. This requires the usage of Zellner's seemingly unrelated regressions (SUR) model (Zellner 1962). We construct a SUR model with 4 equations of the following form:

$$lnCognitiveOutcome_{ki} = \alpha_k + \beta_{ki}\beta HrsChdCareGrp_{ki} + \boldsymbol{\gamma_k}\boldsymbol{X}_{ki} + \varepsilon_i \quad (9)$$

Here, $k = 1, \ldots 4$ denotes 4 cognitive development outcomes: scores based on children's ability to identify picture similarities and to name items given pictures, both observed at ages 3 and 5. The parameters in each of the 4 equations in the system are identified simultaneously using generalized least squares (GLS).

Obtaining Aitken's GLS estimates has two advantages over running a set of multiple OLS regressions. First, despite the fact that OLS estimation for each equation separately would yield consistent estimation of the parameters even if the disturbances were correlated, GLS estimation would improve efficiency. Second, it allows the outcomes to be correlated for a given child while still being uncorrelated across children. A formal justification showing the correlation between the disturbances in our application using a Breusch-Pagan test is provided in the results section of this article.

It is also worth mentioning that a major identification assumption of the SUR model is that for a given child, the stochastic error terms are correlated across the 4 equations in the system, while the error terms across children are independent and homoscedastic. If the error terms are

not correlated across equations, the OLS equation-by-equation estimates will be identical to the ones obtained using GLS estimation and the SUR model. In order to justify using SUR, we conduct a Breusch-Pagan chi-square test for independence of the errors. A rejection of the null hypothesis would confirm that GLS would improve efficiency, and is thus preferred.

4. Data

4.1. Variables

All data for this study are extracted from Growing Up in Scotland (GUS) – Birth Cohort 1, a panel dataset following 5217 children from birth to early childhood, or the age of 10. This dataset contains variables which describe the composition of each participating household. Given the relationship of each family member to the child, we find the number of hours of care provided by grandparents. Growing Up in Scotland also provides a set of variables controlling for household, family, child, and parents characteristics, variables measuring child development and early childhood outcomes, as well as different sources and length of childcare provision, necessary for our analysis.

Social, cognitive, and behavioral development, ability, mental and physical health, behavior, educational and health well-being of children included in Birth Cohort 1 have been tracked for all years of the Growing Up in Scotland study. Families have been first interviewed in 2004/2005 when the study child in the family was 10 ½ months old (wave 1). Interviews have been conducted face-to-face every year with the respondent being either the mother (in 95% of the cases), or the main child-care provider. The respondent has been the same for each family in all waves, whenever possible.

The dependent variables selected for this study include officially reported measures of cognitive, social and behavioral development in the survey. More specifically, picture similarity (PS) and naming vocabulary (NV) raw scores measure the *cognitive development* of the child at the ages of 34 months (wave 3, year 2007) and 58 months (wave 5, year 2009), while the total difficulties (TD) score is a predictor of the *behavioral and social development* of the child at the ages of 46 months (wave 4, year 2008), 58 months (wave 5, year 2009) and 70 months (wave 6, year 2010). In what follows, we describe the method in which these three development scores have been obtained in the Growing Up in Scotland study.

First, PS and NV raw scores are extracted from two subtests of the BAS II test, designed to estimate the cognitive ability of children at the age of 2 years and 6 months, and 17 years and 11 months. BAS is individually administered and considered to be appropriate for "administration in a non-clinical setting" (Bromley, 2009). In the first experiment, children were given four cards with pictures. Then, they were provided a fifth card identical to one of the first four cards, and were asked to match the two identical pictures. Based on this experiment, the interviewer assigned a PS score, measuring the problem solving capacity of each child. An NV score as a predictor of the language skills was obtained by asking children to name items which they were observing on pictures provided by the experimenters.

Second, the TD score was derived based on the computer-based report completed by one of the parents of each child (usually the mother). The report contained the answers to a 25-question Goodman's behavioral screening Strength and Difficulties Questionnaire (SDQ), specifically designed for children between 3 and 16 and aimed to take into account peer relationship problems, emotional symptoms, inattention or hyperactivity, and conduct issues. The total score is calculated as the sum of four scores, assigned to each of the upper-mentioned scales. In the

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original dataset, a lower score indicates a lower level of difficulties, and is thus preferable. In order to facilitate interpretation of the results and be consistent with the other development measures in this study (for which a higher score is preferred), we rescale the TD score. In particular, a score of 35 in the original dataset corresponds to a TD score of 1 in our analysis, the original 34 is transformed to 2, and so on. Thus a higher (transformed) TD score is preferable in this article.

Data on each household member and his/ her relationship to the study child are also available in the original dataset. We use this information to derive a variable for the presence of a mother and a father in the household. Given the legal marital status of each person in the household, we derive whether the parents are legally married. The health status of the study child is also taken into account by generating a dummy variable for the child not being in good health condition, which is equal to one in the instances where the respondent has reported that child's health is in fair, bad or very bad condition. Further, the respondents were asked to release information about each childcare provider and the number of hours of paid or unpaid care provided each week. This allows us to construct a variable denoting the number of hours of childcare provision by a grandparent. We also use the number of hours of care given by all other providers, where the weekly hours of care by external providers are calculated as the sum of the number of hours of child care by all providers, different from the child's grandparents. Thus we are able to evaluate the effects of those hours on child outcomes with greater precision. This gives us a slight advantage over previous papers (e.g., Bernal and Keane 2010) which due to data limitations, had to make imputations about whether alternative sources of child care provided full-time or part-time care, based only on the information whether alternative child care was provided for at least 10 hours per week.

It is important to mention that although the number of siblings the study child has may not be a direct input into the production of skills and ability of the child of interest, it is useful to include it as a control because it may indirectly affect child development because the amount of resources allocated to each child may be different depending on the number of children the family has. Appendix A1 contains the complete set of all variables utilized in this article, as well as their descriptions.

4.2. Descriptive Statistics

Tables 1 and 2 provide summary statistics respectively, of the continuous and binary variables used in the empirical analysis. Evidence suggests that children perform slightly better on the NV test of cognitive ability when they are 3 years old, as compared to their score two years later, and the result is reversed when comparing PS raw scores although the standards remain unchanged. Despite these differences, the mean values of both measures of cognition vary between 14.318 and 16.887 (out of a total of 31) in both years. Further, the average TD scores measured at ages 4, 5 and 6, seem very close to each other, i.e. we do not observe significant differences in this score at different ages, although there is a small upward trend and rising dispersion of the scores as the child grows older. The latter observation is suggestive of children having fewer social and behavioral difficulties as they grow up. The average transformed TD score is 27.53, where the total is 35.

