Stressful home environment and the child's socio-emotional development*

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Abstract

Children's early life socio-emotional skills predict long-run socio-economic outcomes, yet large disparities exist between these skills at early ages. In this paper, we study whether reducing home environmental stressors can reduce these early-life skill disparities, and how this depends on childrens pre-existing socio-emotional skills. To do so, we estimate a dynamic model of socio-emotional skill production that depends on parental investment, including the parents mental health and parenting style, and accounts for unobserved heterogeneity in child ability. Using the model, we find that improving sensitive parenting and mothers psychological well-being has a larger impact on children who have lower initial levels of socio-emotional skills. We also find that childrens pre-existing skills and parental inputs are substitutes, which has implications for which policies may best address later skill disparities.

Keywords: Complementarities, Substitutabilities, Parenting styles, Mother's mental health, Parent engagement, Child behavioural disorders, Diathesis-stress hypothesis.
JEL Classification: I14, I31, O15, J13, D10

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1 Introduction

Inequalities in child socio-emotional skills measuring child psychological well-being emerge at very young ages, persist across the lifetime and lead to socio-economic differences in adult labour market, health and crime outcomes.[1] The home environment is important for the development of child socio-emotional skills. A low level of socio-emotional skills – observed as a child behaving in a disruptive, withdrawn or irritable manner for example – is linked with a deprivation of parent engagement with the child (Zumbuehl et al. 2021; Kalil and Ryan 2020; Del Bono et al. 2016; Fiorini and Keane 2014; Attanasio et al. 2020b), low warmth and strict discipline in parenting style (Bertrand and Pan 2013) and maternal mental depression (see Goodman et al. 2011,Comaskey et al. 2017).[2]

Absence of positive parent inputs creates a stressful home environment and at the extreme, neglect (Currie and Tekin 2012; Fletcher and Schurer 2017; Schurer et al. 2019). Our paper asks whether an improvement in the home environment from a low level of parent inputs can help to close the gaps in early childhood socio-emotional skills. This is equivalent to test for substitutability[3], whereby the marginal effect of an improvement of parent inputs is highest for children with initially low levels of socio-emotional skills. We measure low levels of socio-emotional skills by considering externalising and internalising behavioural issues that are associated with higher probability of being diagnosed with Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD)(Russell et al., 2013). The home environment is characterised by three parent inputs - (1) mothers' mental health, (2) sensitive parenting style and (3) parental engagement - where we interpret low levels of these inputs as a stressful or neglectful home environment.

Our research question is motivated by the *diathesis stress* framework in psychology, whereby behavioural problems emerge from a combination of a stressful environment with a predisposition towards socio-emotional disorders (see Monroe and Simons 1991; Belsky and Pluess 2009). This would suggest that, while children with high socio-emotional skills

[1]See Heckman and Rubinstein (2001); Carneiro and Heckman (2003); Heckman et al. (2006); Cunha and Heckman (2009); Kautz et al. (2014); Attanasio (2015).

[2]Maternal stress during pregnancy has also has been found to affect children outcomes; see Aizer et al. (2016), who measure in-utero maternal stress considering the mother's cortisol level, and Currie and Rossin-Slater (2013), Black et al. (2016), who indirectly measure stress by considering negative in-utero shocks (see also the excellent reviews by Almond and Currie 2011; Almond et al. 2018). There is a growing evidence showing that early interventions after birth have considerable effects on maternal and child mental health (Sievertsen and Wüst, 2017; Hirani et al., 2022; Wüst, 2022).

[3]In a similar setting, substitutability has been alternatively called 'negative complementarity' by Agostinelli and Wiswall (2016).

in early childhood are less at risk of socio-emotional disorders and more resilient to home environmental stress in late childhood, children with low socio-emotional skills would be more vulnerable to stress and would benefit more from an improvement of parenting inputs. Therefore, whilst a large body of literature on the production of child skills has found evidence for a higher input productivity for children with high early skills for many inputs (complementarity), according to the diathesis stress framework we can expect the opposite pattern of substitutability when considering child socio-emotional skills and parenting inputs related to a stressful home environment.[4]

In order to answer our research question, we estimate a dynamic production model of child socio-emotional skills at 11, with inputs given by the child socio-emotional skills at 6 and parenting inputs in the child measured between 6 and 11. To assess the presence of complementarity or substitutability we allow the return of each of the parenting inputs to vary above and below the first quartile of the child socio-emotional skills at 6. To measure whether, as predicted by the diathesis stress framework, we observe substitutability in a stressful home environment, we allow additionally the interaction effects between inputs and the skills at 6 to differ between low and high levels of the inputs.

In estimating how parent inputs drive child outcomes, Cunha and Heckman (2007) and Cunha and Heckman (2008) introduced the innovation of allowing for dynamic complementarity, whereby the return to parental investments will be higher for children with higher initial skills in the presence of complementarity or higher for children with low initial skills in the presence of substitutability. To allow for such complementarity, previous studies on child development have used mainly a Constant Elasticity of Substitution production function which restricts the level of contemporaneous complementarity to be constant across different types of inputs and to be weakly positive. Translog models allow for additional flexibility in this relationship and in particular the complementarity level is allowed to vary for each pair of parental investment and to be both positive and negative (see for example Agostinelli and Wiswall 2016). To answer our research question requires extending the translog specification to allow the effect of an input to vary both across the lagged child's socio-emotional skills and also across the level of the input.

Our paper proposes a novel identification strategy which relies on within-child regressions, i.e. on a child fixed effect estimation which exploits variation in child socio-emotional skills

[4]Empirical evidence on the degree of complementarity between investments and skills in the production of future cognitive or socio-emotional skills can be found in Cunha et al. (2010), Nicoletti and Rabe (2014), Attanasio et al. (2020b, 2017), Hernández-Alava and Popli (2017) and García and Gallegos (2017) where the latter finds evidence of substitutability for some inputs.

across two traits - externalising and internalising behaviours. The identification assumptions are similar to the ones in the papers by Dee (2007), Clotfelter et al. (2010), Bandiera et al. (2010) and Lavy et al. (2012), who exploit within-student between-subject variation, but our paper considers for the first time variation within-child between socio-emotional traits. This child fixed effect estimation is implemented by regressing the differences in socio-emotional skills between externalising and internalising at age 11 on the corresponding difference at age 6 and on the interactions between such difference at 6 and the parental inputs between 6 and 11. Because our regressions are expressed as differences between traits, any observed and unobserved input that does not vary across internalising and externalising traits is controlled for.

Using the UK Millennium Cohort Study, thanks to our novel identification strategy and a flexible specification for the interaction effect between parental inputs and child's socio-emotional skills, we are able to test the diathesis stress hypothesis, which has never been considered by previous economic papers on child development. The main contribution of our paper is therefore to test for the existence of the diathesis stress hypothesis by allowing for the level of complementary between skills and inputs to change across different inputs, across levels of the inputs as well as across the skills distribution, while accounting for unobserved heterogeneity in child's ability.

Our results show that raising parental inputs that reduce stress in the child's environment, in particular maternal mental health for girls and warm parenting style for boys, has a beneficial effect especially for children who are at the bottom of the distribution of socio-emotional skills and who have a low level of these parental inputs. These are novel findings in the child-development literature given that several previous papers have found that parental inputs are more productive for children with high skills.[5] Nevertheless, they are fully consistent with the diathesis stress framework. These empirical results are strengthened by showing similar patterns of substitutability when we anchor socio-emotional skills to measures with an interpretable scale, including criminal and risky behaviours, mental health issues and school exclusions.

[5]Papers which have allowed the productivity of inputs to vary across level of earlier socio-emotional skills are Cunha et al. (2010), Attanasio et al. (2020b), Hernández-Alava and Popli (2017) and Del Bono et al. (2020). The first three find some evidence for complementarity but under the assumption that the level of complementarity does not change across different inputs and across levels of the inputs. Del Bono et al. (2020) allow for different level of complementarity across inputs but not for differences in complementarity across level of the inputs and find some weak evidence of complementarity between the father's socio-emotional skills and the stock of child socio-emotional skills and of substitutability between the stock of child socio-emotional and cognitive skills.

We provide evidence on the validity of the identification assumptions in Section 6; in particular we test for the invariance of the production model across the two trait-specific socio-emotional skills, finding no evidence of a differential effect on internalising and externalising skills from mothers' mental health or parenting style; and from a wider set of parental inputs (e.g. mothers' education and occupation).

Both internalising and externalising behaviour are good measures of socio-emotional skills as they have been found to predict a large set of psychological disorders (see Carragher et al. 2015).[6] Nevertheless, there is substantial variation in socio-emotional skills between the internalising and externalising traits for the same child and, it is such variation that our child fixed effect estimation exploits. When faced with a stressful environment, some children will react more by becoming depressed, lonely and withdrawn (i.e. internalising), whilst others will become more disruptive and hyperactive (i.e. externalising). This different reaction is not something learnt by children, but a genetic or innate predisposition (Cosgrove et al. 2011 and Kendler et al. 2003). Therefore, whilst variation in the general level of socio-emotional skills across individuals at age 6 is likely to be endogenous, differences between the two trait-specific socio-emotional skills for the same individual is mainly driven by a predisposition to either internalising or externalising problems. We provide empirical evidence supporting the validity of this assumption, in particular we test alternative sources of endogeneity for the difference between externalising and internalising traits including unobserved parental trait-specific inputs, measurement error and omitted parental investments which may have a different effect on each dimension of child skills.

The absence of a warm parenting style or low maternal mental health are likely to increase child stress and exacerbate behavioural issues in children especially when their starting socio-emotional skills are low. These findings are important because evidence of substitutability of inputs suggests that there can be interventions in middle childhood that help reducing inequalities in socio-emotional skills in a cost effective manner, such as parenting interventions that help to reduce the impact of mother's mental issues and the lack of a warm parenting style. This is consistent with evidence that improving parenting inputs seem to be one of the keys to successes of early childhood interventions.[7] As emphasized by Heckman and

[6]The concepts of internalising and externalising behaviours, which were first introduced by Achenbach (1966), have been used in more than 75,000 articles (see Achenbach et al. 2016). Previous economic papers have instead measured socio-emotional skills in a variety of ways, e.g., using scores indicating anxiety and hyperactivity (Cunha and Heckman 2008), the big 5 personality traits (Cobb-Clark and Schurer 2012) and measures of child temperament, attentional focusing and inhibitory control behaviour (Attanasio et al. 2020b).

[7]Examples of such interventions are Head Start programme (see Gelber and Isen 2013 and Carneiro and Ginja 2014) and the Perry Preschool Project and the Carolina Abecedarian Project (see Conti et al. 2016).

Mosso (2014) whilst there seems to be little evidence that unconditional income transfers to disadvantaged families would reduce children's inequalities in outcomes, avoiding low quality parenting can improve child development.

The remainder of this paper is organized as follows. We introduce the production model and the estimation strategy in Sections 2 and 3 respectively. We then move to describe the data, variables and the identifying variation for our estimation in Section 4. In Section 5 we proceed to report our main empirical results without and with anchoring of the socio-emotional skills to cardinal measures and the heterogeneity analysis by socio-economic background. In Section 6 we provide evidence on the validity of our model assumptions and in Section 7 we check the robustness of our model to alternative definitions of our variables and a more general specification. Finally, Section 8 concludes.

2 The production model of socio-emotional skills

2.1 The theoretical production model

In this section we lay out our production model that describes the process of development of children's socio-emotional skills between age 6 and 11. Similarly to the model of health capital by Grossman (1972), we allow for dynamics in socio-emotional skills (psychological health) and include investments. As in Cunha and Heckman (2007), we allow for dynamic complementarity by including interactions between investments and past socio-emotional skills. More precisely, we allow children's socio-emotional skills at age 11 to depend on their past socio-emotional skills and on a set of inputs, as described by the following equation:

$$\theta_{i,s}^{N} = f_s\left(L\theta_{i,s}^{N}, \mathbf{I}_i, \mathbf{X}_i, \mu_i\right) \tag{1}$$

where f_s is the production function between age 6 and 11 for $\theta_{i,s}^{N}$, the trait-specific socio-emotional (non-cognitive) skill of the child i for the trait s at age 11, s takes value 1 and 2 for the internalising and externalising traits respectively. $L\theta_{i,s}^{N}$ is the lagged socio-emotional trait s at age 6, $\mathbf{I}_i = [I_i^{MentalHealth}, I_i^{ParentingStyle}, I_i^{Engagement}]$ is the row vector of our three parental inputs of interest, which are measures of mothers' mental health, parenting style, and parental engagement. $\mathbf{X}_i$ is a vector of other inputs that might affect the socio-emotional development of the child between age 6 and 11 and μ_i denotes potential omitted inputs. All inputs are observed between age 6 and 11.

Our aim is to assess whether there are interaction effects between each of the three parental inputs in $\mathbf{I}_i$ and the lagged (starting) socio-emotional skill $L\theta_{i,s}^N$, i.e. to test whether the productivity of each of the three parental inputs varies across levels of the socio-emotional skill at age 6. The presence of complementarity (a positive interaction effect) between a parental input and the lagged socio-emotional skill would imply the presence of dynamic complementarity between the parental inputs in the age period 6-11 and inputs in earlier stages (see Heckman and Mosso 2014). On the contrary, the presence of substitutability (a negative interaction effect) between a parental input and the lagged socio-emotional skill would imply dynamic substitutability between such input and earlier stages' inputs. Knowing whether there exists substitutability or complementarity is therefore relevant to understand which inputs in the age-period 6-11 are most effective to reduce potential gaps in socio-emotional skills.

2.2 The empirical production model

To allow for a different level of substitutability/complementarity across different inputs previous papers have considered the translog production function (see, e.g., Liu et al., 2010; Mueller, 2013; Nicoletti and Rabe, 2017; Agostinelli and Wiswall, 2016) or the less general constant elasticity of substitution (CES) and Cobb-Douglas functions (see, e.g., Cunha et al. 2010; Del Boca et al. 2014). The advantage of adopting the translog production model over a CES model is that it does not impose a constant elasticity of substitution between inputs and lagged socio-emotional skills.

