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Abstract

This paper uses the data on child development collected around the evaluation of a nursery program to estimate the details of the process of human development. We model development as made of three latent factors, reflecting health, cognitive and socio-emotional skills. We observe children from age 1 to age 7. We assume that, at each age, these factors interact among themselves and with a variety of other inputs to determine the level of development at following ages. The richness of the data we use allows us to: (i) let the dynamics be rich and flexible; (ii) let each factors play a role in the production of any other factor; (iii) estimate age-specific functional forms; (iv) treat parental investment as an endogenous input. We show that considering parental investment as endogenous affects the estimated level of its productivity. Furthermore, we find that the dynamics of the process can be richer than usually assumed, which determines the degree of persistence of different inputs in time. Persistence also changes with age. The way the productivity of different inputs and the persistence of the process change with age have important implications for the targeting of investment and interventions, and, therefore, the identification of *windows of opportunities*.

JEL classification: I15, I25, I32, J13, J24, O15.

Keywords: Child development, Human capital, Dynamic production function, Parental investment, Cognitive skills, Health, Socio-emotional skills, Development.

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1 Introduction

It is well established that human capital constitutes an important factor of production and development. Fostering the process of human capital development can be crucial for growth and economic prosperity. From the point of view of poor families, the development of human capital can be an important factor in breaking the intergenerational transmission of poverty and poverty traps. The process through which individuals acquire different skills in the first part of the life cycle is very important in determining the level of inequality observed in a given society.

The characterization of the process of human development is therefore important. Over the last few decades, we have learned much about this process. For instance, we know that what happens in the early years is particular important for long term outcomes.[1] At the same time, it is now pretty much accepted that human capital is a multidimensional object. Its different domains are important both for the different roles they play in the process of development and as final outcomes, as they are related to different aspects of well-being and their combination determines the remuneration individuals get in the labour market.

However, there are still many aspects of human capital formation that are not fully understood. In particular, we still have an imprecise idea about the dynamic properties of such a process, and how they vary during the first few years of life. In particular, the degree of persistence of various dimensions of human capital and the role they play in the growth process is still not characterized completely. Researchers often assume that the process is of the Markov type, so that outcomes at age $a + 1$, after conditioning for outcomes at age a, do not depend on previous realizations of the process. While this assumption is often made for convenience and for the lack of accurate data, it is not an innocuous assumption. Deviations from a Markov process could explain, for instance, the fade-out in the impact of some intervention, followed by a subsequent re-emergence of the impacts. More generally, a flexible dynamic specification might be key in the identification of important ages in the process of development and *windows of opportunities* for specific interventions.

How different dimensions of development interact in the process of formation and how they can be affected by external factors is also key for the design of appropriate policies and for the identification of the role played by different inputs in the process. A comprehensive characterization of these causal links might be of extreme importance to

[1] See Almond and Currie (2011) for a review of the literature.

set the basis for the design of interventions that improve child development in deprived contexts. If one were to establish that certain skills can be influenced by specific factors at a particular age, and that those skills play an important role in the process of human capital formation, interventions that target those specific skills at that age should be the focus of policies that intend to foster child development.

In recent years, several studies have developed this research agenda. In a seminal paper, Cunha, Heckman, and Schennach (2010) specify a model of child development where different dimensions of human capital depend of past realizations of the process and some additional inputs, both observables and unobservables. Importantly, Cunha, Heckman, and Schennach (2010) allow the possibility that some variables of interest in the theoretical model are not observable. Researchers, however, have access to noisy signals of these latent variables of interest. Cunha, Heckman, and Schennach (2010) show the conditions under which such a model is non-parametrically identifiable. In their benchmark specification, they consider a flexible specification for the functional form that links the various components of the process and allow some inputs to be chosen by certain agents (such as parents) and therefore being related to unobservable variables.

The explicit recognition of the existence of measurement error proposed by Cunha, Heckman, and Schennach (2010) is important for several reasons. Such an approach spells out explicitly the assumptions about the available measures that permit to map observable variables into concepts that are relevant for the questions researchers are asking. It provides an effective way to use all the available measures to obtain efficient estimates of the parameters of interest. Furthermore, it allows to choose a metric for measurement, making the aggregate of a set of measures comparable over time and, possibly, across contexts.

Attanasio, Meghir, and Nix (2020) develop Cunha, Heckman, and Schennach (2010)'s contribution and explore alternative specification of the estimation procedure to analyse the development of children in India, using the Young Lives data. In addition to specifying a simpler and more flexible estimation procedure, they pay particular attention to the potential endogeneity of parental investment. Attanasio, Meghir, Nix, and Salvati (2017) also use the Young Lives data, but for Peru and Ethiopia. They use the innovations introcuced by Attanasio, Meghir, and Nix (2020) to explore the implication of alternative functional forms for the process of child development.

Attanasio, Cattan, Fitzsimons, Meghir, and Rubio-Codina (2020) apply the same methods and use the model they estimate, which includes the production function of human capital and parental behaviour, to interpret the evaluation findings of an early childhood intervention in Colombia.[2] Their paper develops at a more formal level the mediation analysis proposed by Heckman, Pinto, and Savelyev (2013).

More recently, Agostinelli and Wiswall (2016a,b), have considered the issue of the metric to be used when modelling child development over different ages and stressed the risk of making strong assumptions in this respect. Repeated normalisations for the same factors at different ages may lead to important biases in the estimates of the exogenous growth process of child development (the equivalent of exogenous technical progress in a production function). In this paper, we address these normalization issue explicitly, as we are considering an extended time period of the early life cycle. As we discuss below, we have to be explicit about the normalization issues even because we do not have the same measures of child development available at all ages.

One of the reasons for the limited evidence on the dynamic properties of the process of human capital formation is the paucity of rich data that would allow researchers to identify the dynamic interactions among the various dimensions of human development, both during the early years and in subsequent periods. Moreover, one of the challenges researchers face even when longitudinal data are available, lies in the fact that available measures vary with children's age, so that the direct comparison and modelling interactions between different dimensions of development is not trivial. In this paper, we exploit the availability of a rich longitudinal data set that follows children every year from age 1 to age 7. At each age, several measures related to different dimensions of development are available. In what follows, we discuss the methodological problems we face to combine effectively this wealth of measures and how we tackle this problem.

This paper makes some original contributions to the literature that tries to quantify the process of child development. First, the fact that we have access to a set of high quality measures about several dimensions of child development covering a relatively long period of time at an annual frequency allows us to estimate processes of human capital formation in the early years that are much dynamically richer than those so far analysed in the literature. In particular, we are not forced to impose a Markov structure on the process, and we can allow for several lags to be relevant at different points in time.

[2]Interestingly, they notice that, while the intervention was randomly allocated across a number of localities and evidently influenced parental investment, it cannot be used in their context to identify the causal link between parental investment and child development. Indeed that paper tries to identify the origin of the observed impact of the intervention and concludes that it has worked mainly by increasing parental investment. Posing this question cannot rule out that the intervention has a direct impact on child development.

Second, the fact that we have high quality information on several dimensions of child development allows us to study possible interactions among these dimensions and their effect in the process of human capital accumulation. Third, we also model the impacts of parental investment and estimate a rich and holistic process of child development that is of special utility in the design of early child development policies. A complete characterisation of the process allows us to identify *windows of opportunities* that can be of particular relevance for policy. The fact that we can model the impact of parental investment and establish its medium run effects tells us at what ages policies aimed at improving parental practices should be targeted. As we discuss below, this is relevant for at least two reasons: parental investment may particularly effective at specific ages and, given its short run effectiveness, its medium run impacts depend on the dynamic features of the process. We show that it is better to improve parental investment when is most effective and just before the persistence of the process of development increases.

The paper also makes a small but important methodological contribution. Because for some particular skills we do not have a single measure available for all ages covered by our data, we need to link different measures over time. This involves some issues with the normalisation of the parameters of the measurement system we estimate below. Given the importance of the dynamics of the process for the results we discuss, these issues are particularly important.

The rest of this paper is structured as follows. Section 2 presents our model for the production of cognitive skills, socio-emotional skills, and health over the child's life-cycle, and describe how we deal with the endogeneity of parental investments. In that section, we also discuss in detail the dynamic properties of the process, paying particular attention to the issues of persistence and non-stationarity. Section 3 describes the latent factor approach that we use to aggregate the available information and take care of measurement error in the data. We pay particular attention to the issues related with the normalisation of the parameters of the measurement system, and propose a methodology to solve those issues. Section 4 describes the data and give some background of the intervention. The main results are presented in Section 5, while the conterfactual exercises are presented in Section 6. Section 7 concludes.

2 The Production Function of Human Capital

In this section, we discuss our formulation of the dynamic process and sketch the way we model it. In particular, we start with a discussion of the dimensions we model. We then discuss the dynamics of the process and how we allow for a flexible specification.

Finally, we discuss the role of different inputs and, in particular, that of parental investment. To do so, we use a simple model of investment which brings about the main assumptions that will drive our empirical strategy.

2.1 Different Dimensions: Cognition, Health and Socio-emotional Skills

As we mentioned above, it is well established that human capital is a multidimensional object. In the context we study, we decided to model the dynamic evolution of three different dimensions: cognitive skills, socio-emotional skills and health. Our choice is partly driven by the measurements available to us that are presumably related to such skills. Richer data sets might allow an even richer specification of the process. For instance, one could consider cognition separately from language development or, more importantly, one could model separately 'internalising' and 'externalising' socio-emotional skills, as in Attanasio, Blundell, Conti, and Mason (2018). In any case, ours specification is one of the richest in the literature, especially with data from developing countries.[3]

As we discuss in Section 3, we map specific available measures to the three factors we model. The availability of detailed and high quality measures of development relevant for different measures is not easy, especially for socio-emotional skills. Having done that we can study the (dynamic) interactions among these different factors in the process of development. Such a structure is useful both from an academic and a policy point of view as it allows us to identify which specific skills might be more important at different ages in the process of child development. Such knowledge is possibly relevant for the design of specific interventions that might target one or another dimension of development.

2.2 The Dynamics of Human Development: Persistence and Non-stationarity

The other important and so far relatively unexplored features of the process of development are its dynamic properties. Often, again for data availability, researchers focus on models where the level of human capital in various dimentions at age a depends only on the level of human capital at age $a-1$ (and other variables). Such assumptions on the nature of persistence of the process are very strong and may be inconsistent with

[3] Attanasio, Meghir, and Nix (2020) and Attanasio, Meghir, Nix, and Salvati (2017), for instance, use the well-known Young Lives data to model simultaneously cognitive skills and health. Cunha, Heckman, and Schennach (2010) use data from the NSLY to model (at much older ages than those we consider here) cognition and socio-emotional skills. Rubio-Codina, Araujo, Attanasio, Munoz, and McGregor (2017) discuss some of the issues in measuring child development during the early years.

the evidence from certain interventions that seem to show an effect in the short run that seems to disappear in the medium run and re-appear in the long run.[4] Moreover, very few data set give the possibility of studying how the persistence of the process changes through various ages. And yet these key parameters are crucial to determine the existence of *windows of opportunities* for child development, and the optimal timing for policies aimed at improving the life chances of disadvantaged children.

In what follows, we consider flexible functional forms for the process of human development, allowing for two lags of the developmental process and letting the coefficients that determine persistence vary with age. The rich data set we have available, with several observations during the first few years, allows us to estimate these models. Armed with these estimate, we can evaluate the medium run effectiveness of different interventions targeting specific stages of the child's life cycle.

2.3 The Production Function of Human Capital

The model we have in mind for the process of human development can be represented by the following equation:

$$\boldsymbol{\theta_{t+1}} = f_t(\boldsymbol{\theta_t}, \boldsymbol{\theta_{t-1}}, \boldsymbol{X_t}, \boldsymbol{Z_t}, \boldsymbol{\epsilon_{t+1}}) \tag{1}$$

where the subscript t represents age. $\boldsymbol{\theta_t}$ is a vector which represent different dimensions of human development, $\boldsymbol{X_t}$ and $\boldsymbol{Z_t}$ are vectors of (potentially) observable variables. The reason we differentiate them is that the variables in vector $\boldsymbol{X_t}$ are assumed to be chosen by some relevant agent, for instance parents, and could be reacting to the evolution of the process itself and would therefore be *endogenous*. The variables in $\boldsymbol{Z_t}$, instead, are environmental factors, including, possibly, parental background factors. The vector $\boldsymbol{\epsilon_{t+1}}$ represents unobservable (by the researcher) factors that affect the evolution of the various dimensions of human development.

The obvious endogenous variable $\boldsymbol{X_t}$ is parental investment. Parental behaviour and parental choices are recognised to be important determinants of child development.[5] However, they clearly must depend on the evolution of child development. The identification of their effect on child development is, therefore, difficult. The variables

[4] See, for instance, Gertler et al. (2014) for the long run effect of an intervention in Jamaica, whose effects in the medium run had partly fade out or Heckman et al. (2010) for the long run impact of the well-known Perry Preschool Program.

[5] See, for instance, McCormick et al. (2020), Boonk et al. (2018), Padilla and Ryan (2018), and Hsin (2007).

$\boldsymbol{Z_t}$ that we consider include family composition and parental backgrouond, such as education.

We keep the fuction f_t, which determines the evolution of human development over time, purposely vague, with the idea of wanting to use a flexible specification where different inputs may play an important role. We note the subscript t to the function f to stress the fact that we let this function change with age. Indeed, one of main goals of this study is to establish how the function f changes over time.

The empirical characterisation of the function f_t in equation (1) faces different challenges. First, $\boldsymbol{\theta_t}, \boldsymbol{X_t}$ and $\boldsymbol{Z_t}$ are not observable directly or without measurement error. Second, while a non-parametric approach to estimate the main features of the process is possible, in practice, especially to characterize several dimensions of child development simultaneously, such an approach would require a very large data set. Therefore, researchers often make functional form assumptions about f_t. It is therefore desirable to use parametric specifications that preserve a degree of flexibility while making the production function estimable. Finally and most importantly, as we mentioned above, some of the arguments of the function f_t are chosen in reaction to the evolution of human capital or simultaneously with other unobservable inputs.Such inputs are therefore *endogenous* and estimating their role in the production function is particularly hard. In this section, we discuss the second and third issue, while the discuss how we deal with the measurement of the various variables in equation (1) in Section 3.

2.3.1 Functional Form Assumptions

Given the data available, we model three factors, which we denote as cognitive skills (which we label C), socio-emotional skills (labelled S), and health labelled H). For each of these factors and for each age considered, we estimate different functional forms for the production function. The first specification we consider for each of the three human capital dimensions considered is the Constant Elasticity of Substitution specification (CES). According to this specification, dimension k of child human capital at age $t+1$ is given by:

$$\begin{aligned} \theta_{k,t+1} = \quad & A_{k,t}[\gamma_{k,C_1,t}\theta_{C,t}^{\rho_{k,t}} + \gamma_{k,C_2,t}\theta_{C,t-1}^{\rho_{k,t}} + \gamma_{k,S_1,t}\theta_{S,t}^{\rho_{k,t}} + \gamma_{k,S_2,t}\theta_{S,t-1}^{\rho_{k,t}} + \\ & \gamma_{k,H_1,t}\theta_{H,t}^{\rho_{k,t}} + \gamma_{k,H_2,t}\theta_{H,t-1}^{\rho_{k,t}} + \gamma_{k,I,t}\theta_{I,t}^{\rho_{k,t}} + \gamma_{k,P,t}\theta_{P}^{\rho_{k,t}}]^{1/\rho_{k,t}} \qquad k \in \{C, S, H\} \end{aligned} \tag{2}$$

where θ_t^I are parental investments, and θ^P represent parental skills, which are assumed to be fixed over time. A_t^k is a factor-neutral productivity parameter, which is allowed to depend on observable characteristics (such as family composition and gender), denoted by $\boldsymbol{G_t}$ and unobserved shocks according to:

$$A_{k,t} = exp(\delta_{k,0,t} + \boldsymbol{\delta'_{k,G,t}} \boldsymbol{G}_t + \epsilon_{k,t}) \tag{3}$$

Several comments on equation (2) are in order. Such a specification allows for a large number of inputs, including two lags of each of the dimension of human capital considered. The effect of these input on the total outcome is not additive or separable. One can impose the assumption of constant return to scale by imposing that the sum of the γ coefficients is equal to 1, but it is not necessary. The CES allows for interactions, and the parameter $\rho_{k,t}$ governs the elasticity of substitution among the various inputs, which is given by $\frac{1}{1+\rho_{k,t}}$. When the parameter $\rho_{k,t}$ converges to zero, the expression in equation (2) converges to a Cobb-Douglas and the elasticity of substitution among the various inputs is unity. This writes as follows:

$$\theta_{k,t+1} = A_{k,t}[\theta_{C,t}^{\gamma_{k,C_1,t}} \theta_{C,t-1}^{\gamma_{k,C_2,t}} \theta_{S,t}^{\gamma_{k,S_1,t}} \theta_{S,t-1}^{\gamma_{k,S_2,t}} \theta_{H,t}^{\gamma_{k,H_1,t}} \theta_{H,t-1}^{\gamma_{k,H_2,t}} \theta_{I,t}^{\gamma_{k,I,t}} \theta_{P}^{\gamma_{k,P,t}}] \tag{4}$$
$$k \in \{C, S, H\}$$

All the arguments of the production function in these equations are potentially not observable directly. In Section 3, we discuss how to estimate the parameters of these functions when we have some noisy signals of these variables.