The statistics related to the time different providers supervise children indicate that the average number of hours of childcare provision by grandparents is about 5 hours per week, with also being 168 in some exceptional cases, which we exclude in one specification to conduct a robustness check. The average number of hours of childcare provided by grandparents does not vary much across the first few years of life of the children. The mean of the number of hours

given by other sources of childcare changes over time: it increases up until the age of 3, and decreases slightly at later age. This is expected because external childcare providers take in children only of a certain minimum age.

Figures 1 and 2 in the Appendix show the distribution of the number of supervision hours provided by grandparents and external care givers. The distribution of hours grandparents supervise grandchildren is highly skewed to the right with the majority of grandparents providing care fewer than 10 hours per week. The shape of the distribution of supervision hours provided by external providers is very similar, with a minor number of external providers supervising a child more than 50 hours a week.

The average number of family members is between 3 and 4, and the average number of siblings is about 1. There is a mother in more than 99% of the households, while a father is present in about a little more than 82% of the families. Both parents are present in the household for 81.83% of the children in the study. 43.83% of the parents of a 1-year-old child living in the household are married, but the percentage declines slightly as the child grows older, which may be an indication of family destruction.

The percentage of people being employed ranges from 59 to 79% for both genders in all years of the study. Fathers are slightly more likely to be employed than mothers. Mothers are more likely to have higher education than fathers. The majority of study children have attended pre-school and primary school during the survey period. More specifically, 96.42% of all children have already attended pre-school at the age of 6, and more than 98% of the 6-year-old children have already started primary school.

5. Results

This section presents the main findings of the article, some secondary results, as well as the diagnostic checks we perform in order to verify the validity of our empirical strategies.

5.1. Main Results

The results from the FE estimations under various specifications are summarized in Tables 3 to 5. In what follows, we present these results, organized by an area of development.

First, we look at the TD measure of *social and behavioral development*. Evidence from the FE regression analysis in Table 3 suggests that an increase in the average number of hours per week a child has been supervised by the parents at the expense of an additional hour spent with a grandparent leads to an increase in the social and behavioral development of the child by 0.1%, or a 1% increase for 10 extra hours of parental care per week (Column 1). The significance and the magnitudes of the differences between the effects of an additional hour of care provided by grandparents relative to that provided by parents in the current period remain the same if we separate current period from past periods (Column 5), or if we add one (Column 6) or two (Column 7) lags of the hours each care provider supervises the child. All effects are highly significant, and imply that spending more time with parents rather than with grandparents is beneficial for the improvement of the social and behavioral components of child development. In contrast, substituting supervision time with parents for time with external care providers does not have a significant impact on children's TD score.

Second, analyzing the results for the NV (Table 4) and PS (Table 5) scores of *cognitive development*, we find that grandparents have a larger influence than parents on the vocabulary enhancement of children. An additional hour of care per week provided by the grandparents in the current period on child's NV score is 0.22% higher than the effect of an extra hour of parental care, holding all other factors constant. Put differently, transferring 10 hours of

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supervision per week from parents to grandparents enhances child's vocabulary skills by 2.2% (Column 1). Contrary to the effect on the TD score, the effect of alternative child care on the NV measure of cognitive ability is also 0.28% higher than the effect of the marginal hour of care provided by parents, and the difference is statistically significant. The same estimates on the PS measure of cognitive development provide evidence that an additional hour of parental care has a larger marginal effect on the PS score relative to the effect of an extra hour of care provided either by a grandparent or an external caregiver. More specifically, an increase in the time input into the child by the parents by one hour per week at the expense of one hour of grandparental care or alternative childcare time leads to an increase in child's PS score by 0.22% and 0.26%, respectively. Similarly to our finding for the TD score, when we distinguish between present and average past effect of care, we find that the significance and the magnitude of the estimates remain the same (Column 5). The initial results are also consistent with the estimates obtained when we add lags of the number of hours different providers spend with children (Columns 6 and 7).

For comparison and illustration of the robustness of all findings, we provide the pooled OLS and the RE estimates in Columns (2) and (3) of Tables 3, 4 and 5. As expected, the results are similar to the ones yielded by the FE regression model. Including time and residential effects does not change the significance, direction or magnitude of the effects of interest as well. These modifications of the regression are presented in Columns (8) and (9) of Tables 3, 4, and 5.

The set of the presented FE estimations provides strong evidence of the grandparental and parental effect on the cognitive, social and behavioral outcomes of children, but fails to capture the potential relationship between these different measures of child development. A formal Breusch-Pagan independence test for verification of the existence of a correlation between the

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error terms of the equations in the system of equations used in the SUR model produces high chi-square statistic of 1698.943, and a p-value of 0.000. This result suggests a high, statistically significant correlation between the disturbances across the equations, and thus justifies the usage of seemingly unrelated regressions.

Under the assumption that all three outcomes are correlated for a given individual but uncorrelated across children, SUR estimation yields the following findings. A simultaneous consideration of different cognitive development measures and the measures at different ages indicates that grandparental involvement has a positive impact on the NV score of children at age 5, and a negative such impact on the PS score at that age, but no significant influence on either of the two scores at the age of 3. More specifically, an additional hour of child care provided by a grandparent is associated with an increase in the NV subsection of the BAS II test score by 0.66%, but contributes to a reduction in the PS score by 0.08%. Both of these results are consistent with the findings from the FE estimation and are available upon request.

Overall, our findings from both the major FE and the SUR estimations provide evidence that on average the grandparental effect exceeds parental involvement on children's vocabulary skills, but parents are more important for the PS aspect of the cognitive development of children, as well as their behavioral and social skills. These results are suggestive of complementarity between parents and grandparents in the child development process.

Our findings are consistent with the development psychology literature. First, although some research in the field showed that children who are more emotionally connected to their grandparents are subject to fewer social and emotional problems, have fewer symptoms of anxiety and depression, and demonstrate more pro-social behavioral (e.g., Ruiz et al. 2007; Kenny et al. 2006), other studies found evidence that as people age, they become more accepting

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and tolerant, lower their expectations, and become more willing to forgive misbehavior of their grandchildren (Seltzer 2016). As a result, although children can obtain specific knowledge and skills from their grandparents which they are less likely to be taught by parents, grandchildren are less likely to be punished for misconduct by their grandparents than by their parents. Therefore a child benefits in the long run if his parents impose rules aimed at disciplining the child and enhancing his behavioral development. This is in accordance with our finding that parents have a larger effect on the social and behavioral aspects of child development than grandparents do. The result is also consistent with the finding of Md-Yunus (2017) that about 13% of children being raised by grandparents exhibit a large degree of behavioral problems between the age of 6 and 17 (Md-Yunus 2017).