In our empirical application we extend the translog model to allow the effect of the interaction between each of the three inputs and the lagged socio-emotional skills to differ not only across the three main parental inputs (mothers' mental health, parenting style, and parental engagement), but also across levels of the input and levels of the lagged skills. This extension is relevant because a low level of mothers' mental health, sensitive parenting style (i.e. strict parenting) and little parental engagement can cause a stressful environment, which, when combined with a predisposition to socio-emotional issues, can lead to a detrimental effect on child socio-emotional development as suggested by the diathesis stress framework. Therefore, we expect an increase in maternal mental health, parenting style and parental engagement to be more productive at the bottom of the distribution of the input than at the top for children whose lagged socio-emotional skill (predisposition) is low. We

therefore consider the following modified translog model

$$
\begin{aligned}
log\theta^{N}_{i,s} = {} & \alpha_1 D1_{i,s} + \alpha_2 D2_{i,s} + logL\theta^{N}_{i,s} D1_{i,s}\rho_1 + logL\theta^{N}_{i,s} D2_{i,s}\rho_2 \\
& + \sum_{k=1}^{3} [logI_{i,k} D^{LowI}_{i,k}]\beta^{LowI}_{k,0} + \sum_{k=1}^{3} [logI_{i,k} D^{LowI}_{i,k} D^{HighL\theta}_{i,s}]\beta^{LowI}_{k,1} \\
& + \sum_{k=1}^{3} [logI_{i,k} D^{HighI}_{i,k}]\beta^{HighI}_{k,0} + \sum_{k=1}^{3} [logI_{i,k} D^{HighI}_{i,k} D^{HighL\theta}_{i,s}]\beta^{HighI}_{k,1} \\
& + D^{HighL\theta}_{i,s}\eta + \sum_{k=1}^{3} D^{LowI}_{i,k}\gamma^{LowI}_{k,0} + \sum_{k=1}^{3} D^{LowI}_{i,k} D^{HighL\theta}_{i,s}\gamma^{LowI}_{k,1} + \mu_i + u_{i,s}
\end{aligned}
\tag{2}
$$

where $log\theta^{N}_{i,s}$ and $logL\theta^{N}_{i,s}$ are the logarithm of the socio-emotional skills at 11 and of the lagged skills at 6, $D1_{i,s}$ and $D2_{i,s}$ are dummy variables taking value 1 if the trait s is equal to 1 (internalising) and 2 (externalising) respectively, $logI_{k,i}$ denotes the logarithm of the $k-$th input in the vector $\mathbf{I}_i = [I_i^{MentalHealth}, I_i^{ParentingStyle}, I_i^{Engagement}]$. We allow the effect of $logI_{k,i}$ to vary across children with low and high levels of such input (defined as below and above the median) and denote children with a low level of the k-th input with the dummy variable $D^{LowI}_{i,k} = 1 - D^{HighI}_{i,k}$. We also allow at the same time the effect of $logI_{k,i}$ to vary between low and high levels of the lagged socio-emotional skills and introduce the dummy $D^{HighL\theta}_{i,s}$ taking value 1 for children with a high level of the lagged skills above the first quartile (skills at 6) and 0 for low levels. Finally, μ_i is the child specific effect which captures the effect of any other observed and unobserved inputs and characteristics that do not change across the two traits, internalising and externalising, including the effects of interactions between inputs that do not vary across traits. $u_{i,s}$ is the idiosyncratic error term.

Moving to the coefficients, α_s is a trait specific intercept, α_1 for internalising and α_2 for externalising. ρ_s is a trait-specific elasticity of the socio-emotional skills at 11 with respect to the socio-emotional skills at 6, i.e. the self-productivity. $\beta^{LowI}_{k,0}$ measures the elasticity of the socio-emotional skills at 11 with respect to the k-th input $I_{i,k}$ for children with a low level of the lagged socio-emotional skills and a low level of the k-th input, whereas $\beta^{LowI}_{k,1}$ measures the differential elasticity for children with a high level of socio-emotional skills and with a low level of the k-th input. Similarly, $\beta^{HighI}_{k,0}$ is the corresponding elasticity for children with a high level of the k-th input and a low level of the lagged socio-emotional skills, while $\beta^{HighI}_{k,1}$ is the differential elasticity for children with a high level of the k-th input as well as of the lagged socio-emotional skills. η, $\gamma^{LowI}_{k,0}$ and $\gamma^{LowI}_{k,1}$ capture the differential intercepts for low and high levels of the lagged socio-emotional skills and for low and high levels of each of the three main parents' inputs.

Our main parameters of interest are $\beta_{k,1}^{LowI}$ and $\beta_{k,1}^{HighI}$ which measure the level of complementarity/substitutability between each of the three main inputs and the lagged skills for children with low and high levels of the k-input. Based on the diathesis-stress framework we expect a negative value for $\beta_{k,1}^{LowI}$ because it would indicate a lower effect of the input for high- relative to low-skilled children when the input is high, i.e. substitutatbility between the input and lagged skills for children with a low level of the k-th input. For high levels of a parental input, we expect instead either complementarity between the input and lagged skills or no differential effect of the input between low and high skilled children, meaning that $\beta_{k,1}^{HighI}$ should be either positive or zero.

Our empirical model 2 relies on the following assumptions:

1. **Assumption A1**: the parameters of the model do not vary across the internalising and externalising traits except for the intercept and the self-productivity,
2. **Assumption A2**: there is no interaction effect between inputs and the child's lagged socio-emotional skills except for maternal mental health, parenting style and parental engagement.

Assumption A1 on equality of the production model across internalising and externalising is not dissimilar to the assumption imposed by previous economic papers that aggregate the internalising and externalising traits or other type of measures of socio-emotional skills into a composite measure. It is also similar to previous papers which measure socio-emotional skills as the sum of the SDQ items including internalising and externalising items, which we call SDQ score. These papers then use such SDQ score as dependent variable (or as explanatory variable), therefore implicitly assuming that each SDQ item follows the same model (see e.g., Gupta and Simonsen, 2010; Nghiem et al., 2015; Del Bono et al., 2016; Black and Kassenboehmer, 2017; Moroni, 2018; Cornelissen and Dustmann, 2019; Attanasio et al., 2020a; Briole et al., 2020; Kuehnle and Oberfichtner, 2020). Some other papers have instead used factor analysis to identify a latent factor measuring socio-emotional skills using different items and have imposed that each item be related to only one latent factor (e.g. Conti et al., 2010; Heckman et al., 2013; Attanasio et al., 2020b,a). These papers implicitly assume that the observed items follow the same production model but allow each of the measures to have a different scale factor. Similarly, we allow for a differential scale factor for internalising and externalising skills in our log-log model (2) by considering a different intercept for the two traits.

Assumption A.1 is also empirically justified. Akee et al. (2018) consider the effect of

income on a set of different measures of socio-emotional skills. In particular, they consider two measures of socio-emotional skills closely related to externalising and internalising behaviours: (1) behavioral disorders defined as conduct, oppositional and antisocial personality symptoms; (2) emotional disorders defined as any anxiety or depression symptoms. Looking at the effect of income on these behavioural issues, Akee et al. (2018) find effects of income that are similar for behavioral and emotional disorders and with 95% confidence intervals always overlapping. Lansford et al. (2006) look at the effect of divorce or separation on children's socio-emotional behavior and find a similar worsening in both internalising and externalising behaviours. Anthonysamy and Zimmer-Gembeck (2007) find that children who experienced maltreatment have both more externalising issues such as physical and verbal aggression as well as more internalising issues such as being withdrawn.

However, these papers do not provide direct tests for the equality of the effect of inputs across the two behaviours. Therefore we provide empirical evidence in section 6 that i) the main parental inputs in our model and ii) other observables (mothers' age, education, occupation, ethnicity and family income) do not have different effects on internalising or externalising skills. Finally, we use our anchors to shed light on the comparability of internalising and externalising skills in predicting child's future outcomes, with results suggesting that both traits are similarly correlated with each anchor.

Our second assumption A2 is needed to guarantee the exogeneity of the three parental inputs in our estimation model. If there were other inputs besides mother's mental health, parenting style and parent engagement that interacted with socio-emotional skills at age 6, then our estimation would be inconsistent if these additional inputs were correlated with our parental inputs of interest. Section 6 provides evidence in support of this assumption, in analysis which interacts a set of inputs widely used in the child development literature with low socio-emotional skills at 6.

3 Identification of the production model

To estimate consistently the production model we need to take account of potential endogeneity caused by the omission of variables and of measurement error issues. The rest of this section is organized as follows. Section 3.1 explains our estimation strategy to take account of omitted inputs in our translog model under the assumption of no measurement errors. In Section 3.2 we describe the measurement model of socio-emotional skills and parental inputs, which we use to derive the latent factors that are theoretically unaffected by measurement

errors.

3.1 Estimation of the production model

To overcome the issue of omitted variables, we adopt a fixed effect estimation that relies on variation in socio-emotional skills between internalising and externalising for the same child. The child fixed effect estimation can be implemented by rewriting equation (2) with variables expressed as differences between internalising and externalising. The model expressed in differences simplifies to

$$\begin{aligned}\Delta log\theta_i^N = {} & \alpha + log\theta_{i,2,1}^N \rho_2 - log\theta_{i,1,1}^N \rho_1 \\ & + \sum_{k=1}^{3} [logI_{i,k} D_{i,k}^{LowI} \Delta D_{i,s}^{HighL\theta}] \beta_{k,1}^{LowI} \\ & + \sum_{k=1}^{3} [logI_{i,k} D_{i,k}^{HighI} \Delta D_{i,s}^{HighL\theta}] \beta_{k,1}^{HighI} \\ & + \Delta D_{i,s}^{HighL\theta} \eta + \sum_{k=1}^{3} D_{i,k}^{LowI} \Delta D_{i,s}^{HighL\theta} \gamma_{k,1}^{LowI} + \Delta u_i\end{aligned} \tag{3}$$

where $\alpha = \alpha_2 - \alpha_1$ and Δ denotes the difference between externalising and internalising of variables that vary across the two traits, e.g. $\Delta log\theta_i^N = log\theta_{i,2}^N - log\theta_{i,1}^N$ and $\Delta u_i = u_{i,2} - u_{i,1}$. Notice that taking the difference between internalising and externalising eliminates all explanatory variables in equation (2) which did not vary across traits, including the individual effect μ_i, hence our model controls also for interactions between inputs that are trait invariant.

This typology of fixed effect estimation has been used in several previous papers, e.g. to estimate the effect of lagged cognitive abilities, school class characteristics or school peers on cognitive abilities or educational achievements.[8] The main difference is that whilst we exploit variation within child across traits in the socio-emotional skills, previous papers exploit variation in school test scores within child across subjects.

Contrary to papers that analyse development models using child fixed effect estimation that exploit variation in skills and inputs across time within child, we do not restrict the unobserved component μ_i^N and the production model to be time invariant across different stages of child development. We only assume that the child fixed effect μ_i^N be the same

[8] E.g. Dee 2007; Clotfelter et al. 2010; Bandiera et al. 2010; Lavy et al. 2012; Del Boca et al. 2017; Nicoletti and Rabe 2017

for internalising and externalising. Similarly, we assume that the effect of included inputs be invariant across the two trait-specific socio-emotional skills. Our model can be identified when we relax the assumption of invariance of the effect for a subset of the inputs and we provide empirical evidence in Section 6 that the conclusions of our paper are robust when we relax this assumption.

Differently from previous papers that have used dynamic factor models to estimate the production function of cognitive and socio-emotional skills (e.g. Cunha et al. 2010; Attanasio et al. 2020b; Agostinelli and Wiswall 2016; Attanasio et al. 2020c), we identify the level of substitutability between the lagged socio-emotional skills and the inputs in the production model by using variation coming from the differences between trait-specific latent socio-emotional skills, i.e. differences between internalising and externalising, rather than variation coming from the general latent socio-emotional skill.[9]

Our identification strategy relies on the validity of the following assumption,

Assumption A3: the variation in the child socio-emotional skills at 6 across internalising or externalising is exogenous.

The variation in $L\theta^N_{i,s}$ across traits is exogenous if it is explained by variation in innate predispositions to specific socio-emotional issues. This assumption is justified in the psychological literature, where for example Cosgrove et al. (2011) and Kendler et al. (2003) show that reacting more strongly with either internalising or externalising behaviour is a genetic or innate predisposition. We provide supportive evidence of the assumption in section 6 by testing possible threats to its validity. First, part of the variation in $L\theta^N_{i,s}$ between traits could be related to trait-specific unobserved inputs that are excluded from our model, such as parental externalising and internalising traits. We can measure these inputs and, when included into our model the estimates are similar to our benchmark model. Second, the age 6 differences in internalising and externalising skills may instead be driven by measurement error. To test whether this is the case we exploit multiple measures of child skills coming from both the mother and the child's teacher and again find no evidence of a bias in our estimates. Finally, if a parental input has a differently sized direct effect on the two skill dimensions, both the level of the skill and the within-child difference will be endogenous. Supporting evidence is provided in our analysis for assumption A1, which suggested that neither our benchmark parental inputs nor an additional five parental inputs have a differential effect on internalising and externalising skills. Seemingly, no differential effects of past

[9]Some other papers identify complementarity or substitutability in investments by exploiting policy variation in inputs, for example Aizer and Cunha (2012), Doyle (2020).

inputs on the lagged internalising and externalising skills would suggest that the variation of $L\theta_{i,s}^N$ across $s = 1$ and 2 is exogenous.

3.2 Measurement models of socio-emotional skills and parental inputs

Since we have multiple measures for each of the two socio-emotional traits – internalising and externalising behaviours – we can allow each of the observed measures of socio-emotional skills to be affected by two types of measurement error: a measurement error which is shared across the two *traits* and across all *measures*, and a measurement error which is instead trait- and measure- specific.

Because the observed traits of internalising and externalising behaviours are derived from the Strength and Difficulty Questionnaire which is administered to mothers, we could have a systematic error shared across all observed socio-emotional traits if mothers systematically under-report or over-report behavioural issues of their child. To allow for such shared measurement error across different observed traits of socio-emotional skills, we allow the observed trait-specific socio-emotional skill $log\theta_{i,s}^N$ to depend on a shared measurement error in the following way:

$$log\theta_{i,s}^N = log\vartheta_{i,s}^N + v_i, \tag{4}$$

where $log\vartheta_{i,s}^N$ is the true trait-specific latent skill and v_i is the measurement error which is common across socio-emotional traits. Note that while the variation in $log\theta_{i,s}^N$ is in part spurious and caused by the measurement error v_i; the variation of $log\vartheta_{i,s}^N$ within child and across the two traits does not depend on v_i. Our fixed effect estimation corrects for the shared error v_i by considering the difference between internalising and externalising behaviours, i.e. $\Delta log\theta_i^N$. Similarly, the fixed effect estimation allows us to control for the shared measurement error across the lagged socio-emotional skills, $L\theta_{i,1}^N$ and $L\theta_{i,2}^N$.

A second type of measurement error is within traits and across *measures*. We can deal with this because for each trait (internalising and externalising behaviour) we can observe multiple measures both at age 6 and at age 11. Following previous papers on the technology of skill formation (see Cunha et al. 2010 and Agostinelli and Wiswall 2016), we assume the following relationship between each of the observed measures of a trait-specific socio-emotional skills at age 11 and the unobserved latent trait-specific socio-emotional skill $log\theta_{i,s}^N$:

$$Y_{i,s}^{N,m} = \lambda_s^m + \alpha_s^m log\theta_{i,s}^N + e_{i,s}^m, \tag{5}$$

where $Y_{i,s}^{N,m}$ is the m-th observed measure of the s trait-specific socio-emotional skill at age 11, $m = 1, ..., M_{s,t}$, $s = 1$ for internalising and 2 for externalising, λ_s^m and α_s^m are the intercepts and factor loadings specific for the measure m. $e_{i,s}^m$ is the measure-specific measurement error which has mean zero and is assumed to be uncorrelated with $log\theta_{i,s}^N$ and independently distributed across children and measures. We consider the same type of measurement model also for the lagged socio-emotional skills at age 6, $logL\theta_{i,s}^N$.

The latent trait-specific socio-emotional skill $log\theta_{i,s}^N$ can be identified only up to scale and location parameters. By setting the mean of $log\theta_{i,s}^N$ to 0 and $\alpha_s^1 = 1$, we fix the location and scale so that we can identify the parameters in λ_s^m and α_s^m for any trait s and we can extract the latent factor. We use measures of peer problems and emotional symptoms for internalising behaviours, and measures of hyperactivity and conduct problems for externalising behaviours. We use measures observed at 5 and 7 as proxies for measures at 6 for $logL\theta_{i,s}^N$; whereas we use only measures observed at age 11 as proxies for internalising and externalising at 11 for $log\theta_{i,s}^N$.[10]

We also consider measurement models similar to Equation (5) for the following parental inputs: mother's mental health, parenting style and parental engagement,[11]

$$I_{i,k}^m = \lambda_k^{I,m} + \alpha_k^{I,m} logI_{i,k} + e_{i,k}^{I,m}, \tag{6}$$

where $I_{i,k}^m$ is the m-th observed measure of the k parental input between age 6 and 11; $m = 1, ..., M_k$; $k = 1$ for mother's mental health, 2 for parenting style, and 3 for parental engagement; $\lambda_k^{I,m}$ and $\alpha_k^{I,m}$ are the intercepts and factor loadings specific for the measure m; $e_{i,k}^{I,m}$ is the measure-specific measurement error which has mean zero and is assumed to be uncorrelated with $logI_{i,k}$ and independently distributed across children, measures and inputs. We identify and extract each of the latent factor $logI_{i,k}$ by setting the factor mean to 0 and $\alpha_k^{I,1}$ to 1.