Although equation (2) is reasonably flexible (and contains as a special case the Cobb Douglas case), it does impose a fair amount of restrictions on the production function. In particular, the assumption that the degree of substitability among all the inputs is the same and governed by a single parameter ($\rho_{k,t}$) is a very strong one. For this reason we also experimented with a Trascendental Logarithmic production function (translog for short) which has both linear and quadratic terms and allows to capture different degrees of substitutability between inputs flexibly (Christensen, Jorgenson, and Lau (1973)). The translog specification (with some abuse of notation) is given by:

$$\begin{aligned} \ln \theta_{k,t+1} = \quad & \gamma_{k,C_1,t} \ln \theta_{C,t} + \gamma_{k,C_2,t} \ln \theta_{C,t-1} + \gamma_{k,S_1,t} \ln \theta_{S,t} + \gamma_{k,S_2,t} \ln \theta_{S,t-1} \\ & + \gamma_{k,H_1,t} \ln \theta_t^H + \gamma_{k,H_2,t} \ln \theta_{H,t-1} + + \gamma_{k,I,t} \ln \theta_{I,t} + \gamma_{P,t} \ln \theta_P \\ & + \tfrac{1}{2} \textstyle\sum_q \sum_r \gamma_{k,qr,t} \ln \theta_{q,t} \ln \theta_{r,t} + \delta_{k,0,t} + \delta_{k,G,t} G_t + \epsilon_{k,t} \\ & k \in \{C, S, H\}; \quad q, r \in \{C, S, H, P, I\} \end{aligned} \tag{5}$$

with $\gamma_{i,j} = \gamma_{j,i}$. The translog production function reduces to the Cobb-Douglas when all $\gamma_{i,j} = 0$. Equation (5), as it is written, does not allow interactions with the lag-2 dimensions of human capital. In practice, we experiment with those interactions as well.

The main focus of the empirical analysis is going to be in assessing the extent of the persistence of the process, as measured by the coefficients on the lagged human capital variables, the extent of the dynamic interactions between different dimensions of human capital (for instance, what role socio-emotional skills play in the development of cognition) and in the role of parental investment. We will also assess how these effects change over time. As discussed above, the size of these parameters has important policy implications.

2.3.2 The Endogeneity of Parental Investment

Parents' choices reflect their resources (financial and time), their tastes and their beliefs. In making these choices they may react to the effect that some unobservable factors have on child development. Furthemore, not all parental choices are observable. Therefore the observed correlation between parental investment and children outcomes does not necessarily have a causal interpretation. In other words the estimates of the γ coefficients in equations (2), (4), or (5) obtained by simple OLS or NLS regressions can be biased. Indeed, the nature of the bias of such coefficients, if it can be estimated, is informative of the motives behind parental behaviour. For instance, a negative bias in the estimation of the marginal product of investment might be indicating compensatory behaviour, where parents react to negative shocks to their offspring's development by increasing investments.

To estimate the coefficients of the production function is necessary to specify a model of parental behaviour, which can be used to derive the conditions under which the coefficients can be identified, and the variables that is necessary to observe to obtain such estimates. In what follows, we assume that parents maximise a certain objective function subject to a resource constraint and their perception of the human capital production function. To clarify the main ideas we sketch here a simple (and unrealistic) model of parental behaviour. In particular, we assume that couples choose investment to solve the following problem:

$$
\begin{aligned}
& Max_{c,X} U(c,H) \qquad (6)\\
s.t. \qquad & c + pX = Y \\
& H = g(X, H_0, W, \epsilon)
\end{aligned}
$$

where c is parental consumption, H child's human capital, X parental investment, p the price of investment in terms of consumption (whose price is normalised to 1) and Y represents parental financial resources. The function g is the parental perception of the human capital production function. The shock ϵ is observed by parents but not by the researchers estimating the parameters in 6.

In this simple model we do not consider separately time and financial resources and we have a very simple utility function, where parental utility does not depend, for instance on X. Furthermore, we assume that parents observe the level of child development H_0, while in a more complex model, parents might have distorted beliefs about such a variable and make their choice on that basis. Such a simple model, however, it is useful to discuss our empirical strategy. In such a model, parental investment depends on parental tastes, as represented by the utility function U, parental resources Y, the price of investment p and by the parental perceptions of the production function of human capital g. We note that the function g does not necessarily coincide with the "true" production function, as represented, for instance, in equation (2) or (5).

A feasible approach to estimate the parameters of the production function in this context would be the use of an IV or, in the non-linear case of equation (2), a control function approach. For such an approach to work, it is necessary to identify variables that drive investment, but that can be plausibly excluded from the production function. Once again, we note that, if the objective is only to estimate the parameters of the "true" production function, rather than the complete model, which would include taste parameters, the parameters of the "perceived" production function, one does not need to specify a completely accurate investment function or assume that parents know the "true" production function. Instead, one can estimate an investment function that includes some variables that drive investment and are not direct determinants of human capital.[6] This approach leads us to estimate the following approximation to the investment function:

$$\theta_{I,t} = \pi_0 + \pi_{C,t}\theta_{C,t} + \pi_{S,t}\theta_{S,t} + \pi_{H,t}\theta_{H,t} + \pi_{P,t}\theta_P + \pi'_{G,t}\boldsymbol{G_t} + \pi_{Z,t}\boldsymbol{W_t} + u_t \tag{7}$$

where the vector $\boldsymbol{G_t}$ are variables that affect the production function, while $\boldsymbol{W_t}$ are the instruments that do not enter the production function directly. Such an equation should be interpreted as a reasonable approximation (not necessarily consistent) to the investment function. Estimating it allows to obtain estimates of u_t, which can then be used to construct a control function to add to the production function equation.

In the context of the model in equations (6), two natural candidate variables that could be used as instruments are the price of investment p and the financial resources

[6] In linear models, the consistency of estimates so obtained can be easily proven. The issue is subtler in non-linear model and one might have to show the robustness of the results with simulations.

Y. As discussed in Attanasio, Cattan, Fitzsimons, Meghir, and Rubio-Codina (2020), prices could constitute a more attractive instrument than financial resources, as the former are plausibly taken as given by households, while the latter could proxy for some omitted input in the production function. Unfortunately, in the context that we will be analysing, there is no variation in prices, as the children in our sample live in two similar neighborhoods of the same city. We therefore decided to use variables related to financial resources as an instrument and discuss possible biases and interpration of results in Section 5. Our results on the effectiveness of parental investment, therefore, should be taken with a grain of salt. It should be stressed that Attanasio, Cattan, Fitzsimons, Meghir, and Rubio-Codina (2020), who performed an extensive analysis of the instruments used to identify the effect of parental investment, obtain estimates of the relevant coefficient that do not depend on whether they use prices or resources as the source of identification and that are substantially different from the estimates obtained by OLS, which ignore the endogeneity of investment.[7]

3 Latent Factors and Measurement

As we mentioned above, several variables (or factors) that enter the production function (or the investment function) are not directly observed. Instead, our data consists of a set of measures that are related to the relevant latent factors. We follow the approach used, among others, by Cunha, Heckman, and Schennach (2010), Attanasio, Meghir, and Nix (2020) and Attanasio, Cattan, Fitzsimons, Meghir, and Rubio-Codina (2020) to estimate a measurement system that allows us to synthetise the available information on these variables in a lower dimensional construct and account explicitly for the presence of measurement error. To obtain estimates of the relevant parameters governing the process of human capital formation, we need to address a number of normalisation and location issues. These issues can be particularly important in this context, as our focus is on the longitudinal and dynamic analysis of this process. As we discuss below, it is crucial to use, at each stage or age considered, a consistent metric and normalisation of the factors considered.

Using the approach introduced by Attanasio, Meghir, and Nix (2020), we obtain estimates of the joint distribution of the latent factors, which we then use in the estimation of the production functions we consider. We consider as factors three dimensions

[7] Attanasio, Cattan, Fitzsimons, Meghir, and Rubio-Codina (2020) also discuss the possibility that the instruments they use are 'weak' and therefore introducing a bias in the estimates. They show that instrument weakness is not an issue in their context.

of human development (cognition and language, socio-emotional skills and health) as well as parental investment and a set of indicators of parental background. We discuss the choice of these dimensions and the measurements we use in detail in Section 4.2.

In this section, we first discuss the measurement system and its estimation, including the normalisation issues we tackle. We then move on to consider the estimation of the production function, taking into account the process to obtain estimates of the relevant latent factor and the endogeneity of parental investment.

3.1 The Measurement System

We specify the measurement system in terms of the log of the latent factors, ensuring that the factors only take positive values, as required by the specification of the production function. Let $m^j_{k,t}$ be a continuous measure at age t for factor k.[8] Assuming a log-linear relationship between the measures and the factors with additive measurement error, we can write:

$$m^j_{k,t} = \alpha^j_{k,t} + \lambda^j_{k,t} \ln \theta_{k,t} + \epsilon^j_{k,t} \tag{8}$$

where $\alpha^j_{k,t}$ is an intercept term and $\lambda^j_{k,t}$ is a factor loading. The intercept captures the *difficulty* of measure $m^j_{k,t}$: a measure with a low value of $\alpha^j_{k,t}$ is one that, for a given level of the factor $\theta_{k,t}$, obtains a lower value. The factor loading captures the *saliency* of variable j for factor k: a measure with a high value of $\lambda^j_{k,t}$ is one that varies much with variation in the factor. Both the intercept and the factor loading are indexed by t, reflecting the fact that these are allowed to vary by age as to capture the potentially different informativeness of the same measure over time. The term $\epsilon^j_{k,t}$ represents the measurement error for variable j. This is assumed to be mean zero and indipendent of the latent factor. Furthermore, the error terms are assumed to be independent between each other ($\epsilon^j \perp\!\!\!\perp \epsilon^{j'}$) and over time ($\epsilon_t \perp\!\!\!\perp \epsilon_{t'}$).[9]

The final and most important element in equation (8) is the latent factior $\theta_{k,t}$, which represents child development in dimension k at age t. Estimation of the measurement system in equation (8) allows to learn the distribution of the child development factor in a population or sample. Moreover, estimates of such a system allows, for any set of measures observed for a given child, to construct an estimate of their development.

[8] If the available measure $m^j_{k,t}$ is discrete (bynomial or otherwise), one can extend the discussion here considering a single index model such as a (multinomial) probit, a logistic or some other discrete variable model, which converts an equation such as (8) into a discrete measure.

[9] These assumptions can be somewhat relaxed, although we need to have some measures whose measurement errors are independent to achieve identification of the model's parameters.

While, under certain conditions on the number of available measures, it is possible to identify the parameters in equation (8) without any assumptions on the distribution of the latent factor $\theta_{k,t}$, in practice researchers often make specific assumptions about such a distribution.[10] The parameters of the distribution of the latent factors constitute another set of parameters to be estimated. Finally, we notice that the way equation (8) is written, assumes that each measure correponds exclusively to one factor. Such a system is referred to as *dedicated* system. While it is possible to relax a bit this assumption, having some measures being affected by more than one factor, identification requires a set of exclusion restrictions.

Because the latent factors are not observable and have no natural metric, we need to impose some normalizing restrictions to set their location and scale (Anderson and Rubin (1956)). This issue is analogous to the discussion of *anchoring* in Cunha, Heckman, and Schennach (2010). As discussed by Agostinelli and Wiswall (2016a), normalizing the mean of the factor to be zero in each period can be an non-innocuous assumption when one is interested in capturing the dynamic growth of the factors over time, as it would restrict the set of admissible production functions to those that are mean stationary. Moreover, valid comparison of technology parameters over time, which is key for the identification of *window of opportunities*, requires that the scale of the latent factors is consistently expressed in the same metric over ages (see Agostinelli and Wiswall (2016a)). Expressing the scale of the latent factor arbitrarily, by normalizing the loading on a *different* measure in each period, would imply that the technology parameters are themselves expressed in different metrics over time.

One straightforward solution to both issues would be readily available if one had at least one exact same measure spanning all time periods. One could then express the location and scale of the factor in terms of this measure, which we label as measure 1, by imposing $\alpha^1_{k,t} = 0$ and $\lambda^1_{k,t} = 1$ $\forall t = 1...T$. The assumption that one of the intercepts $\alpha^h_{k,t}$ is normalised to 0 is necessary if we want to estimate, for each age, the mean of the latent factor $\theta_{k,t}$.[11]

The assumption that the loading factors on one specific measure is set to 1 is a strong one and defines the scale of the estiimated factors. This assumption says that the saliency of the measured whose loading factor is normalised to 1 does not change

[10] Log-normality is often assumed. Alternatively researchers have used more flexible specifications, such as a mixture of log normal. See, for instance, the discussion in Cunha, Heckman, and Schennach (2010)

[11] Alternatively, some researchers leave the $\alpha^j_{k,t}$ unrestricted for every t and constraint the mean of the distribution of $\theta^j_{k,t}$ to zero. The two assumptions are observationally equivalent.

with age. As with the mean, this assumptions allows the variability of the latent factors to change with age.

Given these assumptions, we can estimate the measurement system in equation (8). Both the mean and the scale of estimated latent factor is now comparable over time as they are expressed in terms of this normalizing measure.

Unfortunately, while we do have one such measure in our data for health, socio-emotional skills and investments, we do not have it for cognitive skills. However, we can exploit the fact that there is at least one time period where we have some "overlapping" between different measures to express the location and scale of the cognitive factor consistently over time. In the next subsection we provide the details of this procedure with the help of an illustrative example.

3.1.1 Normalizations on the Location and Scale of the Latent Factors when no Measure is Available for all Ages

Our data consists of two sets of instruments that were used to measure child cognitive skills over time: the first set is only appropriate at younger ages (0 to 3), while the second set is only appropriate for older children (3+). Therefore the simple normalization discussed above cannot be implemented. We extend that procedura in a relatively simple way.

The basic intuition behind our procedure is the following: if there is at least one measure from each set that overlap in at least in one time period then one can work out a mapping between the location and scale parameters (the α_s and λ_s in equation (8)) of the two sets and impose these restrictions in subsequent periods, so to set the location and scale of the latent factors in a common metric over time.

The approach is explained simply with an example where we consider 3 time periods and four measures for a generic factor k: $m_k^{a_1}$, $m_k^{a_2}$,$m_k^{b_1}$, $m_k^{b_2}$. To explain our scaling procedure, we only need one latent factor. For simplicity, therefore, we omit the measurement equations relating to factors different from k from the discussion and drop the subscript k in what follows.

We assume that at age $t = 1$ m^{a_1} and m^{a_2} are available. At age $t = 2$, measures m^{a_1} and m^{b_1} are available, while at age $t = 3$, m^{b_1} and m^{b_2} are available. At this point the distribution of the (log) latent factor is left unspecified with mean μ_θ and variance σ_θ^2. With these assumption, the measurement system can be expressed as follows:

$$t = 1 \quad \begin{cases} m_1^{a_1} = \alpha_1^{a_1} + \lambda_1^{a_1} \ln \theta_1 + \epsilon_1^{a_1} \\ m_1^{a_2} = \alpha_1^{a_2} + \lambda_1^{a_2} \ln \theta_1 + \epsilon_1^{a_2} \end{cases}$$

$$t = 2 \quad \begin{cases} m_2^{a_1} = \alpha_2^{a_1} + \lambda_2^{a_1} \ln \theta_2 + \epsilon_2^{a_1} \\ m_k^{b_1} = \alpha_2^{b_1} + \lambda_2^{b_1} \ln \theta_2 + \epsilon_2^{b_1} \end{cases} \tag{9}$$

$$t = 3 \quad \begin{cases} m_3^{b_1} = \alpha_3^{b_1} + \lambda_3^{b_1} \ln \theta_3 + \epsilon_3^{b_1} \\ m_3^{b_2} = \alpha_3^{b_2} + \lambda_3^{b_2} \ln \theta_3 + \epsilon_3^{b_2} \end{cases}$$

In this example, no measure is available throughout the 3 periods considered. However, both measure m^{a_1} and measure m^{b_1} give a way to construct a metric for the factors that can be used through the 3 periods. In particular, if we normalise the intercepts and factor loadings of measures $m_1^{a_1}$ and $m_2^{a_1}$ to 0 and 1 respectively ($\alpha_1^{a_1} = \alpha_2^{a_1} = 0$ and $\lambda_1^{a_1} = \lambda_2^{a_1} = 1$), we can use the estimates of the intercept and factor loading of $m_2^{b_1}$ to express the location and scale of the latent factor at age 3 in same metric. We can do so by imposing that the location and scale coefficients pertaining to this measure are constant across time periods. Alternatively, a similar exercise could be performed normalizing the parameters of measure m^{b_1} and use that measure as the metric for the three periods. We notice that the parameters of the joint distribution of factors (μ_θ and σ_θ^2) can be identified. Our procedure guarantees that these are constantly expressed in the same metric and are, therefore, comparable over time. More formally, in our example, we would use the following procedure:

Factor scale: We can set the scale of the (log) factor in the first two periods to be equal to each other by setting $\lambda_1^{a_1} = \lambda_2^{a_1} = 1$. In this way the scale of the latent factor would be the same in the first two periods and would be given by the scale of measure m^{a_1}. As the factor loading on measure m^{a_1} in period $t = 2$ is normalized to one, the factor loading on measure $m_k^{b_1}$ in that period will be expressed in terms of measure m^{a_2}.[12] We can then impose $\lambda_2^{b_1} = \lambda_3^{b_1}$ to express the scale of the factor in $t = 3$ to be the same as that of the factor in $t = 1, 2$.