Second, the results of this article confirm Dr. Harris's theory (2009) related to child development. He disproved the so called "nurture assumption" commonly made in the development psychology literature. According to this assumption, children's development and personality depend only on the way they are raised by their parents. The parents are responsible for what children become. Harris challenged this assumption by stating that this was not necessarily true. The environment in which they are raised also plays a role. There is a difference between "nature," or genes, which are highly dependent on the parents, and "nurture," which refers to the way or the environment in which children are raised. Who children socialize with and who they spend time with determine different aspects of their development, such as social, cognitive, behavioral and mental enhancement. This implies that it is likely that some measures of child development can be affected by grandparental involvement more than they are influenced by parental time investment. Our results are suggestive of this theory.

5.2. Secondary Results

The FE estimation provides additional evidence that poor health has an adverse effect on the behavioral development of children between 4 and 6. In addition, higher birth order has a significant beneficial effect on the TD and the NV scores of the child (2.63% and 11.82%, correspondingly, or 2.84% and 12.48% when past and present involvement of grandparents have been separated). The latter finding is expected because older children in the family are likely to help their younger siblings to learn, and thus have a beneficial impact on their cognitive, social and behavioral development although this does not exclude the presence of other channels affecting child growth.

We also use OLS to test the hypothesis that development scores at specific ages are determined by the hours of supervision provided by different providers at each year of childhood from birth until the age at which the specific score has been recorded. The findings indicate that grandparental involvement has a negative impact on the behavioral development of children at the period when the TD score has been measured, but past supervision is insignificant. However, the time different care providers supervise children at any specific age does not significantly affect their cognitive development. Thus we conclude that, as previously found, only the average number of hours of supervision throughout the years and current involvement, rather than the time at any given age, are significant determinants of child development at an early age.

In addition, we perform the major fixed effects estimations using data only on the subsample of children supervised by grandparents fewer than a certain number of hours per week, and separately, only on a subsample of children who are under grandparents' supervision more than a given threshold of hours per week. The former experiment is performed as a robustness check the purpose of which is to verify whether the main estimates from the whole

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sample are driven by outliers, where we define outliers as children whose grandparents are their main care providers, i.e. supervise the child more than a given number of hours per week. The selected thresholds are 20 and 30 hours per week. The results are presented in Table 6, and are discussed in more detail in Section 5.4. They are robust to the choice of an upper bound on the hours of grandparental supervision time, regardless of the development score.

The second experiment involves imposing a lower bound on the number of hours a grandparent supervises a child. It allows us to test the hypothesis that grandparents have a different from the previously found effect on various aspects of child development provided that the child spends a sufficient amount of time under the supervision of a grandparent. The results are located in Table 6. Our previous findings of the impact of grandparents on the behavioral development of grandchildren have been confirmed and are robust to the imposition of a lower or no bound on the amount of supervision time provided by grandparents. However, an interesting finding is that if a grandparent supervises a grandchild for more than 13 hours per week, an additional hour of grandparental supervision has a significant, positive effect on the PS score of cognition of the grandchild. This effect becomes larger with an increase in the lower bound on grandparental supervision time. The latter result suggests that even though on average parents have a larger impact on the cognitive development of children as measured by their PS score, if a sufficiently large number of hours of supervision has been transferred from parents to grandparents making the grandparent a main supervisor of the child, grandparents can have a significant, positive effect on the cognitive enhancement of children at an early age. This observation indicates that grandparents might accept the role of parents in the cognitive development of children given that they supervise the child more than 13 hours per week.

5.3. Diagnostic Tests and Robustness Checks

Formal Hausman tests reject the null hypothesis of the existence of non-systematic differences in the coefficients estimated using FE and RE, and thus support employing FE over RE in all regressions, independent of whether the dependent variable is a measure of social and behavioral, or cognitive development. Simultaneously with this finding, using a Breusch and Pagan Lagrangian multiplier for RE, we find that in all instances in this article, a FE regression model is preferred to pooled OLS. The combination of the latter two results implies that FE estimation would be preferred over RE and pooled OLS, and is thus our choice for estimating the parameters in all panel data models in this paper. Further, a modified test for group-wise heteroskedasticty in a FE model rejects the null hypothesis of homoscedastic error terms in all three equations. In order to be certain of the robustness of the standard errors and to correct for heteroskedasticity, we use robust Huber/ White standard errors in all regressions in this article. The results from the diagnostic tests are available upon request.

We also verify whether the results we obtain are robust to various specifications. First, as mentioned earlier, identification of the parameters in the FE regressions is not influenced by the inclusion of individual, time and regional effects. Second, we run the two major FE models (only with current supervision time investment in the child, and separated past and present involvement) only for children in good or very good health, children whose parents are married, children whose parents are not married, children whose parents both live in the same household, and children living in a single-mother household. All results are identical to the ones reported in the previous subsection, and are available upon request.

Finally, we keep only observations for which the hours of grandparental supervision are fewer than 30 (and separately, 20) hours per week, and estimate the main model of interest. Such

an exclusion of outliers does not change the significance of the estimates, and does not yield large changes in their magnitudes. In particular, as shown in Table 6, transferring one hour of care from the parents to the grandparents increases the NV score of the child by 0.29% (or 0.32% when the threshold is 20), and the effect of an extra hour per week of parental involvement increases child's TD and PS scores, respectively, by 0.11% (regardless of the threshold) and 0.47% (or 0.50% when the threshold is 20) more than does an additional hour of care provided by the grandparents. Thus the effects of care of various providers on children's development remain unchanged when we exclude outliers.

6. Discussion

6.1. Possible Channels of the Effect of Intergenerational Transfers on Child Outcomes

In this section, we discuss several mechanisms through which intergenerational time transfers can influence child outcomes.