We estimate the production model by using directly the factors $log\theta_{i,s}^N$, $logL\theta_{i,s}^N$ and $logI_{i,k}$ for $k = 1, ..., 3$, which are theoretically free of measurement error when expressed as deviations from the mean across traits.

[10] See Section 4 for more details.

[11] Notice that we also adopt a similar measurement model for child cognitive skills.

4 Description of data

We use the UK Millennium Cohort Study (MCS), a cohort longitudinal survey covering a sample of about 19,000 children born in the UK between September 2000 and January 2002. Children and their family members are followed across time and interviewed when the children are aged 9 months, 3, 5, 7, 11, 14 and 17 years old (Dex and Joshi, 2005). The data collected includes a wealth of information about the child, his/her parents and the home environment.

By considering only children who are observed from age 5 to 11 we obtain a sample of 11,411 observations which we call the original sample.[12] Restricting this sample to children whose parents are married or cohabiting and whose mother is the main survey respondent reduces the number of observations to 8,280 observations.[13] We further restrict the sample to children with non-missing information on any of the parental inputs and child's skills measures and we exclude twins and triplets. This leads to a final estimation sample of 6,675 children.

Table 1 shows the demographic characteristics of our estimation sample when children are age 7. The average age of the child in our estimation sample is 86.6 months, with an average age for the mother of about 37. 93% of children are white; 36% of children have mothers in a managerial or professional occupation, 29% in an intermediate occupation and 32% in a routine or manual occupation.

The MCS was designed to over-represent the disadvantaged population. Survey weights can be used to reproduce descriptive statistics for the full population. In Table A.1 in the Appendix we compare the average and standard deviation of family background characteristics for the original sample (Column 1 and 2), the original sample using weights to account for the over-representation of the disadvantaged population (Column 3 and 4) and our estimation sample (Column 5 and 6). Children in the estimation sample have characteristics that are much more similar to the full population, i.e. to the weighted statistics from the original sample than to the unweighted ones. There are slight differences in covariates to suggest the estimation sample is more advantaged than the weighted original sample, but

[12] Our model combines the skills from age 5 and 7 to proxy for child's skills at age 6. See more details in Section 4.1.1.

[13] We only include married and cohabiting couples to exclude non-intact families that might have different parental inputs and other confounding environmental stressors. We only consider mothers as main respondent for comparability with earlier studies on child development focusing on maternal inputs (see for example Del Bono et al. 2016) and because fathers' and other respondents have high non-response rate for the questions related to the inputs and child's skills.

these are small. For example the mothers' age, education and proportion white in the two samples are 37.083 versus 36.975, 18.122 years versus 17.910 and 92.6% compared to 90.6% in the estimation and original sample, respectively.

4.1 Child's skills

4.1.1 Socio-emotional skills

We use the Strengths and Difficulties Questionnaire (SDQ) to construct our two measures of socio-emotional skills - externalising and internalising traits. The SDQ is an international standardised test measuring children's behaviours and emotions in several contexts (Goodman, 1997). It is largely used in psychology as well as in the human capital literature within economics,[14] and it shows correlations with Diagnosis of Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD)(Russell et al., 2013). The questionnaire, administered to parents since age 3 of the child, consists of 25 items on child psychological attributes measuring five scales for (i) Emotional Problems, (ii) Conduct Problems, (iii) Hyperactivity, (iv) Peer Relationship Problems and (v) Pro-social Behaviour. The scales can be either used separately to inform about specific behavioural problems or combined to create two different traits of socio-emotional skills which reflect internalising and externalising behaviours.

Internalising behaviour presents as a child appearing withdrawn and quiet. Our measure for the internalising trait combines the items related to emotional symptoms and peer problems (see Panel A of Table 2), measuring behaviour of the child including being often unhappy, having many fears and playing alone. Externalising behaviour on the other hand is associated with disruptive or other outward displays of emotions. Our externalising trait combines the items for conduct problems and hyperactivity problems (see Panel B of Table 2), measuring whether the child often has tantrums, fights or bullies other children or is easily distracted.

The top panel of Table 3 reports the descriptive statistics of the four scales of socio-emotional skills of the child at age 5, 7 and 11 respectively for boys and girls. For ease of interpretation each scale is reverse-coded, with higher values associated with higher levels

[14]Examples of economic papers that have measured socio-emotional skills using internalising and externalising items from the strength and difficulty questionnaire (SDQ) as we do are Gupta and Simonsen (2010), Nghiem et al. (2015), Del Bono et al. (2016), Black and Kassenboehmer (2017), Moroni (2018), Cornelissen and Dustmann (2019), Attanasio et al. (2020a), Briole et al. (2020), Kuehnle and Oberfichtner (2020).

of socio-emotional skills (or lower levels of socio-emotional problems) and as such the measures are re-labelled as emotional score, peer score, conduct score and hyperactivity score. With the exception of the emotional score measured at age 5 and 7, girls have statistically significantly higher socio-emotional skills. This gender gap is more pronounced for externalising behaviour and especially for the hyperactivity score.[15] The magnitude of the difference in socio-emotional skills may appear small, but the differences, where significant, represent between 7.9-37.6% of a standard deviation.

As explained in Section 3.2, we use factor models to derive the two specific traits of internalising and externalising behaviour at age 6 (by combining the measures at age 5 and 7) and at age 11. The correspondent factor loadings of the latent factors, i.e. internalising and externalising traits, can be found in Tables A.2 in the Appendix, respectively for boys and girls. The correlations between internalising and externalising skills are statistically significant for both girls and boys and corresponds to 0.38 for girls, and 0.41 for boys.

Because our measures of internalising and externalising skills are not cardinal, it is difficult to interpret the scale of the difference between internalising and externalising skills and the self-productivity of skills. To address this issue we anchor our measures of internalising and externalising skills to the probabilities of (1) not having experienced a crime, (2) having no health risky behaviours, (3) having never smoked, (4) having no mental issues, (5) having no school exclusions observed when the child is 14 years old.

The variable 'no criminal behaviour' takes value 1 if the child reports that he has never had criminal behaviour (i.e. carried a knife, being part of a street gang, being warned by the police) or has never being victim of criminal behaviour (i.e. someone been physically violent towards the child, someone hit or used a weapon against the child, someone stolen something from the child) and zero otherwise. The variable 'no risky behaviour' takes value 1 if the child reports that he has never had risky behaviour (i.e. smoked, more than five drinks, consumed cannabis) and zero otherwise. The variable 'never smoke' takes value 1 if the child reports that he has never smoked and zero otherwise. The variable 'no mental health issues' takes value 1 if the parents report that the child does not have longstanding illnesses related to mental health, stamina, ADHD, Autism, Asperger and zero otherwise. The variable 'no school exclusion' takes value 1 if the parents report that the child has never been suspended or excluded from school and 0 otherwise. The detail on the anchoring model are provided in Section 5.1.

[15] Leight and Liu (2020) correlate internalising and externalising traits with child characteristics and find similarly to us a statistically significant difference by child gender.

4.1.2 Cognitive skills

In a sensitivity analysis we include child cognitive skills into the model. Cognitive abilities are derived from the NFER (National Foundation for Educational Research) math test and a set of measures from the BAS (British Ability Scales), which tests child skills differently depending on the age of the child (Elliott et al., 1997; Hansen et al., 2012) and captures child abilities including problem solving, expressive verbal ability and reading and spatial awareness.

The bottom panel of Table 3 reports the descriptive statistics of the different measures of child's cognitive skills at age 5 and 7 respectively for boys and girls. Girls have statistically significantly higher cognitive skills than boys for all the measures, with the exception of reading abilities measured at age 5 where there is no statistically significant gender difference and maths at age 7 where boys outperform girls. Similarly to socio-emotional skills and as explained in Section 3.2, we use factor models to derive the latent cognitive skills of children at age 6 by combining the measures at age 5 and 7. The correspondent factor loadings of the latent factors, can be found in Table A.2 in the Appendix for boys and girls respectively.

4.2 Parental Inputs

It has been documented that the development of socio-emotional skills can be weakened by a deprivation of parental engagement (Kalil and Ryan 2020; Del Bono et al. 2016; Fiorini and Keane 2014; Attanasio et al. 2020b) low warmth and strict discipline in parenting style (Bertrand and Pan 2013), and maternal mental depression (see Goodman et al. 2011,Comaskey et al. 2017). For this reason we consider three main parental inputs which are mothers' mental health, sensitive parenting style and parent engagement.[16]

These different types of parental inputs included in our analysis capture various facets of parent-child interactions. Mother's mental health is assessed with the Mental Health Kessler (K6) Scale (Kessler et al., 2002), a questionnaire intended to collect information on mothers' psychological distress which in psychological medicine has recently been associated with children socio-emotional development (Hope et al., 2019). The mother indicates how frequently she experiences feelings such as being depressed, hopeless, worthless, restless, etc. We use latent factor models as explained in Section 3.2, to estimate the latent factor

[16]The main parental inputs considered are maternal inputs. This is due to data limitations, as there is high non-response rate among fathers. However we include father's socio-emotional skills in our robustness analysis.

measuring mother's mental health. Table A.3 reports the factor loadings for the full set of measures (Column 1) and the signal, i.e. percentage of the variance explained by the latent factor (Column 2). There is considerable variation in the amount of information captured by each measure of the same factor ranging from 31% to 71%. The latent variable capturing mothers' mental health can be interpreted as a positive input with low values associated with poor mothers' mental health and high values associated with good mothers' mental health. Descriptive statistics of the mother's mental health (latent factor) are reported in Table 1 and show that there are no statistically significant differences between boys and girls.

The second type of parental input considered in our analysis is sensitive parenting style (or parenting style for short). Parenting style has recently been recognised as a distinct parental input from the usual material and time investments (Cobb-Clark et al., 2019). Mainly in the psychology literature, but recently also in economics (Doepke and Zilibotti, 2017; Fiorini and Keane, 2014; Cobb-Clark et al., 2019), different categories of parenting style have been used to measure how warm/communicative and how strict/controlling a parent is. We construct a domain of parenting style capturing the degree of parental sensitivity, i.e. low strictness. The degree of sensitive parenting style is measured using the Straus' Conflict Tactics Scale included in the MCS (Straus and Hamby, 1997). The mother reports on a 5 point scale ranging from 'never' to 'daily' how frequently she takes a set of specific actions with her child such as smacking, shouting at or sending their child to their room when naughty, which are described in Table A.3.

Similarly to mothers' mental health, we use latent factor models as explained in Section 3.2 to estimate the latent factor measuring sensitive parenting style which captures how strict-sensitive a parent is when the child misbehaves. The latent variable for parenting style is reverse coded such that it can be interpreted as a positive input going from strict to sensitive parenting, with low values associated with strict parenting and high values associated with sensitive parenting. Table A.3 in the Appendix shows the factor loadings (Column 1) and the signal, i.e. percentage of the variance explained by the latent factor (Column 2). The variance of each observed measure of parenting style is explained by the latent factor by a proportion that varies between 10% to 51%. Descriptive statistics of the parenting style (latent factor) are reported in Table 1 and show that parents adopt a stricter parenting style with boys than with girls.

Finally we consider parental engagement as last parental input. This input aims at capturing quality parental interactions with the child by combining 6 questions regarding how often the mother spends time in formative activities with the child, including drawing,

painting or playing active games with their child, again detailed in Table A.3. The mother is asked to report how frequently she spends time with the child in each of a set of activities using a scale ranging from 'Every day or almost every day' to 'Not at all'. The estimated factor loadings and signal are reported in Table A.3. Similarly to the other inputs, the interpretation of the factor is such that the higher the value, the higher the parent engagement with the child. For all factors in Table A.3, no measure has a signal close to 100% emphasizing the importance of accounting for measurement error through the latent factor model. Descriptive statistics of the parental engagement (latent factor) are reported in Table 1 and show that parents engage more with girls than boys.

Our analysis will focus on substitutability (complementarity) between parental inputs and lagged socio-emotional skills and assess whether the degree of substitutability varies when the level of input is low compared to high. To better understand how to choose the threshold under which an input can be defined as low and conducive with stressful environment, we consider the first, second, third and fourth quartiles for each of the inputs and look at the typology of mother with inputs below each of these quartiles. Table 4 shows the mean value of each measure making up a parent input, across the distribution of the latent factor for each input. Looking at Table 4, when mental health, parenting style and parental engagement are above the median there does not seem to be evidence of stressful environment or neglect. On average, mothers with a mental health above the median have negative feelings (e.g. felt depressed or hopeless) only a little of time or none of the time. A parenting style below the median tends to be associated with strict parenting style, e.g. telling a child off or shouting at child when naughty sometimes, often or daily. Finally, mothers with parental engagement with their child below the median are the ones who draw and paint or tell stories to the child less than once a month or not at all. For this reason we choose the median of each input as the threshold to define a low level of the input. However, in our sensitivity analyses, we will also show our results on substitutability when considering as threshold the first quartile or the third quartile.

4.3 Other inputs

In a sensitivity analysis additional parental inputs of family income and mothers education are included as controls. As largely established in the economic literature, income matters for the development of child human capital (see e.g Dahl and Lochner 2012; Carneiro et al. 2021) through a change in parental investments (Caucutt and Lochner, 2020). We therefore consider a parental input to capture the material investment, measured by the household

weekly income equivalised using the OECD scale.[17] On average the weekly family income is £494 (Table 1).

Mother cognitive skills are proxied by mother's education[18] (the age mothers left school). On average mothers are 18 years old when they leave full time education (Table 1).

As additional measures of parental skills we include trait specific parents' socio-emotional skills, of both mothers' and fathers'. These measures will be used in our sensitivity analysis to show that the intergenerational transmission of trait-specific socio-emotional skills does not represent a threat for our identification strategy. We derived these measures using the questions on parental neuroticism and extroversion available in the MCS which proxy for parental internalising and externalising traits. Table A.3 reports the corresponding factor loadings (Column 1) and the signal (Column 2) for both the mother and the father. We find a correlation of 0.3 both between maternal neuroticism and children internalising skills and between maternal extraversion and children externalising skills, whereas we find a much lower correlation between fathers' and children socio-emotional skills (0.08 and 0.1 for internalising and externalising skills respectively). Descriptive statistics of parent's socio-emotional skills (latent factors) are reported in Table 1 and show no statistically significant difference between boys and girls with the exception of father's extroversion whereby fathers of girls are more extrovert than fathers of boys.

4.4 Descriptive evidence on the variation used for our estimation

Our estimation strategy exploits the within child differences between internalising and externalising skills. While the self-productivity and intercept are allowed to change between internalising and externalising, the substitutability parameter (the differential elasticity of socio-emotional skills at 11 with respect to the parental inputs for high- relative to low-skills children at 6) is assumed to be invariant between internalising and externalising and its identification relies on the presence of children who have internalising skills at age 6 below the first quartile and externalising above the first quartile or vice versa. Table A.4 shows the transition matrix between the trait-specific quartiles of socio-emotional skills and indicates that there is plenty of variation across the quartiles and across traits. The numbers in the

[17] The OECD equivalised income is defined as the household income divided by the OECD equivalent scale, which counts the first adult as 1, each additional adult as 0.5 and each child (aged under 15) as 0.3 equivalent adults.