[12]This approach is analogous to express the value of a currency in terms of another i.e. a nominal exchange rate.

Factor location: We can express the location of the (log) factor in $t = 1$ and $t = 2$ by setting $\alpha_1^{a_1} = \alpha_2^{a_1} = 0$. Taking expectations of the first equation at $t = 1$ and $t = 2$ we get $E(\ln\theta_1) = E(m_1^{a_1})$ and $E(\ln\theta_2) = E(m_2^{a_1})$, respectively. In this way the factor mean in periods 1 and 2 is expressed in terms of the same measure. Using the measurement equation for $m_2^{b_1}$, we can get an expression for $\alpha_2^{b_1}$:

$$\alpha_2^{b_1} = E(m_2^{b_1}) - \lambda_2^{b_1} E(\ln\theta_2) \tag{10}$$

Using the measurement equation for $m_3^{b_1}$, we can then get an expression for $E(\ln\theta_3)$:

$$E(\ln\theta_3) = \frac{E(m_3^{b_1}) - \alpha_3^{b_1}}{\lambda_3^{b_1}} \tag{11}$$

Finally, imposing $\alpha_2^{b_1} = \alpha_3^{b_1}$ and $\lambda_2^{b_1} = \lambda_3^{b_1}$ and substituting (10), we get:

$$E(\ln\theta_3) = E(\ln\theta_2) + \frac{E(m_3^{b_1}) - E(m_2^{b_1})}{\lambda_2^{b_1}} \tag{12}$$

so that the mean of the (log) factor in $t = 3$ will be equal to that of the (log) factor in the previous period (which was expressed in terms of measure m^{a_2}), plus a term that depends on the change in measure m^{b_1} between periods 2 and 3, scaled by the informativeness of this measure in terms of m^{a_2}.

This example can be easily generalised to additional time periods and additional available measures. What we want to make clear is that the availability of two measures in a given time period allows us to "covert" one to the other. We can then impose these conversions in different periods and express the scale and location of the latent factors in a way that is consistent throughout the periods considered. The resulting factors can then be compared over time to establish the rate of growth over time and to derive estimates of the parameters governing the growth process. The crucial identification assumptions, again, is that the factor loadings and the intercepts of some of the measures available at different ages are constant over time. In what follows, we will be using the *Test de Vocabulario en Imàgenes Peabody* (TVIP, Dunn et al. (1986)) to express the scale and the location of the cognitive factor.

3.1.2 Estimation

In order not to impose strong restrictions on the technology of human capital formation, one needs to estimate the distribution of factors using a flexible specification.

Often used assumptions, such as joint normality, in practice impose very strong restrictions on the production function. For instance, the linear relatationship among conditional means implied by joint normality would preclude any complementarity between the inputs in the production function. Thus flexibility in the specification of the production technology requires flexibility in the parametric assumptions about the joint distribution of factors.

In this paper, we follow the approach introduced by Attanasio, Meghir, and Nix (2020). This approach consists in assuming some flexible distributional assumptions for the latent factors and measurement errors, and estimating the parameters of these distributions (together with the parameters of the measurement system) using the observable data. In practice, we assume that the factors are distributed as a mixture of two log-normal distributions and that the measurement errors are normally distributed with mean zero and diagonal variance-covariance matrix.

These distributional assumptions, together with the specified measurement model, imply that the measures will be distributed as a mixture of normal distributions. We thus estimate the parameters of the joint distribution of measurements by maximum likelihood, using the EM algorithm. Using these estimates we can recover the parameters of the joint distribution of factors, the variances of measurement errors, the factor loadings and the intercepts by minimum distance. Following Attanasio, Meghir, and Nix (2020), we augment the measurement system for the latent factors reflecting child development and parental investment, with additional equations, representing the control variables we use as well as the instruments used in the investment equation to take into account the endogeneity of such a variable, which we discuss below.

Having obtained estimates of the joint distrubution of all the variables included in the model. we use it to draw vectors of random variables from this distribution. As we estimate the joint distribution, we reproduce the correlation oberved in the data and use these synthetic data to obtain parameters of the structural model using a control function approach we discuss in what follows.

3.2 Production Functions and Investment Functions: a Control Function Approach

An additional challenge we face in the estimation of a production function, is the fact that some of the arguments are endogenous. In particular, parental investment is likely to be chosen by parents in reaction to the evolution of child development. Moreover, the measured factor might be correlated with other unobservable factors that are relevant for child development. These issues make the identification of the causal link between parental investment and child development challenging.

We use the approach in Attanasio, Meghir, and Nix (2020), by first estimating an *investment function*, which represents the reduced form of a model that relates parental investment to (some of) its determinants. We then use the residual terms of such an equation to construct a *control function*, which can be used to control for the endogeneity of investment in the production function of human capital. The identification assumption is that investment function includes some variables that are important drivers of investment but that do not enter directly the production function. Both the inverstment equation, its residuals and the production function augmented with the relevant control function are estimated on the syntehtic data drawn from the estimated joint distribution derived from the measurement system.

4 *aeioTU*: Available Data and Latent Factors

The longitudinal data set we use in this paper comes from a randomized controlled trial used to evaluate a comprehensive, high-quality early education intervention in Colombia. We use a sample of 1,073 disadvantaged children aged 0 to 5 at baseline in two communities in northern Colombia from 2010 to 2014. Bernal, Giannola, and Nores (2020) and Nores, Bernal, and Barnett (2019) provide additional details of the intervention and its impacts on child development.

4.1 Background on the Intervention and Its Evaluation

The data we use were collected within the evaluation of an important intervention aimed at improving the quality of preschool attended by disadvantaged children in Colombia. In particular, the intervention established two large child care centres, while at the same time implementing a specific curriculum used within them. The curriculum, inspired by the celebrated *Reggio Emilia* model, is promoted by an NGO, called *aeioTU*, which through a public-partnership with the Colombian government, operated 28 centres by 2016, providing comprehensive early childhood education to about 13,300 low-income children aged 05 throughout the country. The program offers early education on a full-day schedule, five days a week and 11 months per year, plus nutritional supplementation corresponding to 70% of childrens daily calorie intake requirements.

The evaluation of the intervention was designed as a randomized control trial, which exploited the excess demand of places in two renewed child care centres on the Caribbean coast in Colombia. The RCT study assigned the children of families who applied to the two centres included in the study to treatment or control. The two centres in the study had capacity for 320 children aged 0 to 5, with just over half of that for children up to age 3. The randomisation stratified children by age (five groups), gender and neighborhood within site (three groups). Slots were randomized for 1,073 children aged 0 to 4. Of these children, 471 were offered slots in the centers (the treatment group), and 602 children were allocated to the control group.

Baseline assessments were conducted on children in late 2010, prior to random assignment and to the beginning of the intervention. Children and their families were assessed every subsequent year (roughly every 10 to 12 months) up until 2014. Baseline data collection in Site 1 took place on July-September 2010 (Y1 henceforth) and the program started in November 2010. Baseline in Site 2 was conducted on October-December 2010 with the program starting in March 2011. The first follow-up (Y2) was collected 8 months into the program, a second follow up (Y3) at 20-22 months later, a third follow-up (Y4) at 32 months, and the last follow-up (Y5) at approximately 41 months since the start of the intervention.

4.2 Available Measures: Different Measures and Different Ages

The data we use is very rich, in that for each of the latent factors that enter the production functions we estimate, we have several measures available. We use the factor models described in Section 3 to summarize all the information they provide. In particular, the available data, an exploratory factor analysis and *a-priori* considerations lead us to consider 3 latent factors of child development: cognition and language, socio-emotional skills, and health.

The instruments used in the evaluation have adequate psychometrics and been used extensively in evaluations of early care and education including studies in developing countries (Fernald, Prado, Kariger, and Raikes (2017)). Child assessments were collected by graduates in psychology and students in their senior year in psychology, who were trained to reliability standards (100% agreement with the trainer) by experienced staff in a two-week training which included live reliability with young children.[13] Data collection was conducted in spaces rented and adapted for that purpose every year, under identical conditions for treatment and control children, with parental informed

[13]Evaluators involved in child assessment at any given wave were offered a refresher training every year, and new assessors (if any) were fully trained in similar conditions.

Table 1: Measures of early development by developmental domain and wave

	Baseline	Y2	Y3	Y4	Y5
Health and Nutrition					
Height, weight, arm circumference	0+ 0+	0+	0+	0+	
Cognitive Development					
Bayley 3rd edition	0-42	0-42	0-42	0-42	-
Peabody Picture Vocabulary Test (Spanish)	30+	30+	30+	30+	30+
ELSA Early Literacy Skills Assessment	36+	36+	36+	36+	-
Woodcock-Muñoz III subscale 10[a]	36+	36+	36+	36+	36+
Woodcock-Muñoz III (subscales 1[b] and 9[c])	-	-	-	36+	36+
Head Toes Knees and Shoulders (HTKS)	48+	48+	48+	48+	48+
Socio-emotional development					
Ages & Stages socio-emotional domain	6-60	6-60	6-60	6-60	6-60
Behavioral and emotional screening system	-	-	36+	36+	36+
Vineland Adaptive Behavior Scales-II	-	-	-	36+	36+

Notes: Each cell reports the ages for which the measure is available (in months).
[a] Applied problems.
[b] Word identification.
[c] Text comprehension.

consent. Parent interviews were carried out in a separate room alongside the childs assessment.

Table 1 summarizes the child assessments used in the evaluation, by developmental domains. These changed as children aged over the course of the study. For health outcomes, we collected height, weight, and arm circumference following World Health Organization (WHO) standards (WHO (2007)).

Cognitive development was measured using the cognitive, motor, and language scales from the Bayley Scales of Infant Development III (BSID) (Bayley (2005)), for children under 36 months of age. We administered the Test de Vocabulario en Imgenes Peabody (TVIP) (Padilla, Lugo, and Dunn (1986)) to children over 30 months of age in each wave. The TVIP measures receptive language. We used the Early Literacy Skills Assessment (ELSA) (DeBruin-Parecki (2005)) to measure early literacy in children over 36 months of age in each wave (with the exception of Y5).

Math and literacy skills were measured using three subtests of the Woodcock-Muñoz III Tests of Achievement (WM-III): subtests #1 (letter-word identification), #9 (text comprehension) and #10 (applied problems) (Muñoz-Sandoval, Woodcock, McGrew, and Mather (2005)). The applied problems subtest was used every year for children above 3 years of age, while the literacy sub-tests were included only in Y4.

Executive Function was assessed using the Head-Toes-Knees and Shoulders (HTKS) which examines behavioral regulation in young children (Ponitz, McClelland, Jewkes, Connor, Farris, and Morrison (2008), Ponitz, McClelland, Matthews, and Morrison (2009)). HTKS requires children to remember, respond and inihibit behavioral commands. We measured HTKS for all children older than 4 years of age in all waves.

Socio-emotional development was assessed using The Ages and Stages Questionnaire: Socio-Emotional (ASQ:SE), a parent-completed assessment for children 660 months old measuring self-regulation, compliance, communication, adaptive functioning, autonomy, affect, and interactions with others (Squires, Bricker, and Twombly (2002)). It was collected for children of all ages (up until 60 months of age) in all waves. Higher scores represent higher levels of socio-emotional risk or negative behaviors. We also used the Vineland Adaptive Behavior Scales (Sparrow, Cicchetti, and Balla (1984)) on children above age 3 starting Y4. The Vineland is a parent questionnaire on personal and social skills, daily living skills, socialization, and motor skills.

As children outgrew the ASQ:SE (starting at Y3), we used the Behavior Assessment System for Children, Second Edition (BASC-II) for all children older than 36 months of age, which measures adaptive functioning and problem behaviors (Bracken, Keith, and Walker (1998), Doyle, Ostrander, Skare, Crosby, and August (1997)).

Finally, to assess the home environment parents were interviewed on: (1) discipline strategies used at home, (2) nutritional and feeding habits at home, and (3) parental engagement with children. Discipline strategies is an 8-item scale asking parents to rate how often they use certain types of discipline strategies that range from physical and verbal punishments to positive alternatives. The scale was collected for all children in all waves. Nutritional and feeding habits were assessed with questions about meal contents which allows constructing a measure of balanced diets (i.e., all nutritional elements in each meal or each day), and a measure of food insecurity (child skipped at least one meal due to lack of resources). Both were collected for all children in all waves but Y1. Parental engagement was assessed using questions regarding the number of hours devoted by parents to childcare during weekdays and weekends, and the frequency of activities with children such as reading, feeding them, playing with them, and walking with them or visiting places. These were collected for all children and in all waves.

In addition to the outcome measures described above, we included a household survey (primarily answered by mothers or the head of the household) inquiring on: schooling attainment, maternal age at birth of the child, race, income and expenditures, employment, assets, health insurance, number of children in the household, and childcare experiences.

4.3 Impacts on Child Outcomes

Bernal, Giannola, and Nores (2020) reports strong positive effects on health throughout the study which were concentrated on boys, and strong positive effects on cognition from Y2 to Y4 for girls but not for boys. No significant program impacts were found on socio-emotional development. The effects on health were around 0.12 standard deviations throughout the study , and up to 0.3 standard deviations for boys in the last wave. The effects were mostly observed in the subgroup of older children in the 2-4 cohort. The treatment on the treated effect was larger, as expected, with an effect of about 0.12 standard deviations for each additional year of effective program participation.

The intent-to-treat effects on cognition started at 0.16 standard deviations at the first follow-up (8 months into the program) and reached 0.36 standard deviations after that, and were close to 0.5 standard deviations for girls. The effects are observed from Y2 to Y4, but disappear in Y5. The treatment on the treated effect was around 0.3 standard deviations for each additional year of effective enrollment in the program. These effects can be thought as percentages of the socio-economic development gap in Colombia, which is close to one standard deviation in receptive vocabulary at age 5 (Bernal, Martínez, and Quintero (2015)). For a detailed discussion on the evaluation results see Bernal, Giannola, and Nores (2020) and Nores, Bernal, and Barnett (2019).

Of course, a finer decompositions of child development and a larger number of factors could be possible. For instance, one could imagine to consider differnt dimensions of cognitive development, including language, executive functions and other types of cognitive skills. Or one could decompose what we call socio-emotional skills into "internalizing skills" (focus, motivation, drive and grit) and "externalising skills" (sociability, the ability to work and communicate with others). However, given the data available and the exploratory analysis we performed, the decomposition we perform seems reasonable and feasible. These three factors, have been used in the literature on child development extensively, although we are the first to model them jointly.

4.4 The Measurement System

Given the available measures, we specify the measurement system as a *dedicated* system. In Table 2, we report the observable variables that we use as markers for each of the unobservable factors we include (cognition, socio-emotional skills, health, and

Table 2: Share of total variance due to signal and noise

	% signal	% noise		% signal	% noise
Child cognitive skills			*Child socio-emotional skills*		
Bayley cognition age 1	0.91	0.09	ASQ selfregulation age 1	0.12	0.88
Bayley expressive age 1	0.58	0.42	ASQ communication age 1	0.01	0.99
Bayley receptive age 1	0.61	0.39	ASQ adaptive functioning age 1	0.22	0.78
Bayley fine motor age 1	0.86	0.14	ASQ compliance age 1	0.63	0.37
Bayley gross motor age 1	0.9	0.1	ASQ interaction age 1	0.01	0.99
Bayley cognition age 2	$1^{\dagger}$	$0^{\dagger}$	ASQ selfregulation age 2	0.11	0.89
Bayley expressive age 2	0.54	0.46	ASQ communication age 2	0.15	0.85
Bayley receptive age 2	0.44	0.56	ASQ adaptive functioning age 2	0.02	0.98
Bayley fine motor age 2	0.6	0.4	ASQ compliance age 2	0.24	0.76
Bayley gross motor age 2	0.6	0.4	ASQ interactiona age 2	0.09	0.91
TVIP age 3	$1^{\dagger}$	$0^{\dagger}$	ASQ selfregulation age 3	0.18	0.82
Bayley cognition age 3	0.89	0.11	ASQ communication age 3	0.2	0.8
Bayley expressive age 3	0.6	0.4	ASQ adaptive functioning age 3	0.19	0.81
Bayley receptive age 3	0.38	0.62	ASQ affection age 3	0.16	0.84
Bayley fine motor age 3	0.5	0.5	ASQ compliance age 3	0.34	0.66
Bayley gross motor age 3	0.43	0.57	ASQ interaction age 3	0.11	0.89
TVIP age 4	0.71	0.29	ASQ selfregulation age 4	0.2	0.8
Woodcock-Munoz age 4	0.26	0.74	ASQ communication age 4	0.26	0.74
ELSA age 4	0.38	0.62	ASQ adaptive functioning age 4	0.15	0.85
TVIP age 5	0.27	0.73	ASQ affection age 4	0.5	0.5
Woodcock-Munoz age 5	0.32	0.68	ASQ compliance age 4	0.25	0.75
ELSA age 5	0.36	0.64	ASQ interaction age 4	0.3	0.7
TVIP age 6	0.43	0.57	ASQ selfregulation age 5	0.15	0.85
Woodcock-Munoz age 6	0.54	0.46	ASQ communication age 5	0.64	0.36
ELSA age 6	0.23	0.77	ASQ adaptive functioning age 5	0.14	0.86
TVIP age 7	0.42	0.58	ASQ affection age 5	0.42	0.58
Woodcock-Munoz age 7	0.44	0.56	ASQ compliance age 5	0.23	0.77
ELSA age 7	0.15	0.85	ASQ interaction age 5	0.34	0.66

continues...