There are ways in which both parents and grandparents can affect child development, but it is possible that some of these effects can be intensified if a grandparent is involved in the child-rearing process. This effect is expected to be larger especially if a non-working or retired grandparent supervises the child because such a grandparent is likely to have not only more time, but also more vigor and willingness to spend quality time in addition to supervision time with the child. Some factors which might determine the impact of supervision time on child development and his/ her later outcomes include personal characteristics of the care provider (Modin and Fritzell 2009), his family background (Jager 2012), academic achievements (Modin and Fritzell 2009; Osler et al. 2005), resources (LaFave et al. 2017), and time investment.[5] Both parents and

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[5] Jager (2012) finds an association between family background of the extended family (parents, grandparents, aunts and uncles) and years of completed schooling of a child (Jager 2012). Personal characteristics of the extended family

grandparents can read to children which fosters greater interest of the child in reading at a later age (Arnold et al. 1994), creates an advantage of the child over his peers in primary school (Wade et al. 2000), and has a positive effect on the literacy achievement of the child (Weinberger 1996). Parents and grandparents can also transfer skills and knowledge to children by playing with them, teaching them the alphabet and the numbers, academic concepts and math problems, creating an enjoyable environment which facilitates giving educational advice to the child, engaging them in activities stimulating learning and creativity, and helping them do homework and handle with academic and personal difficulties at school. The impact of all of the above-mentioned activities is likely to be higher for grandparents than for parents, provided that grandparents' supervision is more valuable than parents' time with the child and/ or that children are more willing to learn from lessons taught by someone different from their parents.

In addition, the effect of grandparental care on the cultural, social, educational, and moral development of the child may be expanded over parental one through grandparents' ability to serve as mentors or role models to the child, and through transmission of life wisdom, which less-experienced parents may not be able to pass on children. Specifically, grandparents' stories about their life experience help children draw lessons and morals, define values, teach them how to handle with obstacles in life, help them learn about family history and culture, and teach them to listen. Such factors prepare children for listening to their teachers at school, and affect their educational attainment at a later age. However, it is crucial that wisdom, experience and knowledge transmission is performed at an early age because studies provide evidence that

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are correlated with cognitive development (Modin and Fritzell 2009), academic outcomes and health (Modin and Fritzell 2009; Osler et al. 2005) of the child as well. Evidence from Indonesia also shows that the resources of parents, grandparents, aunts and uncles affect child's height as a measure of health, non-verbal cognitive assessment performance and age at which the child starts school (LaFave et al. 2017).

contact frequency between grandparents and grandchildren declines with age between ages 18 and 35 (Geurts et al. 2009) because contact is initiated by parents and grandparents when children are small (Brown 2003), while it is initiated by children when they grow up (Roberto and Stroes 1992). In addition, grandchildren may prefer peer relationships when they enter adulthood in order to obtain information and establish contacts (Carstensen 1992).

In addition, while children are small, grandparents can also provide emotional and mental support which may be an integral part of the development of the child while sometimes being impossible to be provided by the parents. For example, a study conducted in Boston College found that "an emotionally close relationship between grandparent and grandchildren is associated with fewer symptoms of depression for both generations."

6.2. Policy Implications

The determinants of child development at an early age are important for the implementation of policies whose goal is to either improve child outcomes directly, or improve other economic outcomes without forfeiting child development.

First, if provision of child care by the grandparents has a positive influence on child outcomes, it may be worthwhile that governments take action to provide incentives to grandparents to assist in the child-rearing process of their grandchildren. Some countries in Europe have started to exploit this opportunity. For instance, the UK implemented such a policy in 2011. Grandparents who renounce work in order to take care of a grandchild under 12 at least 20 hours per week are eligible for national insurance credits contributing to their basic state pension. In Portugal, working grandparents are entitled to claim a financial allowance and leave of work up to 30 days per year to provide child care to a sick grandchild. Germany and Hungary

have transferable parental leave and allowances, i.e. parents are allowed to transfer leave to grandparents.

In addition, such policies may be found to have even greater impact than other Head Start programs which promote education and development at an early age. The reason is that if grandparental childcare provision has a positive impact on grandchildren or the effect is the same as that of care provided by the parents, then such programs could not only contribute to child development but can also be used as tools to improve other economic outcomes without negatively affecting child success. Such economic outcomes include improved fertility rates, and higher female labor participation rates. In particular, Del Boca (2002) shows that grandparenting is associated with higher probability of the mother being in the labor force and a higher probability that the family has had a child in the last two years (Del Boca, 2002). Receiving help from grandparents for child-rearing reduces the cost of childcare, and thus may increase fertility. In fact, a study of 11 countries in Europe provides evidence that receiving help from grandparents increases the likelihood of child-rearing, potentially because receiving help facilitates raising children and reduces child care costs. The effect is stronger in Southern Europe where public childcare is less common. Given that, policies encouraging time intergenerational transfer from grandparents to grandchildren may potentially increase fertility in Europe where natality rates have recently been declining. Such a reform is likely to contribute to the improvement of the demographic composition of European countries.

Receiving help from grandparents with child-rearing is also associated with higher female labor force participation rate (Ogawa et al. 1996; Del Boca 2002; Marenzi et al. 2008). Such an increase in the available labor resources of a country can on its part improve the potential of these countries to produce goods and services and to initiate growth.

Therefore, if grandparents have a positive effect on children, then it might be worthwhile that governments attempt to implement policies encouraging grandparenting as a tool to improve child development and to solve other impending economic issues.

7. Conclusion

This article compares the effect of grandparents' and parents' investment of supervision time in a child on the cognitive, social and behavioral development of children during the first 6 years of life. We find that grandparents have a larger effect than parents on children's vocabulary skills. Although parents' supervision time on average influences the picture similarities score of cognitive ability of children more than does the time children are supervised by grandparents, grandparental care has a significant, positive impact larger than that of the parents provided that a child has been supervised by a grandparent at least 13 hours per week. This positive impact of grandparents' supervision time rises with an increase in the threshold of the time a grandparent supervises a grandchild at the expense of parental supervision time. However, parents influence social and behavioral development of children more than grandparents do, regardless of the number of hours the child has been supervised by each care provider. More specifically, the difference between the effects of an additional hour per week under the supervision of the grandparents and parents on the TD score is negative 0.1%, while the same difference for the NV score is 0.22%. The opposite signs for different development outcomes provide evidence that parents and grandparents complement rather than substitute each other in the mental and behavioral development of the child.