[18] For evidence on the importance of mother's education as a determinant of child development see for example Carneiro et al. (2013).

table can be used to calculate that 28.33% of girls and 26.74% of boys have one of the two traits below the first quartile while the other is above the first quartile (25% of girls have internalising skills in the first quartile and of these (100-43.333)% have externalising skills in the top three quartile, hence [(100-43.333)*0.25*2]%=28.33% of girls have internalising skills below the first quartile and externalising above the first quartile or vice versa).

Figure 1 shows the distribution of the within-child difference between externalising and internalising skills by gender at age 6 separately for boys and girls. A positive within-child difference indicates that a child has higher externalising than internalising skills. Therefore on the left tail there are children with extreme low values of externalising skills relative to internalising, whereas children on the right tail are the ones with extreme low values of internalising skills relative to externalising. The distribution of the difference has a mean of zero for both boys and girls but the standard deviation is higher among boys than girls, respectively 1.529 and 1.377.

If our child fixed effect estimation is driven by children with large differences between internalising and externalising skills and these children are drawn from a selected sample, the variation used in our strategy may not be exogenous. We use the within-child difference from Figure 1 to show that children at the tails (the bottom quartile and top quartile) of the distribution have similar characteristics to the full estimation sample. Figure 2 reports the differences in the average of pre-determined demographic characteristics between the sub-sample of children in the tails and the full estimation sample separately by gender. There are no statistically significant differences between the two samples suggesting that the variation we use to identify the effect of lagged socio-emotional skills and their interaction effect with parental inputs is exogenous.

5 Estimation Results

We estimate the production model for socio-emotional skills at age 11 as described in equation (2) using child fixed effect estimation introduced in Section 3 and we measure the socio-emotional skills at 6 and 11 using the latent factors derived from the measurement models described in Section 3.2. Before presenting our results, we remind the reader of the aim of our paper. We are interested to assess whether there is complementarity or substitutability between parental inputs in middle childhood and child socio-emotional skills in early childhood (at age 6) in producing socio-emotional skills in middle childhood (at age 11). To test for this, we allow the productivity of parental inputs to change across low and high

levels of the lagged socio-emotional skills defined as levels below and above the first quartile (referred to as low and high skilled henceforth). In addition, to test for the diathesis-stress hypothesis, we also allow the productivity of each parental input to vary between high and low levels of the input, defined as values below and above its median (now referred to as high and low inputs).

Table 5 reports our benchmark results separately for girls and boys in columns 1 and 2 respectively and for girls and boys pooled together in column 3. Because we use child fixed effect estimation we identify and report only the differential rather than the absolute elasticity of socio-emotional skills at age 11 with respect to each of the parental inputs for children at the top three quartiles relative to the first quartile of the socio-emotional skills at age 6 and separately for levels of the parental input below and above the median, i.e. we identify the coefficients $\beta_{k,1}^{LowI}$ and $\beta_{k,1}^{HighI}$ in equation (2) (henceforth referred to as the differential elasticity for a low or high input). A negative (positive) differential elasticity at the top three quartiles with respect to the first quartile indicates the presence of substitutability (complementarity). At the bottom of each of the two panels we report the self-productivity or persistence parameter for socio-emotional skills separately for internalising and externalising traits, ρ_1 and ρ_2; this is computed keeping all other inputs at the mean and it should be interpreted as elasticity of socio-emotional skills at 11 with respect to skills at 6.

Looking at girls and focusing on mother's mental health (see Table 5, first column), we find substitutability for low mother's mental health as indicated by the negative differential elasticity of -0.525 percentage points for high-skilled with respect to low skilled girls for a low level of the input. This can be interpreted as a decrease in the elasticity by 0.525 for children in the top three quartiles relative to children in the first quartile. On the contrary, there is no statistically significant differential elasticity between low- and high-skilled girls when considering a level of mother's mental health above the median. These results are consistent with the diathesis-stress hypothesis that poor mother's mental health represents a stressful home environment where girls with low socio-emotional skills would benefit the most from an improvement in the input; whereas an increase in mental health would equally benefit low- and high- skilled girls when the input is above the first quartile. Looking at the parenting style and parent engagement we do not find any statistical significant differential productivity between low and high skilled girls, suggesting that there is neither complementarity nor substitutability between socio-emotional skills at 6 and these two inputs. Results for boys reported in column (2) of Table 5 confirm the implications of the diathesis-stress hypothesis but only for parenting style. For low parenting style (i.e. strict parenting) we find a clear evidence of substitutability between parenting style and early socio-emotional skills. Boys

with early socio-emotional skills at the bottom quartile react more to an increase by one percent in parenting style (i.e. decrease by one percent in strictness), as the elasticity is 0.661 percentage points lower for high-skilled boys than low-skilled boys.

An increase in the elasticity by 0.525-0.661 for high- relative to low-skilled children is large in magnitude if compared with previous studies. As emphasized by Agostinelli and Wiswall (2016), papers that consider a CES function do not allow for elasticities larger than 1 and impose a positive contemporaneous complementarity between parental investments and lagged child's skills, meaning that an elasticity that is decreasing in the child's starting skills would not be even possible. Agostinelli and Wiswall (2016) consider a translog production model similar to ours but for cognitive rather than socio-emotional skills and find that the elasticity of skills with respect to investments does not change between high- and low-skilled children from age 7-8 onward, whereas at age 5-6 they find a positive differential elasticity for low- relative to high-skilled children. More precisely, their estimated elasticity is decreasing in the lagged skills and ranges from 0.2 for the most skilled to 1.5 for the least skilled child. These changes in the elasticity are comparable in magnitude with our estimated differential elasticity of 0.525-0.661 between the first and top three quartiles of the lagged skills when considering the production of socio-emotional skills at age 11.

That the differential elasticity of mothers' mental health at the bottom quartile of the child socio-emotional skills is statistically significant only for girls and not for boys is consistent with previous empirical studies which have found the intergenerational transmission of mental health to be stronger from mothers to girls than from mothers to boys. E.g., Powdthavee and Vignoles (2008) find a statistically insignificant effect of maternal negative emotional stress on boys, but a strong effect on girls, when the children are in adolescence. That the differential elasticity of parenting style at the bottom quartile of the child socio-emotional skills is statistically significant only for boys and not for girls is consistent with empirical evidence that suggests that harsh parenting is more detrimental for boys than girls (e.g., Kingsbury et al., 2020).

When considering the sample of boys and girls together (Column 3) we find substitutability between mother's mental health and early socio-emotional skills as well as between parenting style and early socio-emotional skills for a low level of the inputs. However, these results are driven mainly by girls for mother's mental health and by boys for parenting style, so in the remaining analyses we consider boys and girls separately.

Finally, looking at the self-productivity parameter, we find that a 1% increase in the internalising trait at age 6 raises the internalising trait at age 11 by 0.669% for girls and

0.855% for boys, while the corresponding elasticity of the externalising trait is of 0.269% for girls and 0.343% for boys. The larger self-productivity found for internalising seems reasonable given that previous studies have suggested that externalising behaviours tend to decrease across child age, whereas the internalising behaviours tend to increase (see e.g. Bornstein et al. 2010; Gilliom and Shaw 2004).

Ultimately, our findings in Table 5 suggest that policy can help children who are lagging behind in terms of socio-emotional skills with interventions in middle childhood aiming at improving specific parental inputs but only if these interventions are targeted to parents exhibiting mental health problems or using strict parenting techniques.

5.1 Estimation Results when Anchoring the Internalising and Externalising Traits

The lack of a natural metric of our socio-emotional skills implies that our results might be sensitive to arbitrary scaling of socio-emotional skills. This is especially an issue when regressing arbitrarily scaled outcomes on arbitrarily scaled lagged outcomes (see Cunha and Heckman 2008; Cunha et al. 2010; Bond and Lang 2013; Cunha et al. 2021).[19] We follow Cunha et al. (2010) and re-scale socio-emotional skills by anchoring them to a set of measures that are cardinal, which are the probabilities of each of the following dummy variables of taking value 1 when children are 14: (1) not having experienced a crime as a victim or a perpetrator, (2) having no health risky behaviours (having never smoked, drunk alcohol or took drugs), (3) having never smoked, (4) having no mental issues (disorders), (5) having no school exclusions.

We regress each of these dummy variables separately on internalising and externalising behaviour at ages 6 and 11 using a flexible parametric specification, i.e. using a polynomial in the internalising (externalising) trait and choosing the polynomial's order by testing if the coefficients in successively larger order polynomials remain statistically significant at the 5% level. We use the estimated polynomial coefficients to predict the probabilities for each of our 5 dummies to be equal to 1. Such predicted probabilities become in turn the anchored measure of the internalising (externalising) trait at age 6 and 11 which we include in our model (2) in logs.

[19]Notice that arbitrary rescaling is less of an issue when considering the different quartiles of the socio-emotional skills at age 6 given that any monotonic transformation of the socio-emotional skills would yield the same values for each of these quartiles.

As emphasized by Cunha et al. (2021) the relationship between the trait and the anchoring outcome cannot be interpreted as causal and might reflect unobserved variables and different anchoring outcomes can lead to different conclusions. It is therefore important to assess the robustness of our findings to different cardinal outcomes.

Table 6 displays for each type of anchoring the estimation results for equation (2) when replacing the logs of the internalising and externalising traits with the logs of the corresponding anchored probabilities and focusing on mental health and parenting style. For conciseness we focus only on the estimated differential elasticity ($\beta_{k,1}^{LowI}$) for the two parental inputs for which we found substitutability, which are mother's mental health and parenting style. The findings confirm the presence of substitutabilty between a low level of these two parental inputs and child socio-emotional skills at age 6 in producing socio-emotional skills at age 11 for all anchoring variables.

Similarly to our benchmark results the substitutability is found for mother's mental health for girls and for parenting style for boys. For example, looking at the results when considering the internalising and externalising anchored to the probability of not being involved in crime, we find that the elasticity of the socio-emotional skills at age 11 with respect to the anchored traits decreases by 0.025 percentage points for high relative to low-skilled girls when their mother's mental health is low and by 0.049 percentage points for high relative to low-skilled boys when the parenting style is low (harsher).

These estimates are smaller in absolute magnitude to the benchmark estimates in Table 5 but are comparable when related to the mean and standard deviation of each measure. The benchmark estimated elasticities with respect to maternal mental health and parenting style for girls and boys respectively are 0.525 and 0.661 larger for children in quartile 1 of socio-emotional skills at age 6 relative to quartiles 2-4. If the respective parental input of mental health or parenting style is doubled, the increase in the elasticity in socio-emotional skills for girls and boys in the first quartile relative to the top 3 quartile would lead to a raise with respect to the mean of 0.906 and 0.125 (i.e. 52.5% and 66.1% of the mean of skills, which is 1.894), which is equivalent to an increase of 77% and 87% of a standard deviation. Using the same intuition for the anchored estimates, doubling mothers' mental health (parenting style) differentially lowers the predicted probability of crime, risky behaviours, smoking, mental health problems of the child and school exclusions more for children in quartile 1 of socio-emotional skills at 6 by an estimate equivalent to 45%, 50%, 49%, 27% and 30% (63%, 68%, 67%, 63% and 77%) of a standard deviation for girls (boys). This comparability in the metric of standard deviations strengthens our finding that when a low level of a parental

input creates a stressful home environment, raising the input will benefit the socio-emotional skills more for children with initial low skill levels.[20]

We conclude that our main findings are robust to the issue of lack of cardinality.

5.2 Heterogeneity

Our analysis has concluded that two inputs of mothers' mental health and parenting style exhibit substitutability in the production of child socio-emotional skills when these inputs are low and likely to create a stressful home environment. We explore now whether these results are heterogeneous across the socio-economic status (SES) of the family by stratifying the analysis by the education and occupation of the mother and by family income.

In Table 7 we re-estimate the model from equation (2) for the sub-samples of mothers with low and high education (defined as leaving school at 18 or younger and 19 or older respectively), mothers with low-skilled occupation (defined as working in a routine, manual occupation or not working) and high-skilled occupation (intermediate or managerial occupation) and by low and high family income (defined as below and above the median respectively). Each row refers to a regression for a different sub-sample and reports only the differential elasticity for low maternal mental health for girls, $\beta_{1,1}^{LowI}$; and the differential elasticity for low parenting style for boys $\beta_{2,1}^{LowI}$, which are the coefficients that are found to be statistically significantly different from zero in our benchmark results.[21]

From Table 7 we can see that the substitutability between inputs and socio-emotional skills at 6 seems present for both low and high SES children. However, the magnitude of the substitutability tend to be less precisely estimated for high SES children.

6 Validity of Model Assumptions

In this section we provide supportive evidence for the three main assumptions imposed by our empirical model and estimation strategy: (A1) invariance of the production model across

[20] To be precise, for the anchor of no crime, the differential estimate for girls from raising mother's mental health is -0.025, which is 2% of the mean value of 0.793, and can be expressed as 45% of the standard deviation (reported in Table 6 to be 0.044).

[21] When exploring this heterogeneity it is important to verify that the distribution of parental inputs is similar across the different sub-samples. Figures A.1 in the Appendix show that the distributions of the parent inputs are very similar across the socio-economic status definitions.

the two trait-specific socio-emotional skills, (A2) no interaction effect between inputs and lagged socio-emotional skills except for the three parenting inputs; (A3) exogenous variation in the child socio-emotional skills at 6 across internalising or externalising.

We start checking assumption (A1) by testing if the interactive effect of inputs with lagged socio-emotional skills is the same for internalising and externalising traits. This may be violated if for example the response to a particular shock leads children to increase more their internalising than their externalising behaviour, or vice versa.

It is possible to relax this restriction and test whether our benchmark results are sensitive to allowing the coefficients of Table 5 to be different for internalising or externalising traits. Controlling for a within-child between-trait fixed effect means that it is not possible to allow the interaction of all parental inputs with lagged socio-emotional skills (and the self-productivity parameter) to vary across the two traits at the same time. What is possible is to estimate a more flexible model with respect to one input at a time, whilst restricting the coefficients relating to the other two inputs to be constant across internalising and externalising traits. Given that our benchmark model found evidence of substitutability for mothers mental health below the median for girls and for strict parenting style below the median for boys, we start by testing whether the coefficients of these specific inputs vary across externalising and internalising traits.

The results are reported in Table A.5, where we find that the substitutability between lagged socio-emotional skills and mother's mental health (differential elasticity $\beta_{k,1}^{LowI}$) is not statistically significantly different across internalising and externalising traits for girls with a low level of mother's mental health (p-value 0.419). We also find that there is substitutability between lagged socio-emotional skills and parenting style for boys with low parenting style for both internalising and externalising, but it is somewhat larger in absolute term for internalising than externalising (p-value 0.011).

We further investigate our assumption (A1) by checking if the effect of other parental inputs vary across internalising and externalising skills. To do that we add to our benchmark model (2) one at time the following parental inputs interacted with the dummy for internalising $D1_{i,s}$: mother's age and education, a set of dummy variables for mother's ethnicity and occupation, and family income. The results reported in Table A.6 show that the differential effect across internalising and externalising traits of each of these inputs is never statistically significant at 5% level except in one case (the Pakistani-Bangladeshi ethnicity dummy). Furthermore, the main results on substitutability (see top panel of Table A.6) do no change when we include these additional inputs.

To provide evidence on the credibility of our assumption A2, we include as additional regressors three inputs commonly considered in child human capital models - mothers' education, family income and child cognitive skills - and we interact them with the dummy variable for low socio-emotional skills at age 6. Our results in Appendix Table A.7 show that the conclusions from our benchmark specification remain and there is no evidence of differential returns to the new included inputs across early socio-emotional skills.