Notes: †0 and 1 reflect rounding

parental investment).

After estimating the measurement system for each factor and each age, following the normalization and scaling procedures discussed above, we can estimate, for each of the measures that we include in the system, the fraction of the variance of that variable which is accounted for by variation in the relevant unobservable factor and the fraction that is due to measurement error. These results are reported in Table 2.

Starting with the cognitive measures, we notice that they change with the age of the children, as it is normal practice. Fortunately, there is some overlap at each age, so that we can follow the normalization and anchoring strategy we discuss above. At early ages, from 1 to 3, the sample children are administered various sub-scales of the Bayleys Scale of Infant Development, a test that is considered as the gold standard for these ages. The quality of the Bayleys tests is reflected in the high signal to noise ratios

Share of total variance due to signal and noise (continued)

	% signal	% noise		% signal	% noise
Child socio-emotional skills			*Parental investments*		
ASQ selfregulation age 6	0.4	0.6	Child books ages 1-2	0.05	0.95
ASQ communication age 6	0.28	0.72	Number of play materials ages 1-2	0.41	0.59
ASQ adaptive functioning age 6	0.17	0.83	Books at home ages 1-2	0.93	0.07
ASQ affection age 6	0.33	0.67	Toys ages 1-2	0.08	0.92
ASQ compliance age 6	0.4	0.6	At least 3 child books ages 1-2	0.08	0.92
ASQ interaction age 6	0.29	0.71	Learning materials (score) ages 1-2	0.07	0.93
Child health			Variety (score) ages 1-2	0†	1†
Weight age 1	0.67	0.33	Child books ages 3-4	0.15	0.85
Arm circumference age 1	0.24	0.76	Books at home ages 3-4	0.06	0.94
Height age 1	0.79	0.21	Number of play materials ages 3-4	0.84	0.16
Weight age 2	0.71	0.29	Toys to learn colors ages 3-4	0.73	0.27
Arm circumference age 2	0.09	0.91	Games ages 3-4	0.52	0.48
Height age 2	0.69	0.31	Soft toys ages 3-4	0.69	0.31
Weight age 3	0.88	0.12	Toys to learn numbers ages 3-4	0.59	0.41
Arm circumference age 3	0.1	0.9	At least 10 child books ages 3-4	0.73	0.27
Height age 3	0.91	0.09	Mother activities with child ages 3-4	0.08	0.92
Weight age 4	0.73	0.27	Child books ages 5-6	0.13	0.87
Arm circumference age 4	0.25	0.75	Books at home ages 5-6	0.05	0.95
Height age 4	0.9	0.1	Number of play materials ages 5-6	0.82	0.18
Weight age 5	0.67	0.33	Toys to learn shapes ages 5-6	0.57	0.43
Arm circumference age 5	0.24	0.76	Puzzles ages 5-6	0.48	0.52
Height age 5	0.98	0.02	Toys for music ages 5-6	0.07	0.93
Weight age 6	0.81	0.19	Games ages 5-6	0.6	0.4
Arm circumference age 6	0.51	0.49	Soft toys ages 5-6	0.62	0.38
Height age 6	0.67	0.33	Toys to learn numbers ages 5-6	0.66	0.34
Weight age 7	0.79	0.21	At least 10 child books ages 5-6	0.28	0.72
Arm circumference age 7	0.55	0.45	Toys to learn names ages 5-6	0.46	0.54
Height age 7	0.64	0.36	Musical instruments ages 5-6	0.48	0.52

Notes: †0 and 1 reflect rounding

corresponding to these measures that we report in Table 2. We notice in particular, the high signal to noise ratio for the cognitive and the two language scales (expressive and receptive). Starting age 3, children are also administered the TVIP, which we use as our metric. From age 4, children are also administered the Woodcock- Munoz test and the ELSA test. While these measures perform reasonably well, the signal to noise ratio is not as high as that of the Bayleys or the TVIP.

For socio-emotional skills, children are administered several ASQ sub-scales. Unfortunately, the signal to noise ratio for several of these sub scales is relatively low. The relative low information provided by these measures is one of the reason that prevents us from having different socio-emotional factors.

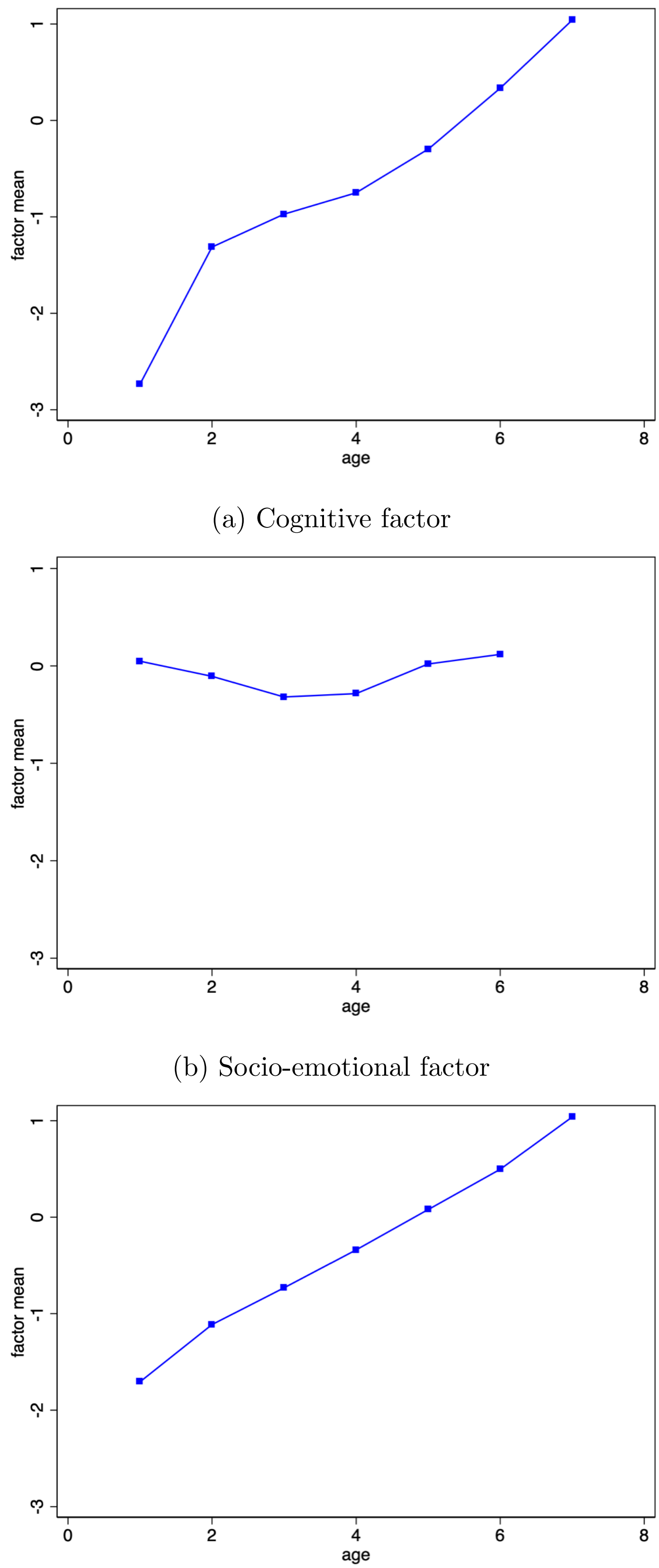
For health, the three measures we have are weight, height and arm circumfference. It is interesting to note that in the first few years of life, weight and height are very informative, while arm circumference starts to be somewhat informative at age 4 and becomes more imprtante past age 5.

Finally, for parental investment we have several measures from the widely used *Family Care Indicators* (FCI) test. As we can see from the table, several of these measures are good markers of parental investment and contain a substantial amount of information. However, we stress that all the items we use refer to material (rather than time) investment, for which we had information of very limited quality.

4.5 The Evolution of Child Development Over Time: Descriptive Evidence

As we estimate the measurent system for all the latent factors we consider and for all the ages in our sample, we effectively estimate the distribution of the latent factors we consider and how these distributions change with age. In Figure 1, we plot the means of the cognitive, socio-emotional and health factors, as implied by the estimated measurement system. We note that, while in estimating the measurement system we normalised to 1 the loading factors corresponding to one of the measures *at a certain age* for each of factors we are considering, we did not impose the same normalisation at different ages. An analogous procedure, as discussed above, was followed for one of the intercepts α^j, k's. This implies that the means of the factors are allowed to vary and possibly grow with age.

We observe that the mean of the cognitive factor, as to be expected, grows with age. The mean of the socio-emotional factor, however, is relatively flat: after a dip after age 1, it recovers after age 4, but the observed changes are not major. Finally, for health, the estimated means grow monotonically with age.

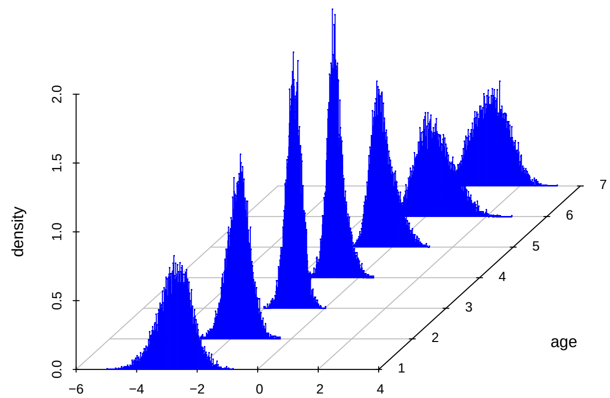


(a) Cognitive factor

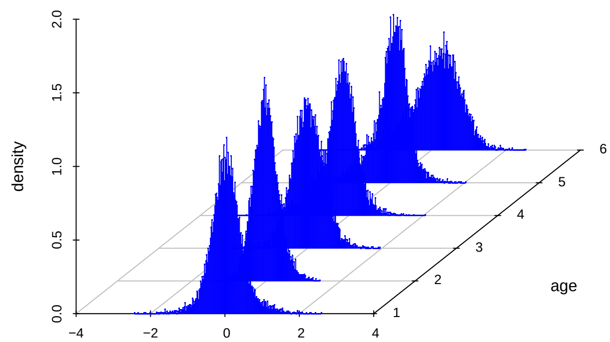
(b) Socio-emotional factor

(c) Health factor

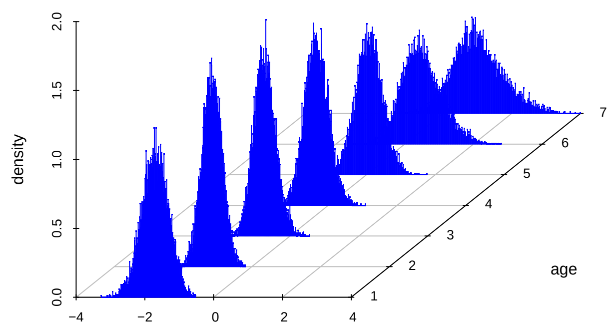
Figure 1: Latent Factors' Means Over Time



(a) Cognitive factor



(b) Socio-emotional factor



(c) Health factor

Figure 2: Latent Factors' Distributions Over Time

Table 3: Evolution of the latent factors standard deviations with age

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
Cognitive factor	0.55	0.36	0.26	0.29	0.41	0.60	0.60
Socio-emotional factor	0.45	0.35	0.43	0.51	0.47	0.65	-
Health factor	0.39	0.29	0.32	0.34	0.39	0.58	0.73

The means of the three factors of child development are not the only interesting moments to consider. Having estimated the entire distribution for our sample and how that distribution changes with age, it is interesting to consider this piece of evidence. In Figure 2, we plot the evolution of the distribution for the three factors we estimate over age, while, in Table 3, we report how the standard deviations of these factors change with age. We notice that, for the three factors and for all the ages considered, the estimated distributions are uni-modal. It is worth noticing that this feature is not imposed in estimation, as we assume that the distribution of the factors is given by a mixture of normal distributions. We also notice that, for the three factors, the dispersion of the distribution increases considerably at age 6. Interestingly, for the cognitive factor, the distribution at age 3 and 4 is considerably tighter.

5 Parental Investment and the Dynamics of Child Development

Having established what are the latent factors that we use in our empirical exercise, and having estimated a measurement system, we can proceed to use estimates of the distribution of the relevant factors from the available measures to estimate an investment function and a *production function* for the various dimensions of child development. This production function establishes the role played by parental investment and other factors in the process of development. Furthermore, it characterises the dynamics of the process and the interactions of different factors at different ages.

5.1 Investment Functions

The first use we make of the factor estimates obtained from the measurement system is to estimate the investment functions (7) discussed in section 2.3.2. In particular, we assume that at each age, parental investment is a function of the developmental status of the children (as measured by the three factors we consider), of parental cognition (as approximated by parental education), the number of children in the house, the gender of the target child, as well as income and wealth, household size and an indicator for the presence of the father. When interpreting these coefficients we should stress that this is material investment in the home, and therefore it excludes time investment as well as investments that parents might perceive their children receive in the nursery or school they attend. The results are reported in Table 4.

Starting with the reaction of parents to their children conditions, we find that the coefficient on cognition in the investment equations is not significantly different from zero at ages 2 , 3 and 5 and it is marginally significant and negative at age 4. This would seem to indicate that children with a lower cognitive development receive a bit more investment at age 4. The coefficients at age 6 and 7, however, identify a strongly significant and positive effect. It seems that at those ages, better developed children receive higher investment.

The coefficients on current socio-emotional skills are never statistically different from zero, with the marginal exception of age 6, where the effect is positive but only significant at the 10% level. Finally, the coefficient on health is marginally statistically positive at age 5 and is not different from zero at all other ages.

Parental cognition has a strong positive effect on investment, which is statistically significant at all ages. The coefficient increases with age and is particularly large at ages 6 and 7. The number of children in the household has a negative impact, which is significantly less then zero at alle ages until 5. We do not find any statistically significant effects of children gender on parental investment.

The presence of the father has a strong positive effect on parentaly investment, while total household size has a negative one. The coefficient on income is always positive and statistically different from zero. The significance of the income variable in the investment equation is important because income drives the identification of the investment coefficient in the production function. While, as we have discussed, the exclusion restriction that states that the impact of income on child investment only works through parental investment might be questionable, at least our instrument in not a *weak* one.

5.2 The Production Function of Human Development

Having estimated the investment function, we can move on to the estimates we obtain for the production function for the three factors we consider. In what follows, we report the results for the Cobb-Doublas specification. We have explored richer specifications, such as a Translog and a CES specification, but, in most cases, we could not reject

Table 4: Investment equations

	Investment equations					
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
Intercept	0.11	0.071	-0.264	-0.103	-0.155	-0.266
	0.206	0.165	0.097	0.103	0.085	0.077
	[-0.254,0.417]	[-0.221,0.327]	[-0.394,-0.071]	[-0.201,0.115]	[-0.252,0.028]	[-0.352,-0.092]
Cognition t	0.084	0.026	-0.099	0.115	0.147	0.093
	0.078	0.087	0.054	0.091	0.077	0.062
	[-0.045,0.205]	[-0.081,0.202]	[-0.198,-0.01]	[-0.014,0.268]	[0.035,0.279]	[-0.01,0.179]
Socio-emotional t	-0.231	-0.05	-0.027	-0.01	0.11	0.022
	0.29	0.114	0.036	0.051	0.07	0.049
	[-0.392,0.491]	[-0.163,0.199]	[-0.088,0.023]	[-0.071,0.088]	[0.027,0.25]	[-0.039,0.123]
Health t	0.045	0.201	0.085	0.118	0.018	0.043
	0.125	0.103	0.067	0.066	0.054	0.04
	[-0.155,0.248]	[-0.024,0.302]	[0,0.217]	[-0.001,0.216]	[-0.072,0.114]	[-0.016,0.118]
Parental Cognition	0.062	0.059	0.233	0.229	0.35	0.357
	0.125	0.114	0.067	0.064	0.092	0.095
	[0.011,0.405]	[0.007,0.377]	[0.144,0.345]	[0.14,0.341]	[0.191,0.489]	[0.192,0.493]
Number of Children	-0.259	-0.296	-0.314	-0.317	-0.329	-0.347
	0.115	0.083	0.058	0.059	0.072	0.071
	[-0.445,-0.057]	[-0.404,-0.143]	[-0.391,-0.197]	[-0.375,-0.177]	[-0.395,-0.157]	[-0.409,-0.176]
Gender	0	0.003	0.043	0.035	0.033	0.029
	0.034	0.031	0.026	0.026	0.031	0.032
	[-0.055,0.053]	[-0.043,0.055]	[-0.01,0.077]	[-0.015,0.069]	[-0.029,0.081]	[-0.04,0.072]
Income	0.185	0.197	0.233	0.232	0.175	0.179
	0.067	0.061	0.044	0.043	0.043	0.044
	[0.064,0.274]	[0.075,0.268]	[0.15,0.29]	[0.14,0.277]	[0.082,0.227]	[0.085,0.232]
Household size	-0.293	-0.295	-0.106	-0.091	-0.056	-0.063
	0.077	0.065	0.044	0.043	0.067	0.067
	[-0.414,-0.168]	[-0.39,-0.184]	[-0.166,-0.015]	[-0.146,-0.002]	[-0.156,0.057]	[-0.161,0.052]
Father present	0.149	0.145	0.126	0.135	0.104	0.12
	0.04	0.04	0.023	0.024	0.03	0.028
	[0.082,0.211]	[0.087,0.208]	[0.076,0.15]	[0.065,0.139]	[0.03,0.124]	[0.047,0.133]

Notes: This Table shows the estimates of the investment functions at different ages. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets.

the restrictions implied by the Cobb Douglas. And even when there were deviations from the Cobb-Douglas specification, the rejections were marginally significant and had relatively small quantitative implications. We therefore concluded that the Cobb-Douglas specification constitutes a good approximation to our data.