The article provides the grounds for the investigation of the effect of allocating supervision time, rather than material and financial assets, to children on their outcomes. However, the study also has limitations. First, none of the development measures we take into account is available

for more than 2 or 3 years of childhood. This prevents a researcher from employing more dynamic panel data methods, such as Arellano-Bond, Arellano-Bover and Blundell dynamic approaches. Finding a unified measure of development available for more or all years of childhood analyzed in the study would solve this issue. It would even be sufficient to have different child outcomes for each year if they measure the same type of development, i.e. either cognitive, or social and behavioral.[6]

Second, we are able to identify the relative effect of grandparental time input as compared to the effect of time investment of the parents but fail to quantify the precise effect of grandparental care on child's outcomes. Estimating the latter effect would be a potential extension of the paper if one could obtain data on the "quality time" each provider spends with a child.

Finally, fixed effects estimation yields consistent estimates, given that all covariates are exogenously determined. In the case of Scotland, external care is a response to its exogenously determined availability[7] and cost[8] so exogenous factors drive the decision of the number of hours

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[6] If the latter kind of data were available, we could apply a method similar to the one used by Bernal and Keane (2010, 2011). Under the assumption that the parameters in the production function are invariant across all test outcomes, they pool all scores, and run the main regression, but including dummy variables for each outcome, except one base outcome, as well as interaction terms of the score indicators with a subset of controls. Such a strategy improves efficiency due to the higher sample size, but is infeasible if the outcomes indicate different aspects of development.

[7] External child care is not available to all children and in all areas across Scotland, especially in some remote parts of the country. Some nurseries are willing to provide more openings but only if they can cover the delivery costs. In order to cover those costs, they either provide lower-quality care, or charge more than some parents are willing or able to afford. In either case, families often turn to alternatives either due to the shortage of childcare, or due to its lack of affordability.

[8] The cost of childcare in Scotland is high relative to other OECD countries, and it is rising much faster than the rate of inflation. According to Citizens Advice Scotland (CAS), such costs put many families at the threshold for poverty if they do not look for alternative sources of care. The Scottish government tried to alleviate the issue by increasing free annual care from 475 to 600 hours for 3- and 4-year-old children, as well as for disadvantaged 2-year-old children. However, the majority of the childcare cost still has to be paid by the parents. More specifically, the approximate annual cost of placing a child under 2 in a nursery for 25 hours a week is £5514, and the same cost but for children between 2 and 5 is £5307 on average. The agency's reports show that families spend 27% of their annual household income on childcare, as compared to 12% on average across the OECD countries. Although not part of our study, childcare costs increased even further in 2016 and 2017. In 2017, the Family and Childcare Trust

of care provided by external care providers, and thus influence the utilization of its substitutes, such as parental and grandparental care. Our analysis can be generalized to countries where external child care is cost-prohibitive or restricted depending on the area. However, if similar analysis is conducted for another country where external care is affordable and ubiquitously available across all parts of the country, then childcare provision would not be randomly determined but instead, it would more likely be a result of a strategic choice of the parents, the grandparents or both. In that case, appropriate instruments have to be found to alleviate endogeneity concerns.[9]

Further research is needed to solve the above-mentioned limitations of this study. In addition, the analysis can be extended by accounting for more factors which are likely to affect development, and later-age outcomes can also be investigated.

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estimated that childcare costs became 4.5% higher as compared to the previous year. Such statistics incentivize families to search for alternatives, and parenting and grandparenting are the common solutions. Even if care provided by parents and/ or grandparents would not be the preferred choice of families, some of them have no alternative if external childcare is cost-prohibitive for them. Some families in which a grandparent is unavailable to serve as a childcare provider, even prefer one of the parents to not work rather than spend all or the majority of their income on child care.

[9] Additionally, as long as the number of hours of childcare provided by external sources is driven to a large extent by availability and affordability of care, and given the number of hours worked by the parents, the number of hours of grandparental involvement in the child-rearing process is mostly affected by these exterior factors. Furthermore, although supervision of the child in the past can affect present outcomes, reverse causality is unlikely in this context. Therefore there is little reason to expect that the allocation of supervision time between different care givers is endogenous. Despite that, it is worth mentioning that the estimates would be biased if grandparents' and parents' hours of care are not exogenous. This might be the case if part of the ability endowment of the child, and parents' or child's tastes for care are unobserved determinants of the outcomes of a child, and the time each provider devotes to a child is influenced by this endowment and preferences.

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Tables

Table 1. Summary statistics of the continuous variables used in the analysis (by wave of the survey)

Variable	Grand Mean	Std. dev.	Min	Max	Mean Wave 1	Mean Wave 2	Mean Wave 3	Mean Wave 4	Mean Wave 5	Mean Wave 6
PSscore	15.142	4.253	0	31	-	-	14.318	-	16.016	-
NVscore	15.871	4.370	0	31	-	-	16.887	-	14.798	-
TDscore	27.535	4.602	1	35	-	-	-	27.275	27.471	27.856
HrsChdCareGrp	4.980	9.719	0	168	5.797	5.892	5.389	4.835	4.296	3.094
TotalNumPplInHhld	3.925	1.049	2	12	3.738	3.793	3.906	4.019	4.065	4.126
Income	23131.34	12716.47	1930.309	68965.52	20396.22	22309	23547.68	24189.38	24534.44	24751.31
NumSiblings	1.005	0.928	0	11	0.770	0.863	0.991	1.108	1.175	1.239
ChildBirthOrder	1.740	0.883	1	9	-	-	-	-	-	-
HoursMomWorksPerWk	15.873	17.482	0	97	24.961	5.212	3.566	31.118	26.095	3.379
HoursDadWorksPerWk	12.795	20.551	0	97	43.145	19.900	2.398	3.276	3.218	3.453
HrsOtherChdCare	7.700	12.735	0	168	7.021	9.512	11.532	8.271	5.635	3.588

Note: Source: Data are obtained from Growing Up in Scotland – Birth cohort 1 longitudinal dataset.

Table 2. Summary statistics of the binary (dichotomous) variables used in the analysis (by wave of the survey and total)

Variable	Percent Total	Percent Sw. 1	Percent Sw. 2	Percent Sw. 3	Percent Sw. 4	Percent Sw. 5	Percent Sw. 6
GrpInHhld	3.67	6.08	3.95	3.43	2.95	2.48	2.21
MotherInHhld	99.52	99.83	99.73	99.55	99.40	99.27	99.18
FatherInHhld	82.06	80.99	82.62	82.78	83.02	82.05	81.00
BothParInHhld	81.83	80.93	82.54	82.61	82.75	82.71	80.50
ParInHhldMarried	37.28	43.82	39.12	36.49	34.83	33.63	33.11
HigherEducMom	75.55	71.82	74.05	75.98	77.02	77.85	78.23
HigherEducDad	12.54	57.35	0.62	0.72	1.18	0.99	1.39
MaleChd	51.43	-	-	-	-	-	-
HealthChdNotGood	5.74	5.75	7.09	5.25	6.61	4.41	5.06

Note: Source: Data are obtained from Growing Up in Scotland – Birth cohort 1 longitudinal dataset.