Finally, assumption A3 in subsection 3.1 states that the difference between the two trait-specific socio-emotional skill picks up a random predisposition to externalising or internalising behaviours at age 6. To test empirically whether this is the case, we consider three potential threats to the assumption validity.

First, the difference in a child's lagged externalising and internalising trait may come from differences in trait-specific inputs that are not included in our model. Inputs in the child's socio-emotional development are not generally trait-specific. The only trait-specific input which comes to mind are trait-specific socio-emotional skills of the parents, which can be transmitted to children. We can measure and include into our model both mothers' and fathers' trait-specific socio-emotional skills, which we measure using neuroticism for internalising and extroversion for externalising. At the top panel of Table A.8 our main findings on substitutabilty are confirmed for both girls and boys (see columns 1 and 2). Furthermore, the bottom panel shows that mothers' and fathers' trait-specific socio-emotional skills have effects that are not statistically significant at 5%.

Second, the differences between the measures of internalising and externalising behaviours can be caused by measurement errors in the mother reports of child socio-emotional skills (Del Bono et al., 2020). To reduce this concern we combine mother's and teacher's reports to derive the latent factors for internalising and externalising behaviours. The results using this new measure of socio-emotional skills are reported in Table A.9 and look similar to our benchmark results.[22] We conclude that there is no systematic empirical bias for our benchmark results. The lack of measurement error bias in our estimates is likely explained by the fact that we use latent factors for the two socio-emotional skills and that the child fixed effect estimation exploits variation in socio-emotional skills within child and across traits and therefore corrects for any potential measurement error which is shared across different measures of socio-emotional skills reported by the mother.

Third, there may be differences in the effects of past investments and inputs between

[22]We use a latent factor model to combine measures of socio-emotional skills using the repeated measures reported by the mother at age 5 and 7 and the measures reported by the teacher at age 7.

externalising and internalising behaviours. As discussed above, this is inconsistent with the evidence which shows that events including family income shocks (Akee et al., 2018), divorce (Lansford et al., 2006) and parent maltreatment (Anthonysamy and Zimmer-Gembeck, 2007; Maschi et al., 2008) induce a similar reaction in externalising and internalising behaviours. Furthermore, even in presence of past investments and inputs with effects that vary between externalising and internalising behaviours at age 6, their omission would not cause any endogeneity bias for the estimation of the production model at age 11 as long as they do not have a direct effect on socio-emotional skills at 11 which varies between the two traits. Although this is not fully testable, the analysis linked to A1 has found no evidence of a differential effect on internalising and externalising for each of the main parental inputs of mothers mental health and sensitive parenting; nor for the five additional parental inputs of mothers' education, age, occupation, ethnicity and family income.

Our findings suggest that we can rule out potential sources of endogenous variation in the differences between externalising and internalising behaviours at age 6, supporting assumption A3. Finally, our anchoring analysis can help to shed some light on the comparability of internalising and externalising scales. If assumption A3 were valid, we would expect that internalising and externalising skills are similarly correlated with each of the five anchored probabilities from subsection 5.1. With this in mind, we check graphically the predicted relationship between each of the 5 anchored probabilities and the internalising and externalising traits. As we can see from Figure A.2, all anchored probabilities are montonically increasing in both the internalising and externalising traits and both at age 6 and 11, except for the probability of no mental issues at age 6 for girls which seems decreasing in the internalising trait at age 6 but only for low values. There do not seem to be any large systematic difference across internalising and externalising, however in some cases there is a steeper slope in internalising than externalising traits. A different slope is not a concern given that our empirical model allows for a differential scale factor of internalising and externalising traits at age 11 and a differential persistence for internalising and externalising at age 6.

7 Sensitivity Analysis

We run another three robustness checks where we (i) use an aggregate measure of stressful home environment to proxy for Adverse Childhood Experiences (ACE) rather than the three separate parental inputs; (ii) consider different thresholds to define low inputs; (iii) test whether the substitutability changes when considering high-skilled children in each of the

three top quartiles of the lagged socio-emotional skills relative to the bottom quartile.

The psychological and medical literature suggests that being exposed to more than one stressful factor (e.g. maternal depression, lack of parental engagement, parental abuse and neglect) is what exacerbates the risk of behavioural issues for children with a predisposition to a behavioral disorder (e.g., Felitti et al. 1998; Anda et al. 2006). The related literature (see for example, Schurer et al. 2019) often uses the Adverse Childhood Experiences (ACE) index - which increases with the number of adverse childhood events - to measure a stressful home environment. In our analysis we construct a proxy of ACE by taking the average of the two main inputs for which we found substitutability (mother's mental health and parenting style) and consider the median of this variable ACE to define low and high levels of parental inputs. Note that the ACE index takes low values when the average of two parental inputs is low and therefore when the child is more likely to experience a stressful or neglectful home environment, e.g. being smacked frequently, which can be defined as an adverse childhood experience. Results of this exercise reported in Table A.10 show that using an aggregate measure of the stressful home environment confirms the presence of substitutability between a low level of parental inputs (high stress home environment) and child socio-emotional skills at age 6 in producing socio-emotional skills at age 11, but the significance is only at the 10% level.

Our analysis sets the threshold for a low level of parental inputs at the median, which was in part motivated by the statistics in Table 4. It could be that a home environment is more stressful for children when inputs are also at less extreme or at more extreme levels. To analyse whether the substitutability of the three inputs exists at different thresholds of low inputs, Table A.11 provides regression results which considers heterogeneity of the interactive effect of socio-emotional skills at age 6 with the level of the three inputs below the first and third quartiles. Because substitutability was found in the return to mothers' mental health for girls, and parenting style for boys, we present results just for these two inputs. Table A.11 shows that for girls, an improvement in mental health has a higher return for low- than high-skilled children when mental health is below the first quartile, below the median or below the third quartile. Choosing the first or the second quartile as the threshold leads to a similar level of substitutability, whereas considering the third quartile leads to a substantial reduction in the substitutability. For boys there is substitutability in the return to strict parenting when a low level of the input is defined as below the second or third quartile, but not when defined as below the first quartile. The highest level of substitutability for boys is found when using the median. In conclusions, the results in Table A.11 seem to justify our choice of the median as threshold to define level of inputs that are low and than can cause

a stressful environment.

Finally, in Table A.12 we show the differential elasticity of the socio-emotional skills at 11 for low and high levels of each of the inputs for children in the 2nd, 3rd and 4th quartile relative to children at the bottom quartile of the socio-emotional skills at age 6. This exercise allows us to test whether the differential elasticity is constant across the three top quartiles (relative to the first quartile) as imposed by our benchmark model. The p-values for such tests are reported in the last columns and show that we never reject the equality at 1% level of significance and we reject it only in one case at 5% level, therefore supporting our benchmark specification.

8 Conclusions

Existing empirical evidence suggests that inequalities in socio-emotional and cognitive skills are present before children start schooling and persist across their childhood. However, socio-emotional skills tend to be malleable much further into childhood than cognitive skills; this suggests that these early life differences can be attenuated through interventions in middle childhood, such as introducing public policies that support parents to improve their parenting behaviour. An example of such a program is the Incredible Years BASIC parent training program which was implemented in UK and Ireland. This program focused on parents of children up to age 7 with existing behavioural problems and consisted in 12 weeks of weekly 2-hour group-training sessions, which provided parents with practices to reduce harsh discipline and increase engagement with their child (McGilloway et al., 2009).

To assess the potential usefulness of interventions of this type in middle childhood and to identify which types of parental inputs should be targeted, we evaluate the degree of complementarity and/or substitutability between different types of parental inputs and socio-emotional skills at age 6 in producing socio-emotional skills at age 11. In particular, we test whether there is heterogeneity in the productivity of mother's mental health, parenting style and parent engagement between low and high skilled children defined as children with socio-emotional skills at age 6 below and above the first quartile.

Our results show that reducing stress in the childs environment by improving maternal mental health for girls and parenting style for boys, has a beneficial effect especially for children who are at the bottom of the distribution of socio-emotional skills and who have a low level of these parental inputs. These finding confirm that children with low socio-

emotional skills early in life are more vulnerable to a stressful home environment, such as strict parenting and poor mothers' mental health. In line with existing evidence in the child development literature our findings suggest that the early years are crucial for the development of socio-emotional skills, as children with low skills at age 6 are set on a different trajectory of skill development up to age 11 compared to those with high early skills.

Coming back to our initial question of whether interventions in middle childhood can be effective to narrow the gaps in socio-emotional skills, the short answer is yes. Nevertheless, to be cost-effective such interventions should be aimed at raising parental inputs that reduce stressful environment experiences for the child and should be targeted exclusively to parents with a low level of such parental inputs.

Although we find that the inputs identified as stressors for socio-emotional skills of boys and girls are different, it is likely that harsh parenting practices and mothers' mental health are closely linked. Indeed, evidence summarised by Furlong et al. (2012) suggests that randomized control trials of parenting training interventions aimed at reducing negative or harsh parenting practices, reduce child conduct problems whilst also improving parents' mental health up to two years after the intervention. According to our evidence, policies targeted at parental behaviour could be an effective way to reduce gaps in socio-emotional skills of children.

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Table 1: Descriptive statistics of all inputs at age 7, by gender

	Boys		**Girls**		**Test diff**
	mean	sd	mean	sd	p-value
Demographic characteristics					
Age in months	86.646	2.896	86.564	2.855	0.243
Mother age	37.071	5.252	37.095	5.350	0.854
Mother's ethnicity					
White	0.928	0.258	0.923	0.266	0.458
Mixed	0.005	0.067	0.005	0.071	0.733
Indian	0.020	0.140	0.019	0.136	0.704
Pakistani Bangladeshi	0.022	0.146	0.028	0.164	0.123
Black	0.013	0.114	0.015	0.121	0.548
Other	0.012	0.109	0.010	0.099	0.399
Mother's occupational status					
Managerial and professional	0.358	0.479	0.364	0.481	0.636
Intermediate	0.298	0.458	0.277	0.447	0.054
Routine and manual	0.315	0.465	0.325	0.469	0.370
Never worked	0.029	0.167	0.034	0.182	0.195
Parental inputs					
Mother's mental health	-0.002	0.521	0.000	0.527	0.885
Parenting style	-0.067	0.512	0.066	0.509	0.000
Parent engagement	-0.027	0.611	0.027	0.596	0.000
Other inputs					
Family income	494.172	242.792	493.697	244.832	0.937
Mother's education	18.126	2.621	18.118	2.560	0.903
Mother's neuroticism (-)	0.003	0.578	-0.005	0.568	0.594
Mother's extroversion	-0.005	0.438	0.004	0.424	0.377
Father's neuroticism (-)	-0.004	0.382	0.005	0.389	0.390
Father's extroversion	-0.016	0.435	0.016	0.441	0.007
Observations	3330		3345		6675

Notes: sd stands for standard deviation. Parenting style, parent engagement, Mother's mental health, Mother's and Father's neuroticism, Mother's and Father's extroversion are obtained from factor models and have zero means. Family income, that is the OECD equivalised weekly family income, is adjusted at 2012 prices. Mother's education measures the age at which mother left full time education. Last column reports the p-value of the test for the equality of means between boys and girls. Data: UK Millennium Cohort Study, Estimation Sample, except for parents' neuroticism and extroversion which are available only for a subsample of 5340 children.

Table 2: Socio-emotional skills. Details on items for Strengths and Difficulties subscales.

Scale	Items within scale
Panel A: Internalising	
1) Emotional symptoms	
	a. Complaints of headaches/stomach aches/sickness
	b. Often seems worried
	c. Often unhappy
	d. Nervous or clingy in new situations
	e. Many fears, easily scared.
2) Peer Problems	
	a. Tends to play alone
	b. Has at least one good friend*
	c. Generally liked by other children*
	d. Picked on or bullied by other children
	e. Gets on better with adults.
Panel B: Externalising	
3) Conduct problems	
	a. Often has temper tantrums
	b. Generally obedient*
	c. Fights with or bullies other children
	d. Can be spiteful to others
	e. Often
4) Hyperactivity	
	a. Restless, overactive, cannot stay still for long
	b. Constantly fidgeting
	c. Easily distracted
	d. Can stop and think before acting*
	e. Sees tasks through to the end*.

Notes: We derive the internalising trait by using a factor analysis of two measures of behavioural issues, emotional symptoms and peer problems, while the latent factor for the externalising trait is derived from two other measures of behavioural issues which are conduct problems and hyperactivity. Each of the 4 behavioral issues are computed by aggregating a set of items described in column 2. * denotes items that are reversed when computing the aggregate score for each type of behavioural issue. All of the 25 items measures specific behavioural problems by asking parents to indicate whether a statement on the child is 'true', 'somewhat true' or 'not true'.

Table 3: Descriptive statistics of child's skills

	Boys		**Girls**		**Test diff**
	mean	sd	mean	sd	p-value
Socio-emotional skills age 5					
Internalising behaviour					
Emotional score	8.810	1.466	8.756	1.446	0.127
Peer score	8.977	1.351	9.119	1.231	0.000
Externalising behaviour					
Conduct score	8.605	1.397	8.819	1.298	0.000
Hyperactivity score	6.716	2.289	7.403	2.105	0.000
Socio-emotional skills age 7					
Internalising behaviour					
Emotional score	8.693	1.631	8.622	1.583	0.070
Peer score	8.959	1.453	9.085	1.306	0.000
Externalising behaviour					
Conduct score	8.692	1.458	8.975	1.285	0.000
Hyperactivity score	6.530	2.443	7.437	2.253	0.000
Socio-emotional skills age 11					
Internalising behaviour					
Emotional score	8.426	1.852	8.229	1.903	0.000
Peer score	8.806	1.597	8.932	1.508	0.001
Externalising behaviour					
Conduct score	8.689	1.511	8.932	1.350	0.000
Hyperactivity score	6.761	2.458	7.685	2.138	0.000
Cognitive skills age 5					
BAS: Picture similarities	82.709	10.902	83.918	10.817	0.000
BAS: Reading abilities	111.058	14.632	111.637	13.935	0.098
BAS: Pattern construction	89.103	18.499	91.538	16.848	0.000
Cognitive skills age 7					
NFER: Maths test	10.112	2.711	9.964	2.515	0.021
BAS: Reading abilities	108.879	30.769	112.639	26.539	0.000
BAS: Pattern construction	118.032	16.281	119.385	15.074	0.000
Observations	3330		3345		6675

Notes: Child's socio-emotional and cognitive skills are measured aggregating together a set of child's psychological and cognitive attributes which we report above. Each of the psychological attributes is reverse-coded from the raw score in Table 2, with higher values associated with higher levels of socio-emotional skills, and the attributes are re-labelled as such. For example the variable peer problems is reverse coded and labelled as peer score. sd stands for standard deviation. Last column reports the p-value of the test for the equality of means between boys and girls. Data: UK Millennium Cohort Study.