This approach allows us to focus on three important issues. First, whether allowing for endogenous investment makes a difference in practice. Second, whether a Markov structure, where child development depends on current development or a richer dynamic structure is necessary for the ages we consider. Third, we can study how the parameters of the production function change over time. These issues are particularly important to identify *windows of opportunities* for potential interventions.

For the three dimensions of child development (cognition, socio-emotional skills and health) we have two tables: one in which we consider only the current level of the relevant domain and one when we add an additional lag of the relevant domain. In all cases we also consider the effect of other current domains on the relevant domain (for instance the effect of current socio-emotional skills and health on cognitive development). While we did explore the possibility of additional lags in these cross-effects, as we did not find any significant effects of this type, we do not report those results to avoid crowding the tables and making the estimates less precise.

In each of the tables below, we consider two panels, the left one in which the endogeneity of investment is ignored and the right one where we use the control function approach discussed above. This structure will allow us to consider both the importance of considering richer dynamics and the importance of considering endogenous investment. On this last issue, we should stress that we are limited by the nature of the data in terms of the instruments we can sue. Effectivelly, our only alternative is to take the model we sketched in Section 2.3.2 literally and use parental income (which enters the budget constraint but not the production function) as an instrument. This choice can obviously be criticised, as income might be correlated with omitted inputs in the production function. Having said that, we notice that while in another data set from Colombia, Attanasio, Cattan, Fitzsimons, Meghir, and Rubio-Codina (2020) use prices and exposure to conflict (which vary across localities) as exclusion restrictions to identify the impact of parental investment. Their results do not change much when they use only household resources, measured in a way similar to the variables we use, as an instrument.

5.2.1 Cognition at Different Ages

We start with a discussion of the results we obtain for the production function of cognitive development. The estimation results are reported in Tables 5 and 6. The left panel of the Tables contains the OLS estimates, which ignore the endogeneity of maternal investment, while the right-hand-side panel reports the estimates of the production function which include the control function derived from the investment function in Table 4. Table 5 contains the estimates of a specification that, for each age, allows only one lag of different dimensions of development in the production function for cognitive skills, while Table 6 allows for an additional lag of cognitive skills.[14]

[14] As mentioned above, we tried specifications with additional lags in the other two dimensions we consider (health and socio-emotional skills), but none of the coefficients was signiticantly different

Finally, we notice that the two panels report the estimates obtained at each age between 2 and 7. The estimation of a production function for child development at this frequency is an important novelty of our paper and it is important as it helps to identify ages and periods in which investment might be particularly important, as we discuss in the next session. It also identifies the ages when the current state of development becomes particularly relevant for subsequent development.

We first notice that the dynamics of the process changes considerably with age, as can be deduced from the coefficient on lagged cognitive development. Up to age 4 included, the coefficient on lagged cognition are significantly different from zero, but the process is far from being very persistent, with coefficients around 0.3. This result holds both in the OLS and CF estimates and whether an additional lag is included or not. At age 5, however, the coefficient on lagged cognition increases considerably and become close to 1. At ages 6 and 7, the dynamics becomes more complex, as the coefficient on the second lag is also significantly different from zero and negative. The sum of the two coefficients is, from age 5 onward, close to 1.[15]

The coefficients on lagged socio-emotional skills are never significant. Instead, the coefficient on lagged health status is, at some ages, significant and important: lagged health seems to be important for cognitive development in particular at ages 2 and 4. At age 3, the coefficient on lagged health is also marginally significant, although considerably smaller in size than at the two adjecent ages. As we will see in the next section, these results turn out to be important for the dynamic targeting of investment and interventions.

Turning to the coefficients on parental investment, we notice that this variable appears significant and important only between ages 2 and 4. At this ages, we notice that the size of the coefficient at ages 3 and 4 doubles when we consider investment as endogenous, a result that is consistent with those in Attanasio, Cattan, Fitzsimons, Meghir, and Rubio-Codina (2020), Attanasio, Meghir, and Nix (2020) and Attanasio, Meghir, Nix, and Salvati (2017). Perhaps surprisingly, the coefficient on parental investment at age 5 and older is not significantly different from zero. This result holds regardless of whether we treat investment as endogenous or not and regardless of the dynamic structure imposed on the production function. Moreover, the fact that the coefficient is not different from zero is not driven by an decrease in the precision of the estimates, but by a clear reduction of the point estimates.

from zero. These results are available upon request.

[15] At age 2, we cannot have two lags of cognitive development for obvious reasons.

Table 5: Production functions for cognitive skills

	Cognitive t+1											
	Exogenous investments						Endogenous investments					
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
TFP	-0.19	0.155	-0.135	0.44	0.552	0.74	-0.29	0.027	-0.176	0.481	0.548	0.739
	0.16	0.11	0.03	0.054	0.043	0.05	0.154	0.114	0.044	0.07	0.05	0.05
	[-0.443,0.079]	[0.048,0.402]	[-0.191,-0.098]	[0.341,0.517]	[0.486,0.624]	[0.651,0.811]	[-0.52,-0.037]	[-0.097,0.299]	[-0.278,-0.145]	[0.37,0.588]	[0.456,0.626]	[0.649,0.813]
Control function	-	-	-	-	-	-	-0.22	-0.268	-0.132	0.133	-0.028	-0.061
							0.145	0.102	0.098	0.113	0.161	0.12
							[-0.423,0.036]	[-0.43,-0.127]	[-0.366,-0.053]	[-0.017,0.333]	[-0.272,0.193]	[-0.223,0.158]
AeioTu	-0.13	0.034	0.03	0.068	0.025	0.05	-0.11	0.046	0.03	0.068	0.026	0.056
	0.081	0.056	0.013	0.018	0.045	0.042	0.078	0.051	0.013	0.018	0.046	0.045
	[-0.217,0.038]	[-0.048,0.125]	[0.007,0.047]	[0.026,0.09]	[-0.048,0.099]	[-0.004,0.122]	[-0.208,0.046]	[-0.036,0.129]	[0.007,0.046]	[0.026,0.088]	[-0.051,0.093]	[-0.005,0.134]
Cognitive t	0.3	0.501	0.436	1.021	1.138	0.908	0.3	0.494	0.423	1.051	1.133	0.898
	0.067	0.081	0.039	0.085	0.059	0.048	0.067	0.082	0.042	0.1	0.072	0.054
	[0.229,0.442]	[0.449,0.692]	[0.372,0.498]	[0.879,1.141]	[1.01,1.205]	[0.805,0.954]	[0.221,0.442]	[0.421,0.678]	[0.349,0.487]	[0.901,1.207]	[0.982,1.22]	[0.79,0.969]
Socio-emotional t	0.08	0.158	0.058	-0.06	0.007	0.058	0.08	0.121	0.046	-0.043	0.002	0.053
	0.103	0.075	0.023	0.031	0.036	0.043	0.101	0.074	0.028	0.035	0.049	0.044
	[-0.007,0.335]	[0.018,0.263]	[0.008,0.085]	[-0.089,0.014]	[-0.074,0.044]	[-0.001,0.133]	[-0.014,0.326]	[-0.022,0.215]	[-0.017,0.071]	[-0.071,0.038]	[-0.1,0.063]	[-0.012,0.139]
Health t	0.39	0.238	0.293	0.006	-0.065	-0.062	0.35	0.161	0.267	0.024	-0.066	-0.066
	0.12	0.103	0.048	0.063	0.044	0.034	0.116	0.097	0.055	0.063	0.045	0.035
	[0.134,0.512]	[0.051,0.366]	[0.193,0.362]	[-0.087,0.108]	[-0.119,0.021]	[-0.095,0.011]	[0.108,0.478]	[-0.003,0.319]	[0.156,0.327]	[-0.067,0.137]	[-0.123,0.02]	[-0.103,0.009]
Parental cognition	0.02	0.013	0.102	-0.011	-0.031	0.101	0	-0.008	0.061	0.025	-0.04	0.079
	0.089	0.054	0.031	0.036	0.045	0.045	0.089	0.061	0.044	0.046	0.068	0.064
	[-0.017,0.233]	[-0.011,0.142]	[0.058,0.159]	[-0.051,0.065]	[-0.085,0.064]	[-0.008,0.142]	[-0.047,0.223]	[-0.103,0.063]	[-0.027,0.118]	[-0.023,0.121]	[-0.138,0.086]	[-0.045,0.16]
Investments	0.2	0.091	0.111	0.043	-0.05	-0.005	0.27	0.231	0.203	-0.057	-0.03	0.036
	0.085	0.068	0.041	0.042	0.053	0.045	0.12	0.103	0.092	0.103	0.145	0.097
	[-0.017,0.28]	[-0.035,0.184]	[0.061,0.191]	[-0.06,0.081]	[-0.129,0.045]	[-0.032,0.106]	[-0.032,0.376]	[0.082,0.387]	[0.134,0.418]	[-0.273,0.04]	[-0.234,0.232]	[-0.113,0.19]

Notes: This table shows the estimates of the production function for cognitive skills. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets. Controls also include child age, gender, and the number of children in the household (see Table 11 for coefficients on these covariates).

Table 6: Production functions for cognitive skills with two self-productivity lags

	Cognitive t+1											
	Exogenous investments						Endogenous investments					
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
TFP	-0.19	0.202	-0.056	0.44	0.422	0.483	-0.29	0.097	-0.098	0.484	0.389	0.478
	0.16	0.102	0.043	0.047	0.073	0.109	0.154	0.101	0.047	0.062	0.083	0.11
	[-0.443,0.079]	[0.1,0.426]	[-0.121,0.012]	[0.353,0.505]	[0.342,0.575]	[0.527,0.876]	[-0.52,-0.037]	[-0.016,0.326]	[-0.199,-0.044]	[0.386,0.574]	[0.298,0.565]	[0.516,0.871]
Control function	-	-	-	-	-	-	-0.22	-0.303	-0.147	0.136	-0.135	-0.077
							0.145	0.107	0.093	0.112	0.157	0.122
							[-0.423,0.036]	[-0.459,-0.124]	[-0.361,-0.066]	[-0.011,0.327]	[-0.395,0.12]	[-0.235,0.145]
AeioTu	-0.13	0.034	0.056	0.068	0.006	0.046	-0.11	0.048	0.057	0.068	0.01	0.054
	0.081	0.057	0.016	0.018	0.046	0.043	0.078	0.051	0.016	0.018	0.047	0.045
	[-0.217,0.038]	[-0.049,0.127]	[0.028,0.08]	[0.025,0.089]	[-0.061,0.085]	[-0.009,0.125]	[-0.208,0.046]	[-0.044,0.127]	[0.028,0.081]	[0.026,0.087]	[-0.055,0.087]	[-0.013,0.132]
Cognitive t	0.3	0.469	0.319	1.022	1.281	1.321	0.3	0.435	0.3	1.044	1.271	1.315
	0.067	0.124	0.069	0.124	0.092	0.178	0.067	0.125	0.071	0.133	0.098	0.181
	[0.229,0.442]	[0.379,0.741]	[0.204,0.427]	[0.808,1.215]	[1.072,1.365]	[0.69,1.211]	[0.221,0.442]	[0.348,0.707]	[0.161,0.403]	[0.834,1.27]	[1.046,1.362]	[0.683,1.213]
Cognitive t-1	-	0.046	0.155	0	-0.248	-0.507	-	0.084	0.162	0.011	-0.275	-0.514
		0.076	0.066	0.073	0.115	0.199		0.075	0.065	0.073	0.117	0.202
		[-0.094,0.134]	[0.067,0.276]	[-0.12,0.101]	[-0.365,0.019]	[-0.377,0.205]		[-0.077,0.147]	[0.071,0.279]	[-0.111,0.121]	[-0.402,-0.014]	[-0.39,0.202]
Socio-emotional t	0.08	0.161	0.049	-0.06	0.053	0.082	0.08	0.123	0.035	-0.043	0.034	0.076
	0.103	0.077	0.023	0.031	0.044	0.042	0.101	0.075	0.027	0.035	0.052	0.043
	[-0.007,0.335]	[0.02,0.264]	[-0.002,0.074]	[-0.088,0.014]	[-0.061,0.085]	[0.006,0.143]	[-0.014,0.326]	[-0.017,0.216]	[-0.027,0.06]	[-0.072,0.039]	[-0.096,0.067]	[-0.012,0.14]
Health t	0.39	0.213	0.269	0.006	-0.03	-0.037	0.35	0.107	0.238	0.02	-0.032	-0.041
	0.12	0.1	0.047	0.051	0.045	0.035	0.116	0.095	0.054	0.053	0.046	0.036
	[0.134,0.512]	[0.034,0.355]	[0.178,0.339]	[-0.066,0.111]	[-0.099,0.044]	[-0.095,0.015]	[0.108,0.478]	[-0.017,0.271]	[0.132,0.309]	[-0.055,0.124]	[-0.105,0.044]	[-0.1,0.018]
Parental cognition	0.02	0.016	0.092	-0.011	0.006	0.12	0	-0.006	0.045	0.026	-0.035	0.092
	0.089	0.059	0.029	0.036	0.048	0.048	0.089	0.062	0.041	0.046	0.067	0.067
	[-0.017,0.233]	[-0.01,0.161]	[0.046,0.144]	[-0.054,0.064]	[-0.065,0.096]	[-0.009,0.149]	[-0.047,0.223]	[-0.092,0.087]	[-0.038,0.094]	[-0.023,0.117]	[-0.14,0.085]	[-0.048,0.171]
Investments	0.2	0.095	0.117	0.043	-0.06	0.02	0.27	0.258	0.221	-0.058	0.036	0.072
	0.085	0.068	0.038	0.044	0.053	0.046	0.12	0.106	0.086	0.103	0.143	0.099
	[-0.017,0.28]	[-0.038,0.176]	[0.066,0.194]	[-0.068,0.083]	[-0.131,0.049]	[-0.036,0.118]	[-0.032,0.376]	[0.088,0.401]	[0.147,0.416]	[-0.275,0.042]	[-0.165,0.297]	[-0.096,0.221]

Notes: This Table shows the estimates of the production function for cognitive skills. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets. Controls also include child age, gender, and the number of children in the household (see Table 12 for coefficients on these covariates).

Parental background does not seem to have a direct and significant role in the production function of cognitive development. We notice, however, that it does play an important role in parental investment, so that its effect on child development is mediated through investment, a result consistent with what reported by Attanasio, Cattan, Fitzsimons, Meghir, and Rubio-Codina (2020). Finally, we notice that the intervention that changed the nature of the care the children received in the nursery they were attending, has a positive and significant, although moderate, effect at ages 4 and 5. The point estimates of the effect at age 7 is of similar magnitude but, as the estimate is less precise, it is not statistically significant.

5.2.2 Socio-emotional Skills at Different Ages

We now move to the results obtained in estimating the production function for socio-emotional skills. We report the results in Tables 7 and 8 in a fashion similar to the results for the production function of cognitive skills, except for the fact that, due to the availability of appropriate measures, we only consider socio-emotional skills up to age 6. Before delving into a discussion of our estimates, it may be worth mentioning that the quality of the available measures of socio-emotional skills is not as high as that of other dimensions of development, as can be inferred from Table 2. For only two measures (one at age 1 and one at age 5) the signal to noise ration is above 0.5. As a consequence, our estimates are likely to be less informative and precise.