Table 3. Estimates from regressions under different specifications of the effect of grandparental, parental and alternative child care supervision time input on child's TD score, years 2008 - 2010

Dependent variable: lnTDscore

Variable	(1) Only current period hours	(2) Only current period hours	(3) Only current period hours	(4) (Combined) Average number of hours	(5) Average hours in the past & separately, present hours	(6) Current period hours and 1 lag	(7) Current period hours, lag 1, and lag 2	(8) Time FE included	(9) Time and residential area FE included
HrsChdCareGrp	-0.001***	-0.001***	-0.001***	-	-0.0012***	-0.0011***	-0.0011***	-0.001***	-0.0009***
	(0.0003)	(0.0003)	(0.0003)		(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HrsOtherChdCare	-0.0003	-0.0002	-0.0002	-	-0.0003	-0.0002	-0.0003	0.00005	0.0001
	(0.0002)	(0.0002)	(0.0002)		(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
L.HrsChdCareGrp	-	-	-	-	-	-0.0003	-0.0004	-	-
						(0.0002)	(0.0003)		
L.HrsOtherChdCare	-	-	-	-	-	-0.0004**	-0.0004**	-	-
						(0.0002)	(0.0002)		
L2.HrsChdCareGrp	-	-	-	-	-	-	0.0001	-	-
							(0.0002)		
L2.HrsOtherChdCare	-	-	-	-	-	-	-0.0003*	-	-
							(0.0057)		
AvgHrsGrpCare	-	-	-	-0.0038***	-	-	-	-	-
				(0.0011)					
AvgHrsCC	-	-	-	-0.0021**	-	-	-	-	-
				(0.0008)					
L.AvgHrsGrpCare	-	-	-	-	-0.0011	-	-	-	-
					(0.0009)				
L.AvgHrsCC	-	-	-	-	-0.0017*	-	-	-	-
					(0.0007)				
Method	FE	RE	POLS	FE	FE	FE	FE	FE	FE
Time FE	No	No	No	No	No	No	No	Yes	Yes
Residential area FE	No	No	No	No	No	No	No	No	Yes
Excluded outliers	No	No	No	No	No	No	No	No	No
Obs.	10,724	10,724	10,724	10,098	10,098	10,417	10,234	10,724	10,723
(Within) R-sq	0.0110	0.0079	0.0079	0.0122	0.0134	0.0132	0.0140	0.0169	0.0171

Notes: All regressions are estimated using data from 2008 to 2010 for which the TD score is relevant. Robust standard errors are reported in parenthesis. *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Columns (1), (2) and (3) contain the results respectively, from FE, RE and pooled OLS regression models, using only the current number of supervision time provided by grandparents and external child care providers. Column (4) presents estimates from a FE model taking into account the average effect of involvement of grandparents, parents and alternative childcare from the first round of the survey until the present, while Column (5) shows the estimates from a model which distinguishes between the effect of the average supervision time in the past, and the current period time input into child development. Columns (6) and (7) represent the results obtained from the same model considered in (1) but with added lags of the time spent with the child by grandparents and external child care providers. One and two lags of the latter variables have been included in the models in Columns (6) and (7), respectively. Columns (8) and (9) present the results from the specification of the model in (1) with fixed effects accounting for different types of unobserved, time-invariant heterogeneity, specifically time and residential FE. Since the dependent variable is used in log terms, one has to multiply the estimate by 100 in order to obtain the effect of the corresponding variable on the TD score in percentages. The following variables have been used as controls: MaleChd, HigherEducMom, HigherEducDad, ChildBirthOrder, lnIncome, HealthChdNotGood, TotalNumPplInHhld, NumSiblings, BothParInHhld, and ParInHhldMarried.

Table 4. Estimates from regressions under different specifications of the effect of grandparental, parental and alternative child care supervision time input on child's NV score, years 2007 and 2009

Dependent variable: lnNVscore

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Only current	Only current	Only current	(Combined)	Average hours in the past &	Current period hours and 1 lag	Current period hours, lag	Time FE included	Time and residential

	period hours	period hours	period hours	Average number of hours	separately, present hours		1, and lag 2		area FE included
HrsChdCareGrp	0.0022***	0.0015***	0.0015***	-	0.0020***	0.0018**	0.0019**	0.0010	0.0010
	(0.0007)	(0.0004)	(0.0004)		(0.0008)	(0.0008)	(0.0009)	(0.0007)	(0.0007)
HrsOtherChdCare	0.0028***	0.0018***	0.0018***	-	0.0029***	0.0030***	0.0024***	0.0002	0.0002
	(0.0004)	(0.0003)	(0.0003)		(0.0004)	(0.0004)	(0.0005)	(0.0004)	(0.0004)
L.HrsChdCareGrp	-	-	-	-	-	0.0011	0.0008	-	-
						(0.0008)	(0.0008)		
L.HrsOtherChdCare	-	-	-	-	-	-0.0003	0.0001	-	-
						(0.0005)	(0.0005)		
L2.HrsChdCareGrp	-	-	-	-	-	-	0.0004	-	-
							(0.0005)		
L2.HrsOtherChdCare	-	-	-	-	-	-	-0.0012**	-	-
							(0.0006)		
AvgHrsGrpCare	-	-	-	-0.0071***	-	-	-	-	-
				(0.0020)					
AvgHrsCC	-	-	-	-0.0060***	-	-	-	-	-
				(0.0013)					
L.AvgHrsGrpCare	-	-	-	-	0.0024	-	-	-	-
					(0.0015)				
L.AvgHrsCC	-	-	-	-	-0.0021*	-	-	-	-
					(0.0012)				
Method	FE	RE	POLS	FE	FE	FE	FE	FE	FE
Time FE	No	No	No	No	No	No	No	Yes	Yes
Residential area FE	No	No	No	No	No	No	No	No	Yes
Excluded outliers	No	No	No	No	No	No	No	No	No
Obs.	7,123	7,123	7,123	6,871	6,871	6,982	6,914	7,123	7,123
(Within) R-sq	0.0590	0.0301	0.0301	0.0502	0.0628	0.0619	0.0636	0.1485	0.1524