Table 4: Means of inputs' measures at different thresholds

Inputs measures	*Means of measures at quartiles of inputs factor* Q=1	Q=2	Q=3	Q=4
Mother's mental health				
How often felt depressed in last 30 days	3.77	4.71	5.00	5.00
How often felt hopeless in last 30 days	3.87	4.91	5.00	5.00
How often felt restless in last 30 days	3.88	4.38	4.89	4.89
How often felt everything an effort in last 30 days	3.46	4.06	4.86	4.86
How often felt worthless in last 30 days	3.96	4.90	5.00	5.00
How often felt nervous in last 30 days	3.95	4.39	4.85	4.85
Parenting styles				
How often tells child off when naughty	4.26	3.77	3.28	2.60
How often smacks at child when naughty	2.01	1.62	1.42	1.22
How often shouts at child when naughty	3.93	3.36	2.88	2.30
How often sends child to bedroom/naughty chair	3.48	2.81	2.46	1.79
How often takes away treats from child when naughty	3.44	2.88	2.62	1.93
How often bribes at child when naughty	2.36	1.97	1.72	1.48
How often ignores at child when naughty	2.87	2.44	2.12	1.72
Parental engagement				
Frequency draw and paint with child	4.75	3.99	3.45	2.62
Frequency tell stories to child	4.79	4.09	3.57	2.72
How often does musical activities with child	3.54	2.74	2.21	1.74
Frequency play active games with child	4.87	3.88	3.34	2.57
Frequency play indoor games with child	4.30	3.73	3.42	2.02
Frequency take child to park or playground	4.24	3.73	3.42	2.94

Notes: We derive mother's mental health, parenting style and parental engagement by using a factor analysis of the items reported above. Each of the items used for mother's mental health takes values from 1 to 5, with 1 meaning All of the time, 2 Most of the time, 3 Some of the time, 4 A little of the time, and 5 None of the time. Each items of parenting style can take values from 1 to 5 with 1 meaning Never, 2 Rarely, 3 Sometimes, 4 Often and 5 Daily. Each item of parental engagement takes values from 1 to 6 with 1 meaning Every day or almost every day, 2 Several times a week, 3 Once or twice a week, 4 Once or twice a month, 5 Less often than once a month, and 6 Not at all. We report the average of each of these items separately for values of the corresponding input (mother's mental health, parenting style or parental engagement) in the first, second, third and top quartile. Data: UK Millennium Cohort Study.

Table 5: Production model of socio-emotional skills (between age 6 and 11). Benchmark model.

	Differential effect at the higher Quartiles (2nd - 3rd - 4th) relative to the 1st Quartile of socio-emotional skills		
	(1) Girls	(2) Boys	(3) Pooled: Boys and Girls
Mother's mental health ≤ Median	-0.525***	-0.142	-0.320***
	(0.145)	(0.152)	(0.106)
Mother's mental health > Median	-1.534	-0.164	-0.974
	(1.962)	(2.077)	(1.423)
Parenting style ≤ Median	-0.194	-0.661**	-0.456**
	(0.277)	(0.282)	(0.201)
Parenting style > Median	0.160	0.221	0.177
	(0.268)	(0.361)	(0.216)
Parent engagement ≤ Median	-0.177	0.095	-0.027
	(0.223)	(0.220)	(0.159)
Parent engagement > Median	0.336	0.157	0.247
	(0.264)	(0.258)	(0.186)
Self-productivity (Internalising)	0.669***	0.855***	0.777***
	(0.077)	(0.068)	(0.051)
Self-productivity (Externalising)	0.269***	0.343***	0.310***
	(0.031)	(0.028)	(0.021)
Mean (dep variable)	1.725	1.894	1.810
SD (dep variable)	1.182	1.432	1.315
σ^2 (fixed effect)	0.492	0.464	0.475
Observations	6690	6660	13350

Notes: The dependent variable socio-emotional skills at age 11 and the explanatory variable socio-emotional skills at age 6 are both expressed in logarithm. All inputs are also measured in logarithm. The model is estimated using the child fixed effect estimation that exploits variation across internalising and externalising traits within each child and period. The empirical model is defined in equation (3). Estimated standard errors are robust to correlation in the error within child. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data: UK Millennium Cohort Study.

Table 6: Production model of socio-emotional skills (between age 6 and 11). Anchoring socio-emotional skills at age 6 and 11 to outcomes at age 14.

	No (victim) criminal behaviour		No risky behavior		Never smoke		No mental health issues		No school exclusion	
	(1) Girls	(2) Boys	(3) Girls	(4) Boys	(5) Girls	(6) Boys	(7) Girls	(8) Boys	(9) Girls	(10) Boys
Mother's mental health ≤ Median	-0.025***	0.004	-0.017***	0.002	-0.016***	0.002	-0.007*	0.003	-0.003**	-0.001
	(0.007)	(0.010)	(0.005)	(0.006)	(0.004)	(0.005)	(0.004)	(0.007)	(0.001)	(0.003)
Sensitive parenting style ≤ Median	-0.019	-0.049**	-0.017*	-0.026**	-0.016*	-0.024**	-0.002	-0.030**	-0.004	-0.021***
	(0.016)	(0.019)	(0.010)	(0.011)	(0.009)	(0.010)	(0.007)	(0.014)	(0.003)	(0.008)
Self-productivity (Internalising)	0.511***	1.681***	0.348**	-0.002	0.383***	-0.011	0.307***	0.245***	0.424***	0.291***
	(0.101)	(0.273)	(0.136)	(0.205)	(0.147)	(0.299)	(0.047)	(0.043)	(0.108)	(0.075)
Self-productivity (Externalising)	0.341***	0.546***	0.374***	0.512***	0.354***	0.547***	0.013	0.183***	0.417***	0.335***
	(0.035)	(0.055)	(0.032)	(0.041)	(0.030)	(0.044)	(0.078)	(0.051)	(0.037)	(0.039)
Mean (Probability)	0.793	0.629	0.878	0.887	0.881	0.892	0.941	0.922	0.985	0.957
SD (Probability)	0.044	0.049	0.030	0.034	0.029	0.032	0.024	0.044	0.010	0.026
σ^2 (fixed effect)	0.483	0.441	0.467	0.391	0.467	0.391	0.477	0.468	0.472	0.445
Observations	5675	5300	5669	5302	5669	5304	5428	4995	5421	4975

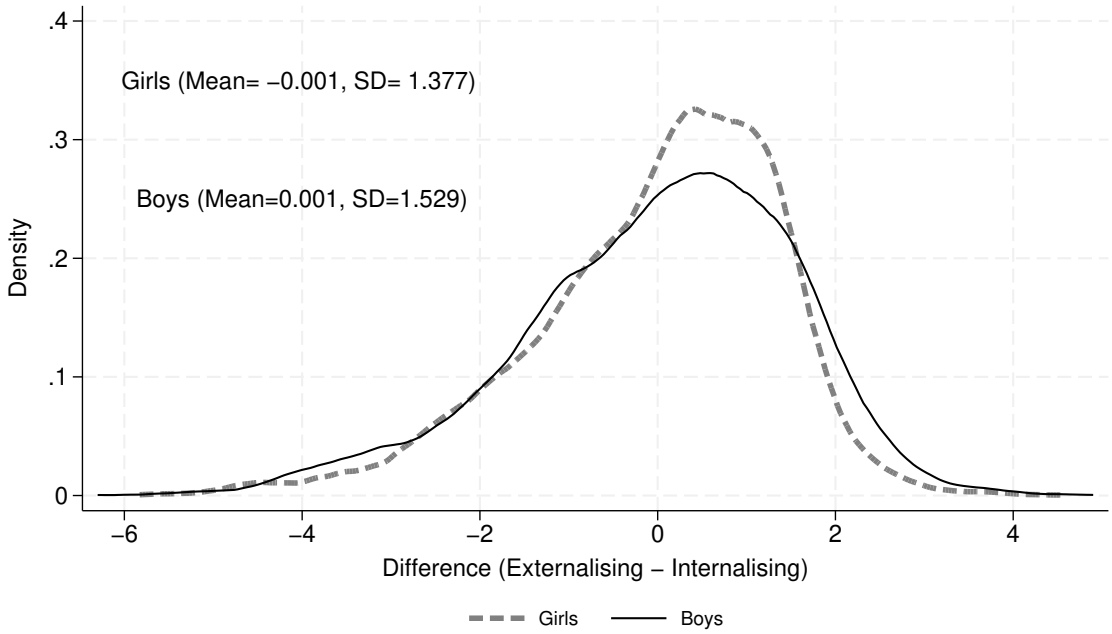
Notes: The dependent variable is the log of the anchored socio-emotional skills at age 11. The regressor socio-emotional skills at age 6 is also the log of the corresponding anchored variable. The variable 'no (victim) criminal behaviour' (Columns 1 and 2) takes value 1 if the child reports that he has never had criminal behaviour (i.e. carried a knife, being part of a street gang, being warned by the police) or has never being victim of criminal behaviour (i.e. someone been physically violent towards the child, someone hit or used a weapon against the child, someone stolen something from the child) and zero otherwise. The variable 'no risky behaviour' (Columns 3 and 4) takes value 1 if the child reports that he has never had risky behaviour (i.e. smoked, more than five drinks, consumed cannabis) and zero otherwise. The variable 'never smoke' (Columns 5 and 6) takes value 1 if the child reports that he has never smoked and zero otherwise. The variable 'no mental health issues' (Columns 7 and 8) takes value 1 if the parents report that the child does not have longstanding illnesses related to mental health, stamina, ADHD, Autism, Asperger and zero otherwise. The variable 'no school exclusion' (Columns 9 and 10) takes value 1 if the parents report that the child has never been suspended or excluded from school and 0 otherwise. All inputs are measured in logs. The model is estimated using the child fixed effect estimation. The empirical model is defined in equation (3). Estimated standard errors are robust to correlation in the error within child. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data: UK Millennium Cohort Study.

Table 7: Production model of socio-emotional skills between age 6 and 11 by gender. Heterogeneity by socio-economic background.

	Differential effects at the higher higher quartiles (2nd- 3rd - 4th) relative to the 1st Quartile of socio-emotional skills	Observations
Panel A: Girls		
Mother has low education		
Mother's mental health ≤ Median	-0.538***	4646
	(0.163)	
Mother has high education		
Mother's mental health ≤ Median	-0.493	2044
	(0.352)	
Mother occupation: routine, manual or not working		
Mother's mental health ≤ Median	-0.661***	2406
	(0.206)	
Mother occupation: intermediate or managerial		
Mother's mental health ≤ Median	-0.361*	4284
	(0.213)	
Low family income		
Mother's mental health ≤ Median	-0.423**	3330
	(0.174)	
High family income		
Mother's mental health ≤ Median	-0.585**	3360
	(0.295)	
Panel B: Boys		
Mother has low education		
Parenting style ≤ Median	-0.666**	4654
	(0.313)	
Mother has high education		
Parenting style ≤ Median	-0.691	2006
	(0.632)	
Mother occupation: routine, manual or not working		
Parenting style ≤ Median	-1.106***	2290
	(0.376)	
Mother occupation: intermediate or managerial		
Parenting style ≤ Median	-0.397	4370
	(0.388)	
Low family income		
Parenting style ≤ Median	-0.812**	3348
	(0.365)	
High family income		
Parenting style ≤ Median	-0.631	3312
	(0.424)	

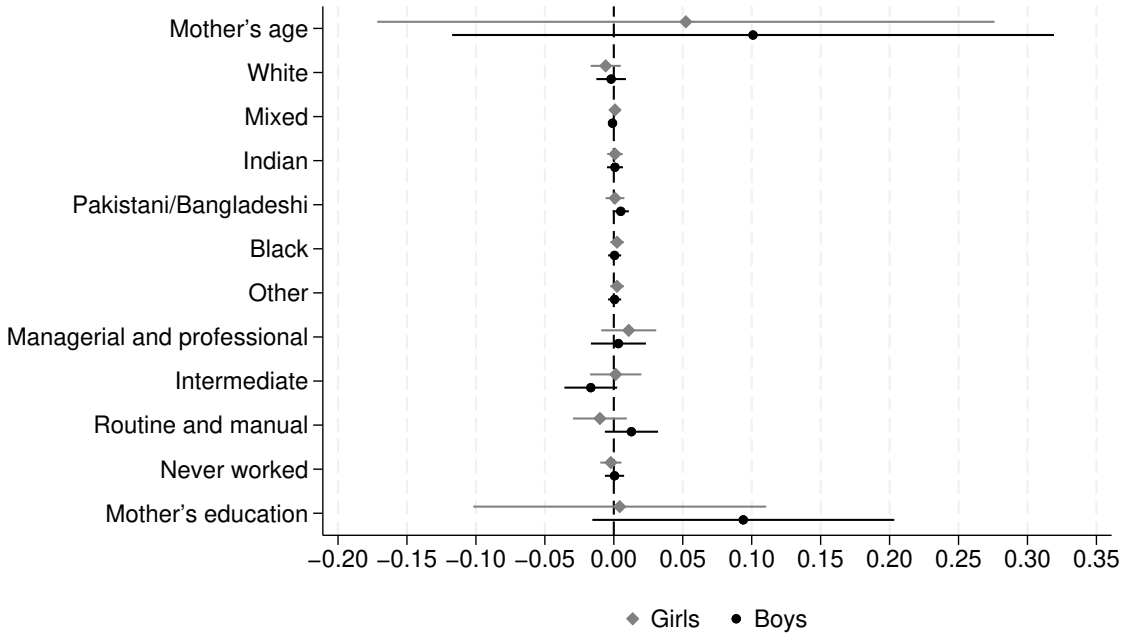
Notes: The dependent variable socio-emotional skills at age 11 and the explanatory variable socio-emotional skills at age 6 are both expressed in logarithm. All inputs are also measured in logarithm. Each row report results for a different sub-sample using the child fixed effect estimation. The empirical model is defined in equation (3). Estimated standard errors are robust to correlation in the error within child. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data: UK Millennium Cohort Study.

Figure 1: Distribution of the difference between internalising and externalising skills, by gender



Notes: The figure shows the kernel density (epanechnikov, bandwidth=1) of the within-child difference between externalising and internalising skills (latent factor) by gender. The means are -0.001 and 0.001 among girls and boys respectively, with no statistical difference by gender (p-value of 0.921, for the test of equivalence between the two means by gender). A positive within-child difference indicates that a child has higher externalising skills than internalising. A negative within-child difference indicates that a child has higher internalising than externalising skills. This means that children on the left tail are children with extreme low values of externalising skills (relative to internalising), whereas children on the right tale are children with extreme low values of internalising skills (relative to externalising).

Figure 2: Difference in average characteristics between children at the extremes tails of Figure 1 and children in the full estimation sample



Notes: Mother's age and mother's education are continuous variables whilst all the other variables are dummy variables. The figure reports the difference in the pre-determined demographic characteristics between the sub-sample of children in the extreme tails (the bottom quartile and top quartile) of the distribution of the within-child difference between externalising and internalising skills reported in Figure 1 and the full estimation sample, separately by gender. Bars indicate 95% confidence interval. None of the differences is statistically significant at 95% level.

A Appendix

Table A.1: Comparison of demographic characteristics between original and estimation sample

	Original sample (unweighted)		Original sample (weighted)		Estimation sample	
	(1) Mean	(2) SD	(3) Mean	(4) SD	(5) Mean	(6) SD
Equivalised income	387.346 [383.081 391.611]	232.435	425.564 [420.115 431.013]	244.178	462.555 [457.077 468.033]	228.299
Mother's age	36.393 [36.285 36.500]	5.869	36.975 [36.854 37.096]	5.696	37.083 [36.956 37.210]	5.301
Mother's education	17.771 [17.723 17.820]	2.626	17.910 [17.854 17.966]	2.601	18.122 [18.060 18.184]	2.590
Ethnic group						
White	0.859 [0.853 0.866]	0.348	0.906 [0.901 0.912]	0.291	0.926 [0.920 0.932]	0.262
Mixed	0.008 [0.006 0.010]	0.089	0.007 [0.005 0.009]	0.084	0.005 [0.003 0.006]	0.069
Indian	0.026 [0.023 0.029]	0.161	0.019 [0.016 0.022]	0.137	0.019 [0.016 0.023]	0.138
Pakistani Bangladeshi	0.061 [0.056 0.065]	0.240	0.034 [0.031 0.037]	0.181	0.025 [0.021 0.029]	0.156
Black	0.029 [0.026 0.032]	0.168	0.021 [0.018 0.024]	0.144	0.014 [0.011 0.017]	0.118
Other	0.016 [0.014 0.018]	0.126	0.012 [0.010 0.014]	0.110	0.011 [0.008 0.013]	0.104
Observations	11411		11411		6675	

Notes: Column (1-2) reports the Mean and SD of the variables in the original sample without using weights. Column (3-4) reports the mean and SD of the variables in the original sample using the MCS sampling weights to account for the MCS sample design that over-represents disadvantaged individuals. Column (5-6) reports the mean and SD of the variables in our estimation sample. 95% Confidence intervals are reported in brackets. Data: UK Millennium cohort Study.