Starting with the dynamics of the process, we notice that lagged cognitive skills and health are never significant in either tables. As for lagged socio-emotional skills, we notice that the persistence of the process does not increase monotonically with age as with cognitive skills. In Table 7 the coefficient on lagged socio-emotional skills is around 0.3, with the exception of age 3, where is estimated (rather imprecisely) at 0.7. As for richer dynamics, Table 8 shows that the coefficient on the second lag is only significant at age 5 and, unlike for cognitive skills, is positive, although not very large.

Moving on to the investment coefficients, we see that the control function is almost always significantly, providing evidence for the endogeneity of investment. As the coefficient on the control function is negative, considering investment as endogenous increases (considerably) the size of its effect. In Table 7, for instance, at age 4 the point estimate of the investment coefficient goes from 0.135 to 0.506. Interestingly, the size of the coefficient on parental investment does not decline significantly with age, unlike with cognitive skills, where at age 5 and older, it was effectively zero. In this case, at age 5 is still very high at 0.654. At age 6, it drop s to 0.354 but it is still significant.

Table 7: Production functions for socio-emotional skills

	Socio-emotional t+1									
	Exogenous investments					Endogenous investments				
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 2	Age 3	Age 4	Age 5	Age 6
TFP	0.4	0.104	0.217	0.312	0.286	0.11	-0.12	0.054	0.09	0.236
	0.303	0.408	0.07	0.064	0.079	0.326	0.409	0.104	0.108	0.089
	[-0.143,0.812]	[-0.596,0.706]	[0.1,0.327]	[0.222,0.451]	[0.158,0.407]	[-0.483,0.597]	[-0.893,0.355]	[-0.141,0.175]	[-0.102,0.251]	[0.102,0.377]
Control function	-	-	-	-	-	-0.62	-0.471	-0.529	-0.728	-0.356
						0.279	0.263	0.237	0.273	0.348
						[-0.979,-0.097]	[-1.045,-0.244]	[-0.955,-0.241]	[-1.288,-0.368]	[-0.947,0.169]
AeioTu	-0.12	0.13	-0.007	-0.115	-0.001	-0.08	0.151	-0.006	-0.117	0.017
	0.181	0.162	0.038	0.031	0.1	0.173	0.156	0.037	0.031	0.106
	[-0.375,0.234]	[-0.305,0.219]	[-0.072,0.05]	[-0.175,-0.072]	[-0.195,0.116]	[-0.343,0.244]	[-0.25,0.218]	[-0.07,0.046]	[-0.172,-0.071]	[-0.201,0.154]
Cognitive t	-0.15	-0.007	0.216	0.099	0.217	-0.16	-0.019	0.167	-0.064	0.151
	0.131	0.206	0.076	0.078	0.088	0.133	0.206	0.088	0.129	0.118
	[-0.369,0.05]	[-0.552,0.138]	[0.062,0.319]	[-0.019,0.224]	[0.072,0.359]	[-0.391,0.035]	[-0.577,0.121]	[-0.019,0.282]	[-0.321,0.083]	[-0.044,0.33]
Socio-emotional t	0.28	0.77	0.41	0.436	0.378	0.26	0.707	0.361	0.345	0.316
	0.159	0.216	0.077	0.067	0.092	0.148	0.229	0.089	0.075	0.109
	[0.118,0.609]	[0.304,0.983]	[0.332,0.568]	[0.332,0.543]	[0.242,0.548]	[0.106,0.538]	[0.208,0.912]	[0.258,0.538]	[0.211,0.454]	[0.148,0.495]
Health t	0.42	0.09	0.156	0.242	0.103	0.31	-0.044	0.05	0.144	0.09
	0.176	0.198	0.082	0.068	0.073	0.184	0.21	0.087	0.086	0.077
	[0.122,0.685]	[-0.106,0.556]	[0.051,0.315]	[0.16,0.38]	[-0.017,0.219]	[0.012,0.605]	[-0.287,0.425]	[-0.077,0.208]	[0.022,0.296]	[-0.069,0.201]
Parental cognition	0.04	-0.021	0.083	0.115	0.206	-0.01	-0.058	-0.084	-0.079	0.088
	0.111	0.129	0.068	0.056	0.089	0.152	0.146	0.095	0.094	0.149
	[-0.071,0.291]	[-0.054,0.37]	[-0.068,0.15]	[0.03,0.217]	[0.054,0.336]	[-0.323,0.145]	[-0.309,0.103]	[-0.309,-0.007]	[-0.231,0.06]	[-0.172,0.287]
Investments	0.41	0.167	0.135	0.108	0.095	0.6	0.415	0.506	0.654	0.354
	0.163	0.137	0.068	0.083	0.099	0.232	0.246	0.203	0.243	0.286
	[0.104,0.593]	[-0.052,0.386]	[0.043,0.264]	[-0.054,0.202]	[-0.049,0.257]	[0.259,0.944]	[0.223,0.989]	[0.256,0.92]	[0.368,1.136]	[-0.049,0.869]

Notes: This Table shows the estimates of the production function for socio-emotional skills. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets. Controls also include child age, gender, and the number of children in the household (see Table 13 for coefficients on these covariates).

Table 8: Production functions for socio-emotional skills with two self-productivity lags

	Socio-emotional t+1									
	Exogenous investments					Endogenous investments				
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 2	Age 3	Age 4	Age 5	Age 6
TFP	0.4	0.03	0.175	0.316	0.31	0.11	-0.079	0.06	0.107	0.272
	0.303	0.535	0.076	0.065	0.078	0.326	0.508	0.102	0.106	0.088
	[-0.143,0.812]	[-0.997,0.783]	[0.034,0.271]	[0.226,0.438]	[0.195,0.452]	[-0.483,0.597]	[-1.126,0.534]	[-0.133,0.177]	[-0.053,0.268]	[0.159,0.424]
Control function	-	-	-	-	-	-0.62	-0.258	-0.447	-0.683	-0.242
						0.279	0.243	0.25	0.268	0.347
						[-0.979,-0.097]	[-0.747,0.012]	[-0.935,-0.127]	[-1.228,-0.303]	[-0.749,0.369]
AeioTu	-0.12	0.147	0.035	-0.1	0.01	-0.08	0.158	0.012	-0.105	0.021
	0.181	0.15	0.038	0.033	0.097	0.173	0.148	0.039	0.034	0.102
	[-0.375,0.234]	[-0.222,0.24]	[-0.034,0.093]	[-0.158,-0.05]	[-0.18,0.125]	[-0.343,0.244]	[-0.217,0.271]	[-0.058,0.062]	[-0.16,-0.059]	[-0.191,0.142]
Cognitive t	-0.15	-0.041	0.212	0.093	0.17	-0.16	-0.04	0.173	-0.059	0.133
	0.131	0.272	0.077	0.081	0.094	0.133	0.266	0.088	0.124	0.116
	[-0.369,0.05]	[-0.721,0.182]	[0.051,0.31]	[-0.032,0.23]	[-0.003,0.312]	[-0.391,0.035]	[-0.716,0.138]	[-0.018,0.282]	[-0.286,0.1]	[-0.064,0.313]
Socio-emotional t	0.28	0.728	0.39	0.338	0.314	0.26	0.702	0.36	0.275	0.282
	0.159	0.211	0.085	0.076	0.103	0.148	0.224	0.09	0.078	0.111
	[0.118,0.609]	[0.245,0.918]	[0.293,0.557]	[0.193,0.448]	[0.149,0.484]	[0.106,0.538]	[0.173,0.887]	[0.248,0.534]	[0.116,0.369]	[0.099,0.46]
Socio-emotional t-1	-	0.087	0.171	0.114	0.164	-	0.066	0.075	0.088	0.139
		0.246	0.093	0.079	0.119		0.246	0.096	0.078	0.125
		[-0.265,0.61]	[0.034,0.3]	[0.054,0.283]	[0.013,0.393]		[-0.243,0.588]	[-0.081,0.215]	[0.015,0.242]	[-0.024,0.383]
Health t	0.42	0.078	0.118	0.263	0.093	0.31	0.005	0.05	0.166	0.086
	0.176	0.203	0.083	0.071	0.072	0.184	0.21	0.085	0.087	0.074
	[0.122,0.685]	[-0.121,0.555]	[0.003,0.268]	[0.162,0.397]	[-0.025,0.205]	[0.012,0.605]	[-0.246,0.468]	[-0.073,0.203]	[0.031,0.318]	[-0.043,0.196]
Parental cognition	0.04	-0.024	0.065	0.111	0.178	-0.01	-0.044	-0.066	-0.07	0.102
	0.111	0.112	0.066	0.055	0.088	0.152	0.122	0.097	0.09	0.144
	[-0.071,0.291]	[-0.097,0.249]	[-0.084,0.13]	[0.016,0.203]	[0.007,0.302]	[-0.323,0.145]	[-0.256,0.101]	[-0.28,0.018]	[-0.227,0.062]	[-0.148,0.312]
Investments	0.41	0.173	0.044	0.082	0.081	0.6	0.311	0.409	0.6	0.259
	0.163	0.15	0.071	0.089	0.095	0.232	0.22	0.22	0.247	0.28
	[0.104,0.593]	[-0.029,0.45]	[-0.042,0.199]	[-0.101,0.171]	[-0.067,0.245]	[0.259,0.944]	[0.087,0.843]	[0.204,0.895]	[0.222,1.072]	[-0.189,0.697]

Notes: This Table shows the estimates of the production function for socio-emotional skills. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets. Controls also include child age, gender, and the number of children in the household (see Table 14 for coefficients on these covariates).

We also notice that when considering parental investment as endogenous, parental cognition is not significant in the production function, a result that mirrors the one for cognitive skills.

5.2.3 Health at Different Ages

We now discuss the estimates of the production function of the health dimension of child development. Again we report two different tables, Tables 9 and 10, the first with just one lag of the three dimensions of development we are considering and the second with an additional lag for health. In each of the two Tables, the left panel consider parental investment as exogenous while on the right panel we use the control function approach to account for the possible endogeneity of investments. As for cognition, we estimate the function for ages 2 to 7.

Starting with the discussion of the dynamic properties, we notice that at some ages, both socio-emotional and cognitive skills appear marginally significant. However, the size of these coefficients is quite small, so that their effect is at best marginal. Lagged health status, however, is very important, signaling a strong persistence of the process. Already aat age 2, the coefficient is larger than 0.7. At older ages, the coefficient reaches 1. At ages 5, 6 and 7, the additional lag attracts a negative and sizeable coefficient, which, for ages 6 and 7, is significantly different from zero. At these ages, the sum of the coefficients on the two lags of health is close to 1. The process, therefore, seems to have a complex dynamics.

Moving to the effect of parental investment, we notice that the only age at which it is productive is age 2, when it also seems to be the only age at which it should be considered as endogenous. As with other estimates of production functions, the control function takes a negative sign at age 2, so that its introduction increases the estimate of the coefficient on parental investment from 0.27 to 0.37. Past age 2, parental investment does not attract coefficients significantly different from zero.

Finally, we notice that neither the *aeioTU* intervention nor parental cognition have a direct effect in the health production function, except at ages 6 and 7, when the intervention is marginally significant. For parental cognition, we remind the reader that it has an important effect on parental investment, which in turn is significant at age 2. We also notice that, given the high persistence of the process, an impact at an early age, can be traced in subsequent outcomes.

Table 9: Production functions for health

	Health t+1											
	Exogenous investments						Endogenous investments					
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
TFP	0.1	0.382	0.347	0.38	0.331	0.496	-0.06	0.402	0.368	0.353	0.35	0.497
	0.145	0.062	0.017	0.021	0.026	0.026	0.135	0.071	0.021	0.025	0.033	0.027
	[-0.14,0.319]	[0.252,0.449]	[0.323,0.379]	[0.338,0.407]	[0.305,0.391]	[0.455,0.538]	[-0.288,0.166]	[0.235,0.47]	[0.341,0.409]	[0.307,0.391]	[0.323,0.425]	[0.455,0.539]
Control function	-	-	-	-	-	-	-0.33	0.042	0.067	-0.09	0.132	0.033
							0.116	0.061	0.037	0.046	0.137	0.098
							[-0.473,-0.119]	[-0.102,0.106]	[0.015,0.128]	[-0.13,0.011]	[-0.012,0.433]	[-0.061,0.236]
AeioTu	-0.03	0.004	0.005	0.005	0.069	0.105	0	0.002	0.005	0.005	0.062	0.102
	0.061	0.042	0.005	0.007	0.032	0.028	0.05	0.041	0.005	0.007	0.032	0.03
	[-0.104,0.086]	[-0.069,0.059]	[-0.002,0.016]	[-0.009,0.014]	[0.004,0.105]	[0.05,0.137]	[-0.076,0.076]	[-0.068,0.06]	[-0.002,0.016]	[-0.01,0.014]	[-0.005,0.097]	[0.04,0.133]
Cognitive t	-0.02	0.061	0.002	-0.13	-0.1	-0.122	-0.03	0.062	0.008	-0.151	-0.075	-0.117
	0.063	0.1	0.022	0.033	0.038	0.033	0.062	0.098	0.022	0.036	0.049	0.036
	[-0.108,0.096]	[-0.043,0.268]	[-0.037,0.037]	[-0.191,-0.086]	[-0.152,-0.031]	[-0.177,-0.072]	[-0.108,0.093]	[-0.043,0.26]	[-0.03,0.044]	[-0.214,-0.093]	[-0.126,0.026]	[-0.171,-0.05]
Socio-emotional t	-0.01	0.069	0.026	0.042	-0.037	-0.035	-0.02	0.075	0.032	0.031	-0.014	-0.032
	0.098	0.052	0.011	0.014	0.036	0.027	0.087	0.05	0.014	0.016	0.049	0.028
	[-0.1,0.225]	[0.003,0.18]	[0.006,0.041]	[0.009,0.055]	[-0.088,0.028]	[-0.085,0.005]	[-0.1,0.187]	[0.006,0.169]	[0.012,0.057]	[-0.005,0.052]	[-0.07,0.079]	[-0.078,0.021]
Health t	0.77	0.892	0.95	1.107	1.196	1.237	0.71	0.904	0.963	1.095	1.202	1.239
	0.107	0.155	0.028	0.034	0.043	0.034	0.097	0.162	0.03	0.034	0.045	0.036
	[0.533,0.872]	[0.543,1.036]	[0.914,1.009]	[1.051,1.164]	[1.103,1.249]	[1.173,1.291]	[0.495,0.822]	[0.522,1.056]	[0.925,1.022]	[1.047,1.159]	[1.11,1.263]	[1.181,1.301]
Parental cognition	0	-0.006	-0.023	0.029	-0.017	-0.071	-0.03	-0.002	-0.002	0.005	0.027	-0.06
	0.071	0.029	0.015	0.02	0.035	0.032	0.058	0.031	0.018	0.023	0.063	0.049
	[-0.017,0.189]	[-0.026,0.062]	[-0.047,0.003]	[-0.013,0.052]	[-0.075,0.031]	[-0.123,-0.017]	[-0.062,0.095]	[-0.028,0.062]	[-0.03,0.03]	[-0.04,0.036]	[-0.049,0.16]	[-0.118,0.034]
Investments	0.27	-0.017	0.045	-0.048	-0.043	-0.009	0.37	-0.039	-0.002	0.02	-0.139	-0.031
	0.073	0.045	0.019	0.022	0.04	0.035	0.083	0.064	0.034	0.041	0.13	0.082
	[0.061,0.301]	[-0.061,0.082]	[0.01,0.069]	[-0.059,0.014]	[-0.102,0.023]	[-0.053,0.061]	[0.18,0.443]	[-0.117,0.099]	[-0.063,0.046]	[-0.038,0.101]	[-0.401,0.006]	[-0.196,0.061]

Notes: This Table shows the estimates of the production function for health. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets. Controls also include child age, gender, and the number of children in the household (see Table 15 for coefficients on these covariates).