Notes: All regressions are estimated using data from 2007 and 2009 for which the NV score is relevant. Robust standard errors are reported in parenthesis. *** p<0.01, ** p<0.05, * p<0.10. Columns (1), (2) and (3) contain the results respectively, from FE, RE and pooled OLS regression models, using only the current number of supervision time provided by grandparents and external child care providers. Column (4) presents estimates from a FE model taking into account the average effect of involvement of grandparents, parents and alternative childcare from the first round of the survey until the present, while Column (5) shows the estimates from a model which distinguishes between the effect of the average supervision time in the past, and the current period time input into child development. Columns (6) and (7) represent the results obtained from the same model considered in (1) but with added lags of the time spent with the child by grandparents and external child care providers. One and two lags of the latter variables have been included in the models in Columns (6) and (7), respectively. Columns (8) and (9) present the results from the specification of the model in (1) with fixed effects accounting for different types of unobserved, time-invariant heterogeneity, specifically time and residential FE. Since the dependent variable is used in log terms, one has to multiply the estimate by 100 in order to obtain the effect of the corresponding variable on the NV score in percentages. The following variables have been used as controls: MaleChd, HigherEducMom, HigherEducDad, ChildBirthOrder, lnIncome, HealthChdNotGood, TotalNumPplInHhld, NumSiblings, BothParInHhld, and ParInHhldMarried.

Table 5. Estimates from regressions under different specifications of the effect of grandparental, parental and alternative child care supervision time input on child's PS score, years 2007 and 2009

Dependent variable: lnPSscore

Variable	(1) Only current period hours	(2) Only current period hours	(3) Only current period hours	(4) (Combined) Average number of hours	(5) Average hours in the past & separately, present hours	(6) Current period hours and 1 lag	(7) Current period hours, lag 1, and lag 2	(8) Time FE included	(9) Time and residential area FE included
HrsChdCareGrp	-0.0022**	-0.0013***	-0.0013***	-	-0.0022**	-0.0022**	-0.0021*	-0.0008	-0.0008
	(0.001)	(0.0005)	(0.0005)		(0.0010)	(0.0011)	(0.0012)	(0.001)	(0.001)
HrsOtherChdCare	-0.0026***	-0.0015***	-0.0015***	-	-0.0026***	-0.0029***	-0.0026***	0.0006	0.0006
	(0.0005)	(0.0003)	(0.0003)		(0.0005)	(0.0006)	(0.0007)	(0.0006)	(0.0006)
L.HrsChdCareGrp	-	-	-	-	-	-0.0003	-0.0003	-	-
						(0.0012)	(0.0013)		
L.HrsOtherChdCare	-	-	-	-	-	0.0007	0.0006	-	-
						(0.0007)	(0.0007)		
L2.HrsChdCareGrp	-	-	-	-	-	-	7.85e-06	-	-
							(0.0008)		
L2.HrsOtherChdCare	-	-	-	-	-	-	0.0007	-	-
							(0.0008)		
AvgHrsGrpCare	-	-	-	-0.0054*	-	-	-	-	-
				(0.0030)					
AvgHrsCC	-	-	-	-0.0046***	-	-	-	-	-
				(0.0018)					
L.AvgHrsGrpCare	-	-	-	-	-0.0004	-	-	-	-
					(0.0022)				
L.AvgHrsCC	-	-	-	-	0.0025	-	-	-	-
					(0.0018)				
Method	FE	RE	POLS	FE	FE	FE	FE	FE	FE
Time FE	No	No	No	No	No	No	No	Yes	Yes
Residential area FE	No	No	No	No	No	No	No	No	Yes
Excluded outliers	No	No	No	No	No	No	No	No	No
Obs.	7,145	7,145	7,145	6,891	6,891	7,002	6,934	7,145	7,145
(Within) R-sq	0.0274	0.0190	0.0190	0.0236	0.0309	0.0307	0.0309	0.0920	0.0941

Notes: All regressions are estimated using data from 2007 and 2009 for which the PS score is relevant. Robust standard errors are reported in parenthesis. *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Columns (1), (2) and (3) contain the results respectively, from FE, RE and pooled OLS regression models, using only the current number of supervision time provided by grandparents and external child care providers. Column (4) presents estimates from a FE model taking into account the average effect of involvement of grandparents, parents and alternative childcare from the first round of the survey until the present, while Column (5) shows the estimates from a model which distinguishes between the effect of the average supervision time in the past, and the current period time input into child development. Columns (6) and (7) represent the results obtained from the same model considered in (1) but with added lags of the time spent with the child by grandparents and external child care providers. One and two lags of the latter variables have been included in the models in Columns (6) and (7), respectively. Columns (8) and (9) present the results from the specification of the model in (1) with fixed effects accounting for different types of unobserved, time-invariant heterogeneity, specifically time and residential FE. Since the dependent variable is used in log terms, one has to multiply the estimate by 100 in order to obtain the effect of the corresponding variable on the PS score in percentages. The following variables have been used as controls: MaleChd, HigherEducMom, HigherEducDad, ChildBirthOrder, lnIncome, HealthChdNotGood, TotalNumPplInHhld, NumSiblings, BothParInHhld, and ParInHhldMarried.

Table 6. Test of the hypothesis that grandparents accept a parents' role if they supervise a grandchild more than a certain amount of time per week: Effect of grandparents' supervision time for various thresholds of grandparents' supervision time

Hours of grandparents' supervision time per week	(1) Effect on TD score	(2) Effect on NV score	(3) Effect on PS score
<20	-0.0011***	0.0032***	-0.0050***
	[0.0003]	[0.0010]	[0.0013]
<30	-0.0011***	0.0029***	-0.0047***
	[0.0003]	[0.0008]	[0.0012]
≥ 10	-0.0013***	0.0007	0.0018
	[0.0004]	[0.0011]	[0.0015]
≥ 12	-0.0013***	0.0007	0.0024
	[0.0004]	[0.0012]	[0.0016]
≥ 13	-0.0013***	0.0007	0.0034**
	[0.0004]	[0.0013]	[0.0017]
≥ 15	-0.0013***	0.0008	0.0034**
	[0.0004]	[0.0013]	[0.0017]
≥ 20	-0.0014***	0.0009	0.0052**
	[0.0004]	[0.0017]	[0.0021]
≥ 30	-0.0015***	0.0047	0.0092***
	[0.0005]	[0.0032]	[0.0020]

Notes: All regressions are estimated using FE estimation using the years for which each score is relevant. Robust standard errors are reported in parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Only current period hours different care providers supervise the child are taken into account. The table provides the effect of supervision time provided by grandparents under different restrictions on grandparental supervision time. Column (1) presents the effect of grandparents' supervision time on the TD score of social and behavioral development. Column (2) shows the effect of the same variable on the NV score of cognition or the vocabulary skills of the grandchild, and Column (3) presents the effect of the supervision time provided by grandparents on PS score of cognitive ability of the grandchild.