Table A.2: Factor loadings of child's skills, by type, age - By gender

	(1) Factor Loadings	(2) Signal
Panel A: Socio-emotional skills - Boys		
Internalising behaviour		
Peer score (age 5)	1.000	0.457
Peer score (age 7)	1.105	0.485
Emotional score (age 5)	0.934	0.340
Emotional score (age 7)	1.123	0.398
Externalising behaviour		
Hyperactivity score (age 5)	1.000	0.636
Hyperactivity score (age 7)	1.094	0.667
Conduct score (age 5)	0.482	0.394
Conduct score (age 7)	0.512	0.412
Internalising behaviour		
Peer score (age 11)	1.000	1.000
Emotional score (age 11)	0.525	0.205
Externalising behaviour		
Hyperactivity score (age 11)	1.000	1.000
Conduct score (age 11)	0.341	0.308
Panel B: Socio-emotional skills - Girls		
Internalising behaviour		
Peer score (age 5)	1.000	0.391
Peer score (age 7)	1.026	0.368
Emotional score (age 5)	1.149	0.376
Emotional score (age 7)	1.304	0.403
Externalising behaviour		
Hyperactivity score (age 5)	1.000	0.605
Hyperactivity score (age 7)	1.103	0.638
Conduct score (age 5)	0.491	0.385
Conduct score (age 7)	0.497	0.402
Internalising behaviour		
Peer score (age 11)	1.000	1.000
Emotional score (age 11)	0.528	0.213
Externalising behaviour		
Hyperactivity score (age 11)	1.000	1.000
Conduct score (age 11)	0.309	0.240
Panel C: Cognitive skills - Boys		
BAS: Picture similarities	1.000	0.220
BAS: Reading abilities	1.430	0.249
BAS: Pattern construction	2.418	0.445
NFER: Maths test	0.369	0.484
BAS: Reading abilities	3.492	0.336
BAS: Pattern construction	2.117	0.442
Panel D: Cognitive skills - Girls		
BAS: Picture similarities	1.000	0.215
BAS: Reading abilities	1.445	0.271
BAS: Pattern construction	2.126	0.401
NFER: Maths test	0.356	0.503
BAS: Reading abilities	2.909	0.301
BAS: Pattern construction	2.079	0.479

Notes: Column (1) reports the factor loadings for each measure. Column (2) indicates for each of the measures the fraction of the variance explained by the latent. Data: UK Millennium cohort Study.

Table A.3: Factor loadings of parental inputs

	(1) Factor Loadings	(2) Signal
Mother's mental health		
How often felt depressed in last 30 days	1.000	0.630
How often felt hopeless in last 30 days	0.980	0.708
How often felt restless in last 30 days	0.827	0.367
How often felt everything an effort in last 30 days	1.036	0.471
How often felt worthless in last 30 days	0.951	0.625
How often felt nervous in last 30 days	0.751	0.312
Parenting style		
How often tells child off when naughty	1.000	0.507
How often smacks at child when naughty	0.468	0.173
How often shouts at child when naughty	0.976	0.426
How often sends child to bedroom/naughty chair	0.980	0.391
How often takes away treats from child when naughty	0.879	0.376
How often bribes at child when naughty	0.519	0.104
How often ignores at child when naughty	0.679	0.156
Parent engagement		
Frequency draw and paint with child	1.000	0.378
Frequency tell stories to child	0.954	0.195
How often does musical activities with child	0.872	0.189
Frequency play active games with child	1.069	0.341
Frequency play indoor games with child	1.082	0.440
Frequency take child to park or playground	0.613	0.160
Mother's internalising skills		
I get overwhelmed by emotions	1.000	0.444
I get caught up in my problems	0.960	0.476
I bottle up my feelings	-0.845	0.286
I am a very private person	-0.509	0.118
Mother's externalising skills		
I grumble about things	1.000	0.330
I get angry easily	1.109	0.420
I take offence easily	0.867	0.252
Father's internalising skills		
I get overwhelmed by emotions	1.000	0.255
I get caught up in my problems	1.359	0.458
I bottle up my feelings	-1.276	0.315
I am a very private person	-0.800	0.141
Father's externalising skills		
I grumble about things	1.000	0.295
I get angry easily	1.143	0.442
I take offence easily	0.827	0.248

Notes: Column (1) reports the factor loadings for each measure. Column (2) indicates for each of the measures the fraction of the variance explained by the latent. Data: UK Millennium cohort Study, Main Sample.

Table A.4: Switchers - Transition matrix of socio-emotional skills at age 6, by gender

Panel A: Girls					
	Externalising Skills age 6 - Quartile				
Internalising Skills age 6 - Quartile	Q=1	Q=2	Q=3	Q=4	Total
Q=1	43.333	25.714	20.238	10.714	100.000
Q=2	26.216	26.097	26.809	20.878	100.000
Q=3	17.360	24.376	30.321	27.943	100.000
Q=4	13.276	23.873	28.989	33.861	100.000
Panel B: Boys					
	Externalising Skills age 6 - Quartile				
Internalising Skills age 6 - Quartile	Q=1	Q=2	Q=3	Q=4	Total
Q=1	46.523	26.739	16.787	9.952	100.000
Q=2	24.224	28.162	26.969	20.644	100.000
Q=3	17.312	27.482	29.419	25.787	100.000
Q=4	12.139	20.553	31.611	35.697	100.000

Notes: The table shows the transition matrix between the trait-specific quartiles of socio-emotional skills at age 6, by gender. Data: UK Millennium Cohort Study.

Table A.5: Production model of socio-emotional skills (between age 6 and 11). Testing invariance of the differential productivity of mother's mental health and parenting style across socio-emotional traits

	Differential effects at the higher quartiles (2nd- 3rd - 4th) relative to the 1st Quartile of socio-emotional skills
Panel A: Girls	
Externalising	
Mother's mental health ≤ Median	-0.659***
	(0.178)
Self persistence (Externalising)	0.304***
	(0.037)
Internalising	
Mother's mental health ≤ Median	-0.579***
	(0.165)
Self persistence (Internalising)	0.614***
	(0.094)
Observations	6690
Panel B: Boys	
Externalising	
Parenting style ≤ Median	-0.755**
	(0.327)
Self-productivity (Externalising)	0.234***
	(0.033)
Internalising	
Parenting style ≤ Median	-1.221***
	(0.293)
Self-productivity (Internalising)	0.877***
	(0.080)
Observations	6660

Notes: The dependent variable socio-emotional skills at age 11 and the explanatory variable socio-emotional skills at age 6 are both expressed in logarithm. All inputs are also measured in logarithm. The model is estimated using the child fixed effect estimation. The empirical model is defined in equation (3) but allowing the differential elasticity $\beta_{k,1}^{LowI}$ to vary between internalising and externalising. $\beta_{k,1}^{LowI}$ does not change significantly between internalising and externalising when considering mother's metal health for girls (p-value is 0.419) but it does when considering parenting style for boys (p-value 0.011). Estimated standard errors are robust to correlation in the error within child. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data: UK Millennium Cohort Study.

Table A.6: Production model of socio-emotional skills (between age 6 and 11). Testing invariance of additional inputs across socio-emotional traits

	(1) Girls	(2) Boys	(3) Girls	(4) Boys	(5) Girls	(6) Boys	(7) Girls	(8) Boys	(9) Girls	(10) Boys
Mother's mental health ≤ Median	-0.521***	-0.143	-0.523***	-0.133	-0.525***	-0.149	-0.525***	-0.131	-0.524***	-0.137
	(0.145)	(0.152)	(0.144)	(0.152)	(0.145)	(0.151)	(0.145)	(0.153)	(0.145)	(0.151)
Parenting style ≤ Median	-0.187	-0.665**	-0.186	-0.653**	-0.190	-0.655**	-0.193	-0.664**	-0.206	-0.679**
	(0.277)	(0.282)	(0.276)	(0.282)	(0.277)	(0.281)	(0.277)	(0.283)	(0.276)	(0.283)
Self-productivity (Internalising)	0.678***	0.858***	0.672***	0.862***	0.670***	0.857***	0.668***	0.864***	0.674***	0.865***
	(0.077)	(0.068)	(0.077)	(0.068)	(0.077)	(0.068)	(0.077)	(0.068)	(0.077)	(0.068)
Self-productivity (Externalising)	0.264***	0.339***	0.272***	0.343***	0.272***	0.337***	0.271***	0.337***	0.267***	0.339***
	(0.031)	(0.028)	(0.031)	(0.028)	(0.032)	(0.028)	(0.032)	(0.028)	(0.032)	(0.028)
Invariance across observables										
Mother's age										
Mother's age × Internalising problems=0	0.010*	0.007								
	(0.006)	(0.006)								
Mother's ethnicity										
White=1 × Internalising problems=0			-0.147	-0.213						
			(0.263)	(0.260)						
Mixed=1 × Internalising problems=0			0.850*	0.066						
			(0.507)	(0.393)						
Indian=1 × Internalising problems=0			-0.259	-0.143						
			(0.304)	(0.318)						
Pakistani Bangladeshi=1 × Internalising problems=0			-0.151	-0.644**						
			(0.320)	(0.318)						
Black=1 × Internalising problems=0			0.017	-0.607*						
			(0.328)	(0.330)						
Other=1 × Internalising problems=0										
Baseline category										
Mother's education										
Mother's education × Internalising problems=0					-0.151	0.408*				
					(0.206)	(0.211)				
Mother's occupation										
Managerial and professional=1 × Internalising problems=0									0.196	0.339*
									(0.173)	(0.191)
Intermediate=1 × Internalising problems=0									0.254	0.335*
									(0.174)	(0.192)
Routine and manual=1 × Internalising problems=0									0.172	0.258
									(0.174)	(0.191)
Never worked=1 × Internalising problems=0										
Baseline category										
Family income										
Internalising problems=0 × Family income							-0.015	0.131**		
							(0.053)	(0.055)		
σ^2 (fixed effect)	0.493	0.463	0.492	0.461	0.490	0.464	0.492	0.464	0.492	0.463
Observations	6690	6660	6690	6660	6690	6660	6690	6660	6690	6660

Notes: The dependent variable socio-emotional skills at age 11 and the explanatory variable socio-emotional skills at age 6 are both expressed in logarithm. All inputs are also measured in logarithm. Each column extend our benchmark model (3) by including extra inputs and allowing the effect of such inputs to differ across internalising and externalising. All models are estimated using the child fixed effect estimation so we are able to identify only the differential effect of each additional input for externalising relative to internalising. Estimated standard errors are robust to correlation in the error within child. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data: UK Millennium Cohort Study.

Table A.7: Production model of socio-emotional skills (between age 6 and 11), by gender. Additional inputs.

	Differential effect at the higher Quartiles (2nd -3rd- 4th) relative to the 1st Quartile of socio-emotional skills	
	(1) Girls	(2) Boys
Mother's mental health ≤ Median	-0.509***	-0.165
	(0.149)	(0.154)
Parenting style ≤ Median	-0.238	-0.635**
	(0.277)	(0.282)
Family Income ≤ Median	0.215	0.195
	(0.193)	(0.189)
Family Income > Median	0.114	0.030
	(0.387)	(0.383)
Mother's education ≤ Median	0.051	-2.048
	(2.168)	(1.778)
Mother's education > Median	0.180	-0.076
	(0.932)	(0.877)
Child's cognitive skills ≤ Median	-0.003	0.028
	(0.031)	(0.027)
Child's cognitive skills > Median	0.024	0.016
	(0.050)	(0.045)
Self-productivity (Internalising)	0.672***	0.846***
	(0.077)	(0.068)
Self-productivity (Externalising)	0.270***	0.340***
	(0.031)	(0.028)
σ^2 (fixed effect)	0.504	0.847
Observations	6690	6660

Notes: The dependent variable socio-emotional skills at age 11 and the explanatory variable socio-emotional skills at age 6 are both expressed in logarithm. All inputs are also measured in logarithm. The empirical model is defined in equation (3) but including additional inputs. The model is estimated using the child fixed effect estimation. Estimated standard errors are robust to correlation in the error within child. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data: UK Millennium Cohort Study.

Table A.8: Production model of socio-emotional skills (between age 6 and 11). Controlling additionally for mother's and father's trait-specific socio-emotional skills

	Differential effect at the higher Quartiles (2nd -3rd- 4th) relative to the 1st Quartile of socio-emotional skills	
	(1) Girls	(2) Boys
Mother's mental health ≤ Median	-0.554***	-0.103
	(0.181)	(0.168)
Parenting style ≤ Median	-0.252	-0.774**
	(0.309)	(0.320)
Self-productivity (Internalising)	0.696***	0.864***
	(0.084)	(0.072)
Self-productivity (Externalising)	0.279***	0.338***
	(0.035)	(0.030)
Mother's Socio-emotional skills	-0.008	0.093
	(0.066)	(0.069)
Father's Socio-emotional skills	0.075	0.107
	(0.074)	(0.078)
σ^2 (fixed effect)	0.470	0.473
Observations	5484	5616

Notes: The dependent variable socio-emotional skills at age 11 and the explanatory variable socio-emotional skills at age 6 are both expressed in logarithm. All parental inputs are also measured in logarithm. The empirical model is defined in equation (3) but additionally controls for mothers' and fathers' trait-specific socio-emotional skills, which we measure using neuroticism for internalising and extroversion for externalising. The model is estimated using the child fixed effect estimation. Estimated standard errors are robust to correlation in the error within child. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data: UK Millennium Cohort Study, subsample with details on mother's and father's trait specific socio-emotional skills.

Table A.9: Production model of socio-emotional skills between age 6 and 11. Combining mother's and teacher's reports to measure child socio-emotional skills

	Differential effect at the higher Quartiles (2nd -3rd- 4th) relative to the 1st Quartile of socio-emotional skills	
	(1) Girls	(2) Boys
Mother's mental health ≤ Median	-0.481***	-0.215
	(0.183)	(0.174)
Parenting style ≤ Median	-0.371	-0.674*
	(0.373)	(0.368)
Self-productivity (Internalising)	0.865***	1.240***
	(0.205)	(0.125)
Self-productivity (Externalising)	0.165***	0.358***
	(0.059)	(0.044)
σ^2 (fixed effect)	0.522	0.448
Observations	4547	4576

Notes: The dependent variable socio-emotional skills at age 11 and the explanatory variable socio-emotional skills at age 6 are both expressed in logarithm. All inputs are also measured in logarithm. The empirical model is defined in equation (3). The model is estimated using the child fixed effect estimation. Estimated standard errors are robust to correlation in the error within child. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data: UK Millennium Cohort Study, subsample with details on teacher's reports of socio-emotional skills.

Table A.10: Production model of socio-emotional skills between age 6 and 11 by gender. Aggregate measure of stressful home environment (ACE).