Table 10: Production functions for health with two self-productivity lags

	Health t+1											
	Exogenous investments						Endogenous investments					
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
TFP	0.1	0.394	0.298	0.256	0.076	0.376	-0.06	0.407	0.318	0.222	0.08	0.371
	0.145	0.065	0.026	0.072	0.095	0.059	0.135	0.068	0.028	0.079	0.097	0.062
	[-0.14,0.319]	[0.252,0.472]	[0.261,0.347]	[0.298,0.53]	[-0.022,0.28]	[0.306,0.486]	[-0.288,0.166]	[0.249,0.479]	[0.282,0.369]	[0.266,0.517]	[-0.003,0.3]	[0.301,0.498]
Control function	-	-	-	-	-	-	-0.33	0.034	0.06	-0.1	0.204	-0.032
							0.116	0.07	0.038	0.048	0.12	0.099
							[-0.473,-0.119]	[-0.112,0.101]	[0.002,0.12]	[-0.13,0.018]	[0.027,0.411]	[-0.125,0.184]
AeioTu	-0.03	0.004	0.009	0.001	0.028	0.074	0	0.003	0.009	0.001	0.014	0.076
	0.061	0.042	0.006	0.007	0.03	0.029	0.05	0.042	0.006	0.007	0.03	0.03
	[-0.104,0.086]	[-0.068,0.058]	[0.002,0.02]	[-0.008,0.014]	[-0.026,0.068]	[0.029,0.121]	[-0.076,0.076]	[-0.069,0.059]	[0.002,0.021]	[-0.008,0.014]	[-0.034,0.061]	[0.027,0.119]
Cognitive t	-0.02	0.05	0.012	-0.092	-0.032	-0.092	-0.03	0.054	0.017	-0.113	0.012	-0.096
	0.063	0.084	0.023	0.042	0.041	0.033	0.062	0.082	0.023	0.043	0.048	0.036
	[-0.108,0.096]	[-0.069,0.212]	[-0.031,0.047]	[-0.22,-0.077]	[-0.091,0.042]	[-0.157,-0.045]	[-0.108,0.093]	[-0.062,0.203]	[-0.025,0.054]	[-0.24,-0.094]	[-0.054,0.095]	[-0.158,-0.044]
Socio-emotional t	-0.01	0.067	0.025	0.038	-0.007	-0.01	-0.02	0.072	0.031	0.025	0.031	-0.012
	0.098	0.051	0.012	0.014	0.039	0.029	0.087	0.049	0.014	0.017	0.045	0.028
	[-0.1,0.225]	[0.002,0.168]	[0.005,0.041]	[0.008,0.056]	[-0.058,0.063]	[-0.068,0.032]	[-0.1,0.187]	[0.005,0.153]	[0.008,0.053]	[-0.004,0.054]	[-0.03,0.113]	[-0.063,0.028]
Health t	0.77	0.857	1.051	1.472	1.752	1.546	0.71	0.876	1.06	1.47	1.815	1.554
	0.107	0.233	0.066	0.215	0.208	0.152	0.097	0.248	0.067	0.217	0.206	0.16
	[0.533,0.872]	[0.381,1.119]	[0.955,1.175]	[0.639,1.327]	[1.278,1.97]	[1.26,1.744]	[0.495,0.822]	[0.334,1.132]	[0.965,1.186]	[0.654,1.335]	[1.323,2.006]	[1.226,1.743]
Health t-1	-	0.041	-0.117	-0.385	-0.698	-0.396	-	0.03	-0.113	-0.397	-0.766	-0.409
		0.144	0.06	0.223	0.252	0.176		0.149	0.061	0.228	0.249	0.191
		[-0.178,0.272]	[-0.214,-0.021]	[-0.219,0.491]	[-0.976,-0.155]	[-0.626,-0.066]		[-0.192,0.286]	[-0.208,-0.02]	[-0.229,0.488]	[-1.005,-0.193]	[-0.635,-0.018]
Parental cognition	0	-0.006	-0.019	0.034	0.012	-0.063	-0.03	-0.003	0	0.007	0.082	-0.074
	0.071	0.033	0.016	0.02	0.036	0.033	0.058	0.032	0.019	0.023	0.056	0.045
	[-0.017,0.189]	[-0.026,0.079]	[-0.041,0.011]	[-0.015,0.05]	[-0.053,0.056]	[-0.116,-0.008]	[-0.062,0.095]	[-0.028,0.063]	[-0.027,0.034]	[-0.038,0.036]	[-0.015,0.172]	[-0.119,0.014]
Investments	0.27	-0.009	0.047	-0.068	-0.027	0.015	0.37	-0.029	0.005	0.007	-0.174	0.036
	0.073	0.053	0.019	0.028	0.037	0.038	0.083	0.081	0.034	0.042	0.109	0.081
	[0.061,0.301]	[-0.069,0.095]	[0.01,0.073]	[-0.065,0.025]	[-0.089,0.028]	[-0.039,0.076]	[0.18,0.443]	[-0.119,0.141]	[-0.059,0.053]	[-0.035,0.107]	[-0.382,-0.037]	[-0.122,0.122]

Notes: This Table shows the estimates of the production function for health. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets. Controls also include child age, gender, and the number of children in the household (see Table 16 for coefficients on these covariates).

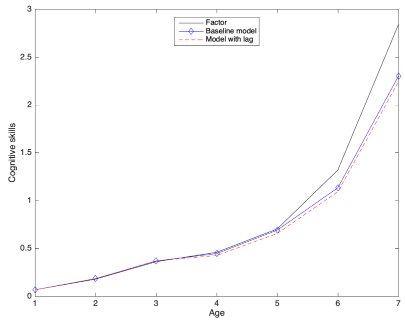
6 *Windows of Opportunity*

In this section, we use the model to better characterise the process of human development in its various dimensions, focusing on aspects that might be relevant for the design of policy. In particular, we want to establish whether the nature of the process of development points to the existence of *windows of opportunities*, that is periods in which interventions (or investment) could be particular effective and their effect sustainable. To do so, we perform some simulations where we force some changes to the inputs in the production function of human development and then study the long term effects of such changes by looking at the *impulse response function* of these changes for the variables we consider. This exercise is particularly useful because it takes into account all dynamic interactions between the various components of development as well as the effect of parental investment. Before performing the simulations, however, we present some evidence on how well the model fits the data and some graphical representation of the marginal productivity of parental investment at different ages.

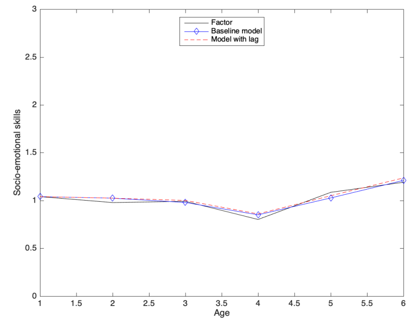
6.1 Model Fit

We start to use our estimates of the production functions for the three dimensions of human development we consider at the various ages, checking how well the model fits the data on which it was estimated. In Figure 3, we plot the evolution of cognitive skills, socio-emotional skills and health over time as predicted by our model estimates, as reported in Tables 6, 8 and 9, as well as the average factor corresponding to each dimension considerd, implied by the available measures and the estimated measurement system. The figures are constructed assigning the median initial conditions in our sample and holding investments fixed at their median value in each period. In each graph we plot both the estimates from the baseline model and the estimates from the model with self-productivity lags.

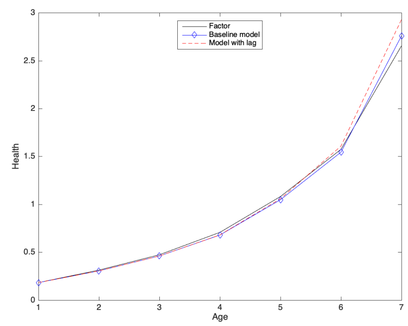
The figures show that, perhaps not suprisingly, our model fits remarkably well. For the cognitive factor, however, both the baseline model and the one with an additional lag in cognition, underpredict child development at age 6 and, more severely, at age 7. For the other two dimensions (socio-emotional skills and health) the fit of both versions of the model is remarkably good.



(a) Cognitive skills



(b) Socio-emotional skills



(c) Health

Figure 3: Evolution of Skills Over Time (Model Estimates)

Notes: The figure plots the evolution of cognitive skills (panel a), socio-emotional skills (panel b), and health (panel c) over time as predicted by our model estimates reported in Tables 6, 8 and 9, as well as the average factor corresponding to each dimension considered. The figures are constructed assigning the median initial conditions in our sample and holding investments fixed at their median value in each period. In each graph we plot both the estimates from the baseline model (solid blue line) and the estimates from the model with self-productivity lags (dashed red line).

6.2 Marginal Product of Investment

In Figure 4, we plot the marginal product of investment (MPI) by baseline skills level, computed using the estimates from the production functions for cognitive skills, socio-emotional skills and health, as implied by our model estimates. As before, the estimates used here are those reported in Tables 6, 8 and 9. The first three graphs plot the MPI for cognitive skills, the following three for socio-emotional skills and the last three for health. Within each row, each column shows how the marginal product varies by baseline level of cognitive skills (column 1), socio-emotional skills (column 2) and health (column 3). In each graph, we plot the MPI at different ages. The figures are constructed evaluating the marginal product at different levels of baseline skills, while holding all other inputs at their median value in the sample. We note that the scale is different in each graph.

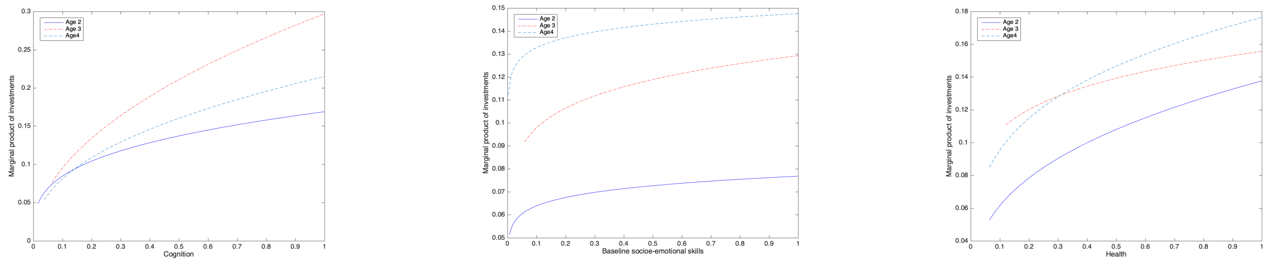
First,we note the complementarity of investment in each of the three dimensions with the relevant level of development (the graphs on the diagonal). These are evident in particular for cognition and socio-emotional skills, while for health it is only relevant for the production function at age 2. For cognition the complementarity (the slope of the marginal productivity lines) becomes more evidence at age 3. Moreover, investment seems to be complementary also with health and, to an extent, with socio-emotional skills. These results point to the fact that investments in children with higher baseline skill levels are more productive.

In the case of socio-emotional skills, there are no strong complementarities of investment with lagged cognitive development. However we do find evidence of complementarity between lagged health and parental investments in the production for socio-emotional skills at age 2. Finally, in the case of the health production function we find no complementarities between lagged cognition or socio-emotional skills and parental investments.

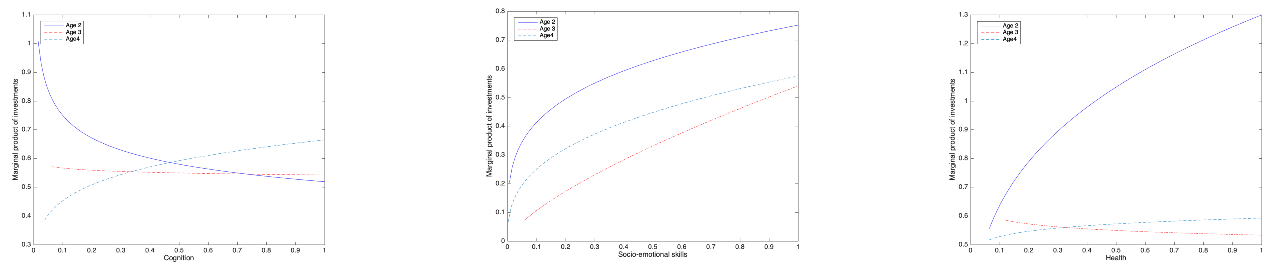
6.3 Impulse Response Functions

In Figure 5, we plot the impulse response functions (IRFs) for cognitive skills following an investment innovation, as implied by the estimated production functions. The IRFs are dynamic and take into account the effects that, over time, a given change in investment has on all dimensions of child development we consider. In each plot, we increase investments by one standard deviation at a particular age (panels a, b, c and d). In panel e, investment is increased at ages 2, 3 and 4, while in panel f, it is increased at ages 3 and 4. We compare the evolution of cognitive skills to what would have occurred if investments were fixed at their median level observed in the data. We assume that at baseline all other inputs are fixed at their median level. Each graph reports both the evolution of skills predicted by the production function that allows for only one lag of the various dimensions of child development and that predicted by the model with an additional self-productivity lag.

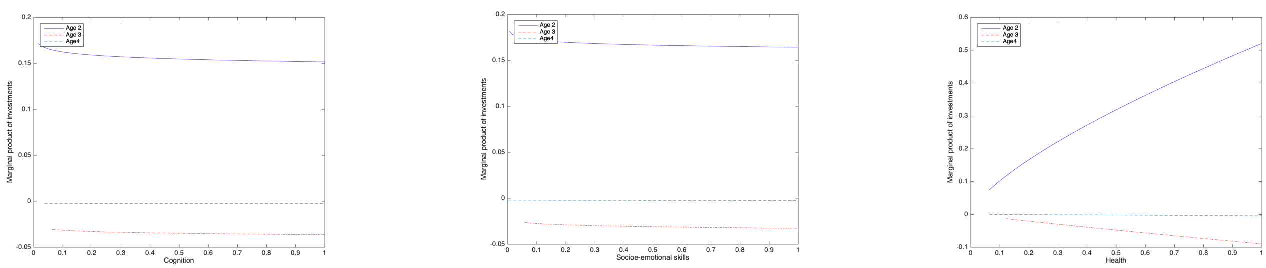
A striking difference is that observed between panels a and b. In the former, when investment increases at age 2 only, it gives an impact of about 0.12 when it occurs. Such effect is sustained through age 7, although the model with a richer dynamics implies a slight decline in particular at ages 6 and 7. The picture is very different in the increase happens at age 3: while on impact the effect of the increased investment is very similar, this effect vanishes completely from age 4 onwards. The main reason



(a) Cognitive skills



(b) Socio-emotional skills



(c) Health

Figure 4: Marginal Product of Investment

Notes: This figure plots marginal product of investment (MPI) by baseline skills level, computed using the estimates from the production functions for cognitive skills, socio-emotional skills and health, as implied by our model estimates. The top three panels plot the MPI for cognitive skills, the middle three for socio-emotional skills and the bottom three for health. Within each row, each column shows how the marginal product varies by baseline level of cognitive skills (column 1), socio-emotional skills (column 2) and health (column 3). In each graph, we plot the MPI at age 2 (solid blue), age 3 (dashed red) and age 4 (dashed blue). The figures are constructed evaluating the marginal product at different levels of baseline skills, while holding all other inputs at their median value in the sample. We note that the scale is different in each graph.

behind this differences is the different dynamics of the process at different ages. We notice that investment at age 2 has a considerable effect on the health dimension at age 2. This effect is then reflected on cognition at age 3 and subsequent ages.

We also notice that investment at age 4 has a persistent effect, while the effect of parental investment at age 5 is absent. Finally, the comparison between panel e and f and the previous four panel makes clear not only the importance of starting the investing early, but the importance of sustaning investments for several periods. The cumulate effect in panel e is much larger than that in panel f and that of short lived increases in investment considered in previous panels.

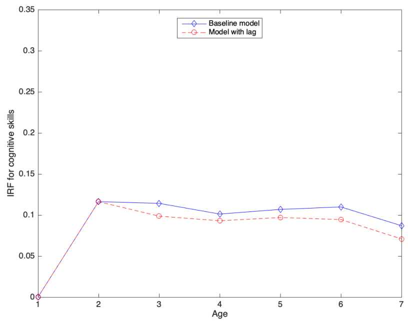
While we do not report confidence interval for these exercises, they show the importance of considering the process of child development as a whole in its various dimensions. The dynamic of this process can be complex and has important implications for the identification of windows of opportunities to target interventions and policies to improve the chances of disadvantaged children.

In Figure 6, we repeat for socio-emotional skills the exercise perfomed for cognitive skills. Again, we increase investment exogenously by one standard deviation at different ages, following the same scheme we used for cognitive skills. We then compare the evolution of socio-emotional skills to what would have occurred if investments were fixed at their median level. Again, at baseline, all other inputs are fixed at their median level. Each graph reports both the evolution of skills predicted by our baseline model and that predicted by the model with an additional self-productivity lag.

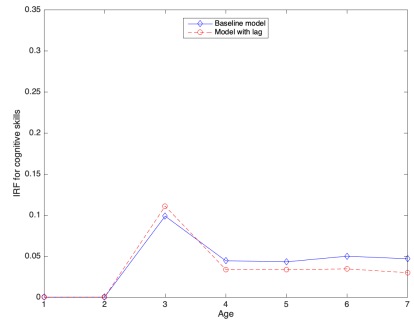
While we do not find the dramatic difference in dynamics we observe for cognitive skills, again the impact of investment is much more pronounced at age 2 than at subsequent ages. The effects of the two models (with or without additional lags) are very simliar. When looking at the effects of changing the investment at ages 2, 3 and 4, rather than only at ages 3 and 4, it is clear that the cumulate impact of the former is much higher than that of the former.

An impressive feature of the impacts on the accumulation of socio-emotional skills is the effect of investment at age 5, which is quite high and compares with a zero impact on cognitive skills at the same age. While we do not report the IRF for an increase at ages 2 to 5, it is clear from this picture and the coefficients in the production function, that the effect of such an intervention would be vey high.