Appendix A1

Set of variables used in the analysis and their descriptions

Dependent variables:

PSscore	Picture similarity raw score used as a measure of cognitive ability of the study child at the age of 34 months (wave 3) and 58 months (wave 5)
NVscore	Naming vocabulary raw score used as a measure of cognitive ability of the study child at the age of 34 months (wave 3) and 58 months (wave 5)

TDscore	Total difficulties score used as a measure of the social and behavioral development of the study child at the age of 46 months (wave 4), 58 months (wave 5) and 70 months (wave 6)

Explanatory variable of interest (used in all wave*):*

HrsChdCareGrp	Number of hours of childcare provided by (a) grandparent(s)

Controls to account for observed household composition characteristics (used in all waves):

TotalNumPplInHhld	Total number of individuals in the household
Ln(Income)	Natural logarithm of total household income
BothParInHhld	An indicator $= 1$ if both the biological/ adoptive/ foster mother and father reside with the child, and 0, otherwise

Controls to account for observed parents characteristics (used in all waves):

ParInHhldMarried	An indicator $= 1$ if the parents in the household are married, and 0, otherwise
HigherEducMom	An indicator $= 1$ if the mother has higher education or higher, and 0, otherwise
HigherEducDad	An indicator $= 1$ if the father has higher education or higher, and 0, otherwise

Controls to account for observed characteristics of the study child (used in all waves):

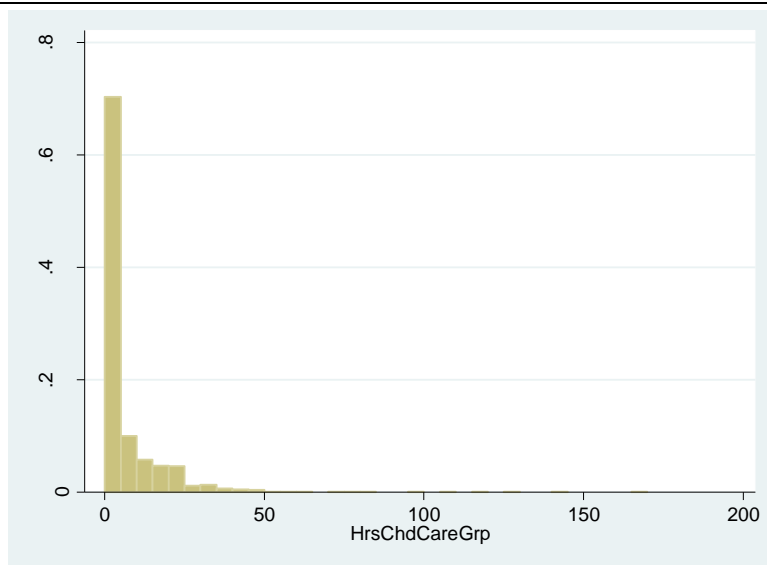| NumSiblings	Number of siblings the study child has
MaleChd	An indicator $= 1$ if the study child is a boy, and 0, otherwise
ChildBirthOrder	Birth order of the study child
HealthChdNotGood	An indicator $= 1$ if the health condition of the study child is fair, bad or very bad, and 0, otherwise

Controls to account for other forms of child care (used in all waves):

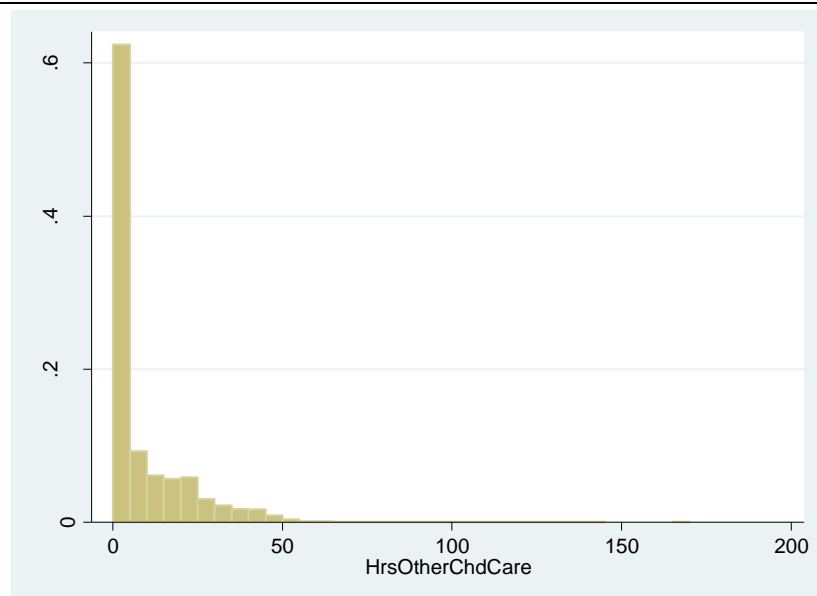| HrsOtherChdCare	Number of hours of external childcare provision (i.e. not provided by grandparents)

Note: Source: Data are obtained from Growing Up in Scotland – Birth cohort 1 longitudinal dataset.

Figure 1. Distribution of the number of hours grandparents

supervise grandchildren per week

Notes: The graph represents the distribution of the number of supervision hours provided by grandparents. Data are obtained from Growing Up in Scotland – Birth Cohort 1.

Figure 2. Distribution of the number of hours other childcare providers

supervise a child per week

Notes: The graph represents the distribution of the number of supervision hours provided by external care providers.

Data are obtained from Growing Up in Scotland – Birth Cohort 1.

Declarations

Declaration of Interest Statement

The author declares no conflict of interest.

Funding Statement

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Ethical Approval

The author declares that this article does not contain any studies with human participants or animals performed by the author.

Data statement

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