	Differential effect at the higher Quartiles (2nd -3rd- 4th) relative to the 1st Quartile of socio-emotional skills	
	(1) Girls	(2) Boys
ACE ≤ Median	-0.422*	-0.508*
	(0.252)	(0.262)
Self-productivity (Internalising)	0.674***	0.857***
	(0.076)	(0.068)
Self-productivity (Externalising)	0.267***	0.346***
	(0.031)	(0.028)
σ^2 (fixed effect)	0.438	0.452
Observations	6690	6660

Notes: The dependent variable socio-emotional skills at age 11 and the explanatory variable socio-emotional skills at age 6 are both expressed in logarithm. The aggregate measure of stressful home environment ACE is the average of the two main inputs (mother's mental health and parenting style) and also expressed in logarithm. The ACE measure is coded so that low levels translate into low parental investments (high adverse experiences) and is included in our model (3) in place of the separate parental inputs. The model is estimated using the child fixed effect estimation. Estimated standard errors are robust to correlation in the error within child. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data: UK Millennium Cohort Study.

Table A.11: Production model of socio-emotional skills between age 6 and 11 by gender. Defining low inputs using different thresholds.

	Differential effects at the higher quartiles (2nd- 3rd - 4th) relative to the 1st Quartile of socio-emotional skills
Panel A: Girls	
Mother's mental health ≤ Q1	-0.548**
	(0.213)
Observations	6690
Mother's mental health ≤ Median	-0.525***
	(0.145)
Observations	6690
Mother's mental health ≤ Q3	-0.304***
	(0.116)
Observations	6690
Panel B: Boys	
Parenting style ≤ Q1	0.120
	(0.476)
Observations	6660
Parenting style ≤ Median	-0.661**
	(0.282)
Observations	6660
Parenting style ≤ Q3	-0.372*
	(0.201)
Observations	6660

Notes: The dependent variable socio-emotional skills at age 11 and the explanatory variable socio-emotional skills at age 6 are both expressed in logarithm. All inputs are also measured in logarithm. Each panel report the estimation results for model (3) using the child fixed effect estimation, but adopting different thresholds to define low inputs (below the first quartile, the median, and the third quartile). Estimated standard errors are robust to correlation in the error within child. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data: UK Millennium Cohort Study.

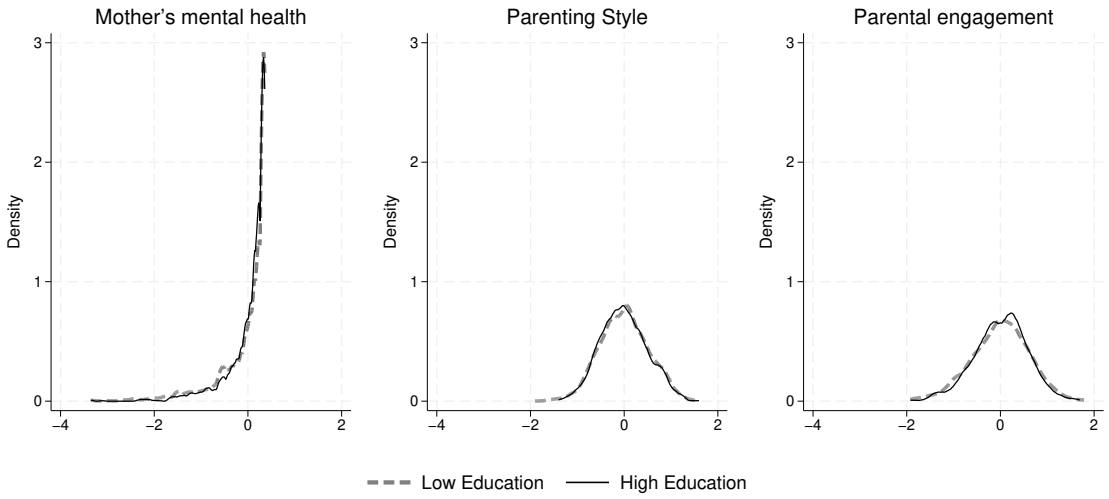
Table A.12: Production model of socio-emotional skills (between age 6 and 11). Allowing for differences across the three top quartiles of socio-emotional skills.

	Differential effect at the 2nd Quartile	3rd Quartile	4th Quartile	Test equality coeffi-cients
	relative to the 1st Quartile of socio-emotional skills			p-value
	(1)	(2)	(3)	(4)
Panel A:Girls				
Mother's mental health ≤ Median	-0.510***	-0.628***	-0.504***	0.826
	(0.150)	(0.186)	(0.188)	
Mother's mental health > Median	-1.136	-1.640	-2.076	0.654
	(2.154)	(2.168)	(2.086)	
Parenting style ≤ Median	0.034	-0.352	-0.537	0.512
	(0.337)	(0.360)	(0.365)	
Parenting style > Median	0.110	0.130	0.298	0.274
	(0.301)	(0.290)	(0.283)	
Parent engagement ≤ Median	-0.184	-0.047	-0.339	0.640
	(0.251)	(0.256)	(0.259)	
Parent engagement > Median	0.256	0.323	0.450	0.407
	(0.288)	(0.279)	(0.290)	
Self-productivity (Externalising)		0.269***		
(1st Quartile)		(0.058)		
Self-productivity (Internalsing)		0.681***		
(1st Quartile)		(0.113)		
σ^2 (fixed effect)		0.490		
Observations		6690		
Panel B:Boys				
Mother's mental health ≤ Median	-0.251	0.108	-0.324	0.026
	(0.180)	(0.163)	(0.255)	
Mother's mental health > Median	-2.588	1.579	0.959	0.080
	(2.292)	(2.277)	(2.231)	
Parenting style ≤ Median	-0.462	-0.938***	-0.839**	0.441
	(0.322)	(0.332)	(0.344)	
Parenting style > Median	0.162	0.200	0.417	0.288
	(0.396)	(0.383)	(0.379)	
Parent engagement ≤ Median	0.117	0.042	0.198	0.397
	(0.244)	(0.240)	(0.250)	
Parent engagement > Median	0.229	0.267	-0.017	0.683
	(0.284)	(0.301)	(0.304)	
Self-productivity (Externalising)		0.361***		
(1st Quartile)		(0.058)		
Self-productivity (Internalising)		0.907***		
(1st Quartile)		(0.100)		
σ^2 (fixed effect)		0.456		
Observations		6660		

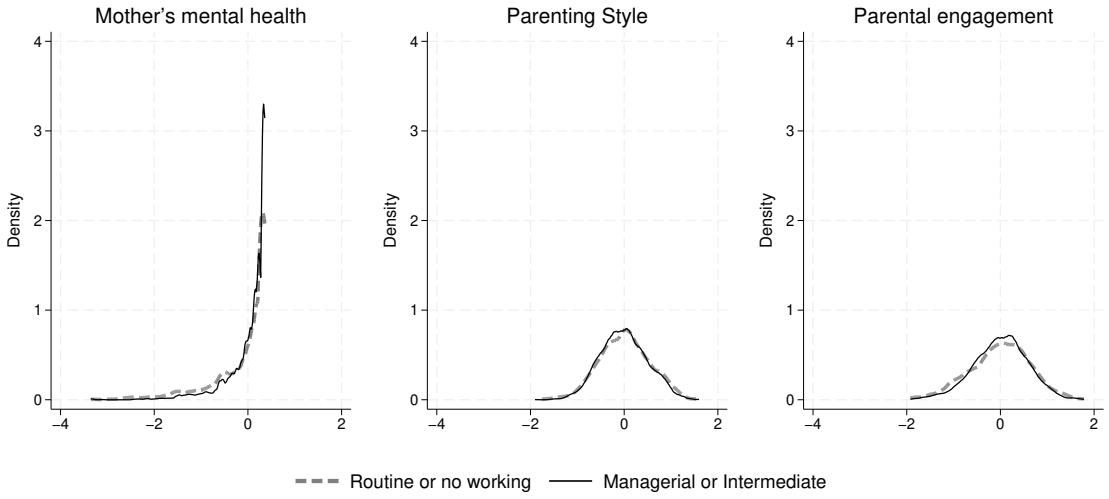
Notes: The dependent variable socio-emotional skills at age 11 and the explanatory variable socio-emotional skills at age 6 are both expressed in logarithm. All inputs are measured in logarithm. The empirical model is defined in equation (3) but allows the differential elasticities $\beta_{k,1}^{LowI}$ and $\beta_{k,1}^{HighI}$ and the self-productivity to change across the three top quartiles relative to the first quartile. Column 4 reports the p-value for the test of equality of the coefficients across the three top quartiles. The model is estimated using the child fixed effect estimation. Estimated standard errors are robust to correlation in the error within child. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Data: UK Millennium Cohort Study.

Figure A.1: Distribution of inputs by mother's level of education

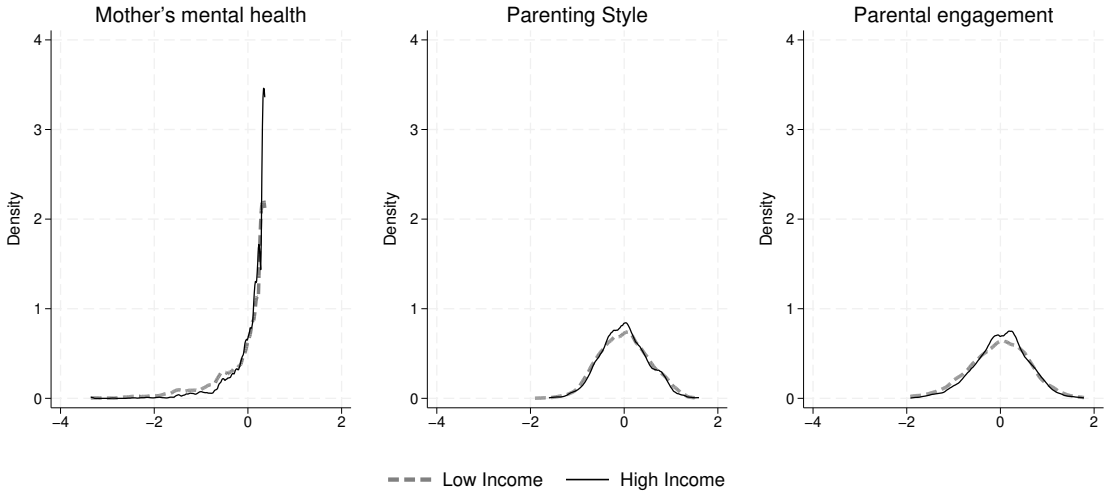
(a) Mother's level of education



(b) Mother's occupation

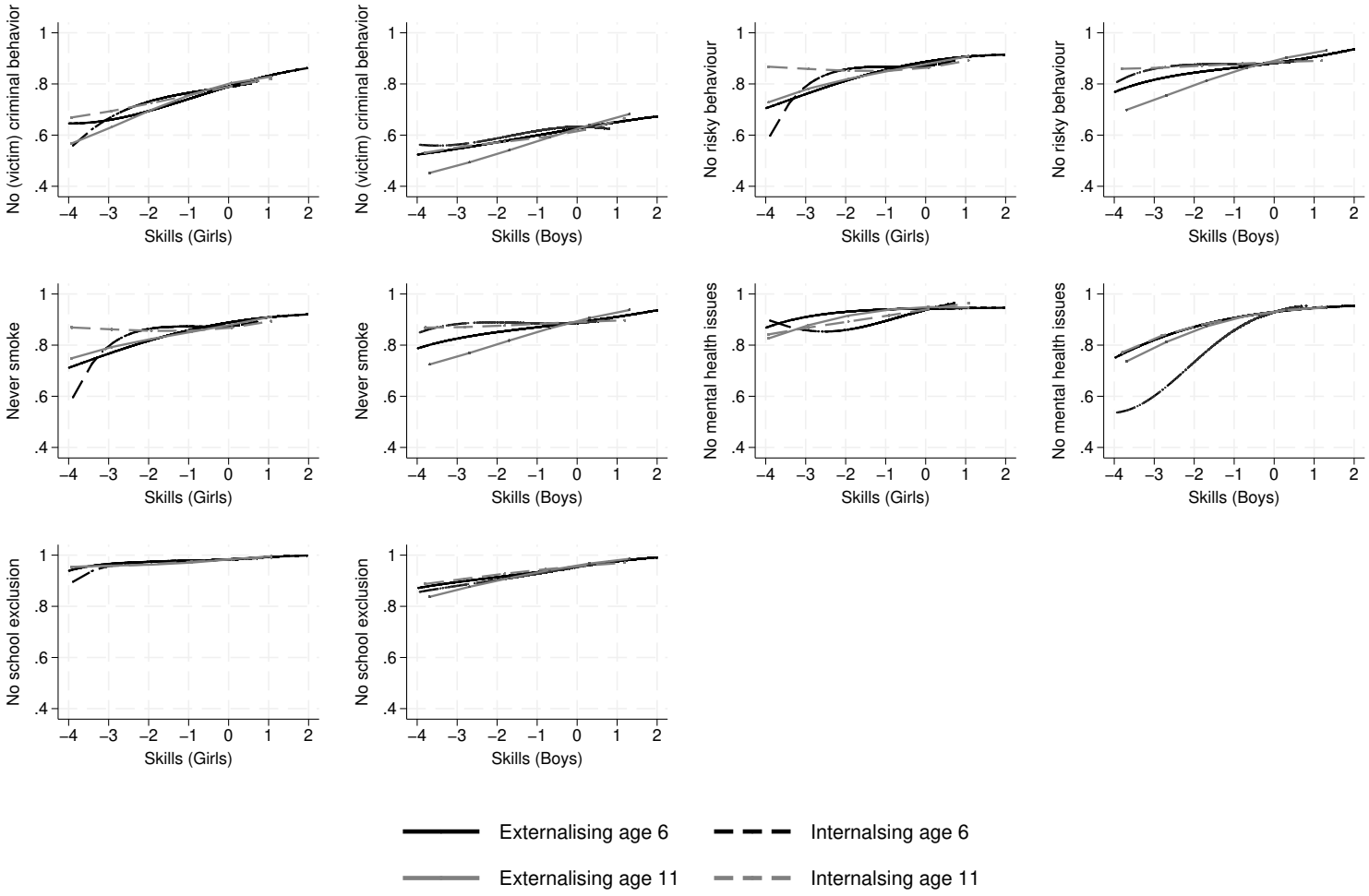


(c) Family income



Notes: The figures show the kernel density (epanechnikov, bandwidth=1) of parental inputs (latent factor) by mother's level of education (Panel A), mother's occupation (Panel B), family income (Panel C).

Figure A.2: Predicted probabilities of anchoring dummy variables against internalising and externalising traits at age 6 and 11 by gender



Notes: The relationships between the dummy variables for (1) no (victim) criminal behaviour, (2) no risky behaviour, (3) never smoke, (4) no mental health issues, (5) no school exclusions, and the internalising and externalising traits are estimated using a polynomial whose order is chosen testing the significance of the coefficients in successively larger order polynomials. The variable 'no (victim) criminal behaviour' takes value 1 if the child reports that he has never had criminal behaviour (i.e. carried a knife, being part of a street gang, being warned by the police) or has never being victim of criminal behaviour (i.e. someone been physically violent towards the child, someone hit or used a weapon against the child, someone stolen something from the child) and zero otherwise. The variable 'no risky behaviour' takes value 1 if the child reports that he has never had risky behaviour (i.e. smoked, more than five drinks, consumed cannabis) and zero otherwise. The variable 'never smoke' takes value 1 if the child reports that he has never smoked and zero otherwise. The variable 'no mental health issues' takes value 1 if the parents report that the child does not have longstanding illnesses related to mental health, stamina, ADHD, Autism, Asperger and zero otherwise. The variable 'no school exclusion' takes value 1 if the parents report that the child has never been suspended or excluded from school and 0 otherwise. Because the observations of internalising and externalising traits are very sparsely distributed in the tails, we drop few observations in the right and left extremes which reduces the sample size by less than 5%.

”””_”””__