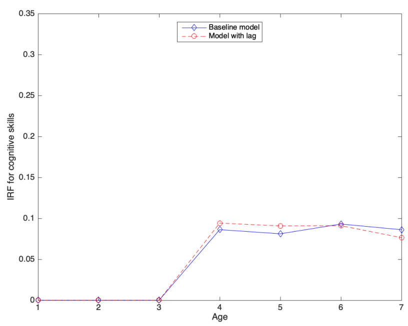
Finally, in Figure 7, we plot the impulse response functions (IRFs) for health following the same investment innovations considered for cognition and socio-emotional skills. As before, we assume that at baseline all other inputs are fixed at their median



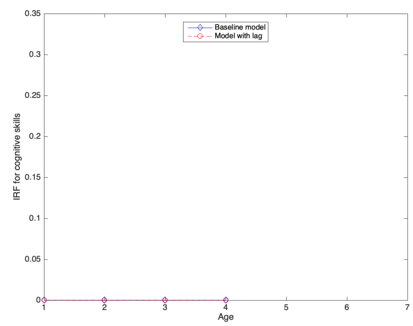
(a) Increase in investment at age 2



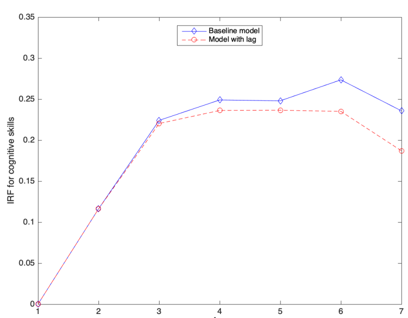
(b) Increase in investment at age 3



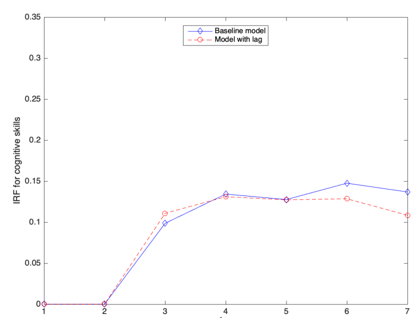
(c) Increase in investment at age 4



(d) Increase in investment at age 5



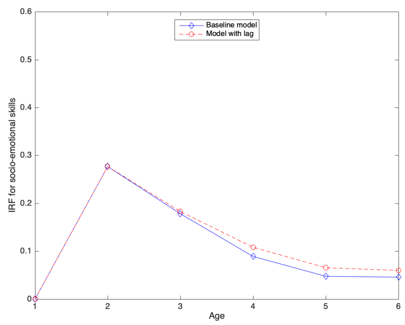
(e) Increase in investment at age 2, 3 and 4



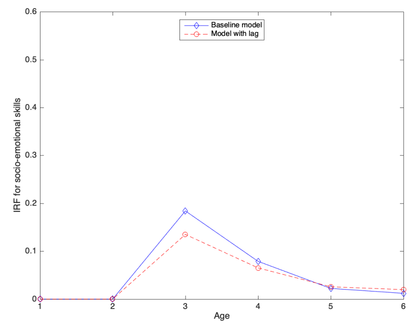
(f) Increase in investment at age 3 and 4

Figure 5: IRFs for cognitive skills

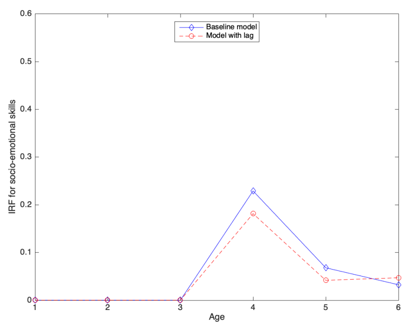
Notes: This figure plots the impulse response functions (IRFs) for cognitive skills following an investment innovation, as implied by the estimated production functions. In each plot, we increase investments by one standard deviation at age 2 (panels *a*), age 3 (panel *b*), age 4 (panel *c*) and age 4 (panel *d*). In panel *e*, investment is increased at ages 2, 3 and 4, while in panel *f*, it is increased at ages 3 and 4. In the plot, we assume that at baseline all other inputs are fixed at their median level. Each graph reports both the evolution of skills predicted by the production function that allows for only one lag of the various dimensions of child development (in blue) and that predicted by the model with an additional self-productivity lag (in red).



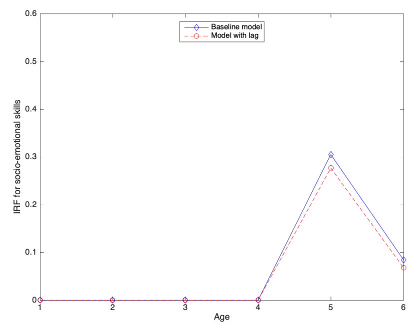
(a) Increase in investment at age 2



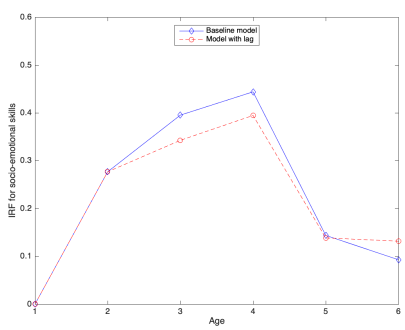
(b) Increase in investment at age 3



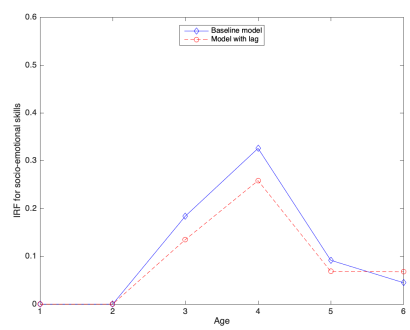
(c) Increase in investment at age 4



(d) Increase in investment at age 5



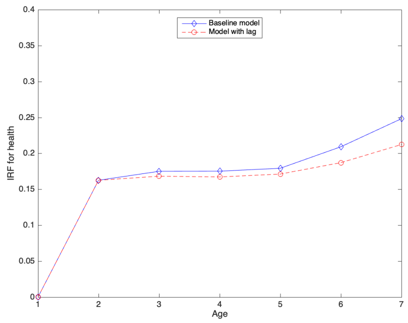
(e) Increase in investment at age 2, 3 and 4



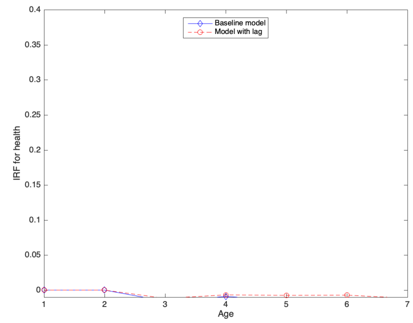
(f) Increase in investment at age 3 and 4

Figure 6: IRFs for socio-emotional skills

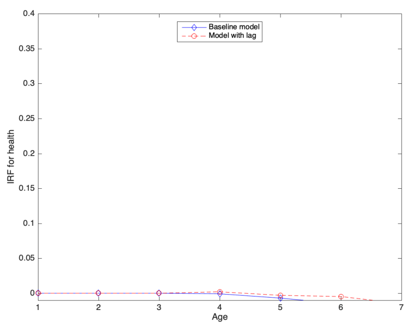
Notes: This figure plots the impulse response functions (IRFs) for socio-emotional skills following an investment innovation, as implied by the estimated production functions. In each plot, we increase investments by one standard deviation at age 2 (panels *a*), age 3 (panel *b*), age 4 (panel *c*) and age 4 (panel *d*). In panel *e*, investment is increased at ages 2, 3 and 4, while in panel *f*, it is increased at ages 3 and 4. In the plot, we assume that at baseline all other inputs are fixed at their median level. Each graph reports both the evolution of skills predicted by the production function that allows for only one lag of the various dimensions of child development (in blue) and that predicted by the model with an additional self-productivity lag (in red).



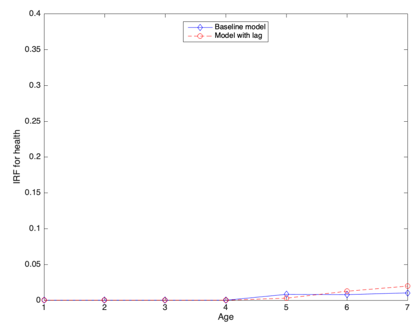
(a) Increase in investment at age 2



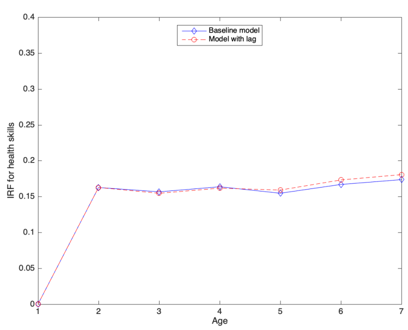
(b) Increase in investment at age 3



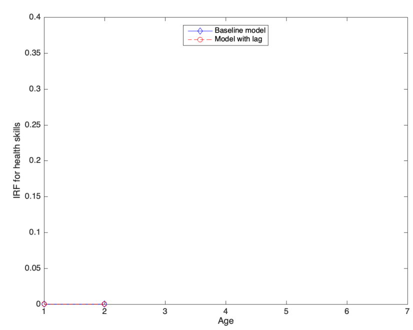
(c) Increase in investment at age 4



(d) Increase in investment at age 5



(e) Increase in investment at age 2, 3 and 4



(f) Increase in investment at age 3 and 4

Figure 7: IRFs for health

Notes: This figure plots the impulse response functions (IRFs) for health following an investment innovation, as implied by the estimated production functions. In each plot, we increase investments by one standard deviation at age 2 (panels a), age 3 (panel b), age 4 (panel c) and age 4 (panel d). In panel e, investment is increased at ages 2, 3 and 4, while in panel f, it is increased at ages 3 and 4. In the plot, we assume that at baseline all other inputs are fixed at their median level. Each graph reports both the evolution of skills predicted by the production function that allows for only one lag of the various dimensions of child development (in blue) and that predicted by the model with an additional self-productivity lag (in red).

level and we report the effects implied by the two versions of the model we consider.

We notice that out estimates imply a persistent effet of investment on the health dimension of child development if done at age 2 but not for subsequent ages. Once again, we observe some differences in the long run effect of the two models in panel *a* but not in the other panels. As we discussed above, while not particularly surprising, given the coefficients of the health production function, these results, and in particular the effect of investment on health age age 2, are important to better understand the effect of investment on other dimensions of child development.

7 Conclusions

In this paper, we study the process of human development from age 1 to 7, in three important dimensions: cognition, socio-emotional skills and health. We use a rich and unique data set from Colombia, which contains high frequency information fo a large sample of children from vulnerable families . We show that there are important interactions among the different dimensions, and that these change with age. We also study the dynamics of the process and show that, especially for the case of cognition, a simple Markov structure, with an individual lag of the dimension being studied, might not be enough to capture what is observed in reality.

Consistently with other studies we have show that to get consistent estimates of the effect of parental investment on child development, it is important to take into account the endogeneity of such a variable. The impact that parental investments have on child development vary with age and dimension considered. In the case of health, parental investment seems to be important only early on (at age 2). For cognition, instead, parental investment is effective at ages 2,3 and 4. After that, it becomes not particularly important. For socio-emotional skills, instead, parental investment is important for a longer interval of ages and it seems particularly effective at age 5.

We have used the model, which include the interactions among various components, to study how the productivity of investment changes with age, once we take into account these interactions. We also study the sustainability and persistence of certain interventions targeted to different domains of development.

We present a rich analysis of the process of child development which has important implications for policy design. We are not aware of studies that have characterised the process with such high frequency of data over the first period of life. We also introduce some innovations in the way available measures are summarized and how they are compared over different ages.

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Appendix Tables

Table 11: Production functions for cognitive skills (full results)

	Cognitive t+1											
	Exogenous investments						Endogenous investments					
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
TFP	-0.19	0.155	-0.135	0.44	0.552	0.74	-0.29	0.027	-0.176	0.481	0.548	0.739
	0.16	0.11	0.03	0.054	0.043	0.05	0.154	0.114	0.044	0.07	0.05	0.05
	[-0.443,0.079]	[0.048,0.402]	[-0.191,-0.098]	[0.341,0.517]	[0.486,0.624]	[0.651,0.811]	[-0.52,-0.037]	[-0.097,0.299]	[-0.278,-0.145]	[0.37,0.588]	[0.456,0.626]	[0.649,0.813]
Control function	-	-	-	-	-	-	-0.22	-0.268	-0.132	0.133	-0.028	-0.061
							0.145	0.102	0.098	0.113	0.161	0.12
							[-0.423,0.036]	[-0.43,-0.127]	[-0.366,-0.053]	[-0.017,0.333]	[-0.272,0.193]	[-0.223,0.158]
AeioTu	-0.13	0.034	0.03	0.068	0.025	0.05	-0.11	0.046	0.03	0.068	0.026	0.056
	0.081	0.056	0.013	0.018	0.045	0.042	0.078	0.051	0.013	0.018	0.046	0.045
	[-0.217,0.038]	[-0.048,0.125]	[0.007,0.047]	[0.026,0.09]	[-0.048,0.099]	[-0.004,0.122]	[-0.208,0.046]	[-0.036,0.129]	[0.007,0.046]	[0.026,0.088]	[-0.051,0.093]	[-0.005,0.134]
Cognitive t	0.3	0.501	0.436	1.021	1.138	0.908	0.3	0.494	0.423	1.051	1.133	0.898
	0.067	0.081	0.039	0.085	0.059	0.048	0.067	0.082	0.042	0.1	0.072	0.054
	[0.229,0.442]	[0.449,0.692]	[0.372,0.498]	[0.879,1.141]	[1.01,1.205]	[0.805,0.954]	[0.221,0.442]	[0.421,0.678]	[0.349,0.487]	[0.901,1.207]	[0.982,1.22]	[0.79,0.969]
Socio-emotional t	0.08	0.158	0.058	-0.06	0.007	0.058	0.08	0.121	0.046	-0.043	0.002	0.053
	0.103	0.075	0.023	0.031	0.036	0.043	0.101	0.074	0.028	0.035	0.049	0.044
	[-0.007,0.335]	[0.018,0.263]	[0.008,0.085]	[-0.089,0.014]	[-0.074,0.044]	[-0.001,0.133]	[-0.014,0.326]	[-0.022,0.215]	[-0.017,0.071]	[-0.071,0.038]	[-0.1,0.063]	[-0.012,0.139]
Health t	0.39	0.238	0.293	0.006	-0.065	-0.062	0.35	0.161	0.267	0.024	-0.066	-0.066
	0.12	0.103	0.048	0.063	0.044	0.034	0.116	0.097	0.055	0.063	0.045	0.035
	[0.134,0.512]	[0.051,0.366]	[0.193,0.362]	[-0.087,0.108]	[-0.119,0.021]	[-0.095,0.011]	[0.108,0.478]	[-0.003,0.319]	[0.156,0.327]	[-0.067,0.137]	[-0.123,0.02]	[-0.103,0.009]
Parental cognition	0.02	0.013	0.102	-0.011	-0.031	0.101	0	-0.008	0.061	0.025	-0.04	0.079
	0.089	0.054	0.031	0.036	0.045	0.045	0.089	0.061	0.044	0.046	0.068	0.064
	[-0.017,0.233]	[-0.011,0.142]	[0.058,0.159]	[-0.051,0.065]	[-0.085,0.064]	[-0.008,0.142]	[-0.047,0.223]	[-0.103,0.063]	[-0.027,0.118]	[-0.023,0.121]	[-0.138,0.086]	[-0.045,0.16]
Investments	0.2	0.091	0.111	0.043	-0.05	-0.005	0.27	0.231	0.203	-0.057	-0.03	0.036
	0.085	0.068	0.041	0.042	0.053	0.045	0.12	0.103	0.092	0.103	0.145	0.097
	[-0.017,0.28]	[-0.035,0.184]	[0.061,0.191]	[-0.06,0.081]	[-0.129,0.045]	[-0.032,0.106]	[-0.032,0.376]	[0.082,0.387]	[0.134,0.418]	[-0.273,0.04]	[-0.234,0.232]	[-0.113,0.19]
Number of children	0.01	0.001	0.005	-0.018	-0.006	-0.001	0.01	0.006	0.008	-0.023	-0.004	0.002
	0.016	0.009	0.006	0.009	0.013	0.011	0.016	0.009	0.007	0.009	0.013	0.011
	[-0.03,0.02]	[-0.014,0.013]	[-0.006,0.012]	[-0.029,0]	[-0.027,0.014]	[-0.017,0.02]	[-0.028,0.02]	[-0.008,0.02]	[-0.003,0.017]	[-0.032,-0.004]	[-0.027,0.015]	[-0.016,0.019]
Gender	0.08	-0.037	-0.037	-0.107	-0.019	0.011	0.07	-0.042	-0.037	-0.108	-0.02	0.006
	0.066	0.046	0.019	0.029	0.032	0.029	0.065	0.042	0.019	0.029	0.034	0.031
	[-0.07,0.146]	[-0.118,0.025]	[-0.06,-0.002]	[-0.137,-0.038]	[-0.071,0.035]	[-0.044,0.052]	[-0.071,0.149]	[-0.114,0.021]	[-0.06,0]	[-0.138,-0.039]	[-0.075,0.034]	[-0.047,0.053]
Age	0	-0.011	0.03	0.059	0.011	-0.037	0	-0.006	0.03	0.059	0.011	-0.035
	0.012	0.011	0.01	0.014	0.015	0.015	0.012	0.011	0.009	0.014	0.015	0.014
	[-0.016,0.023]	[-0.033,0.002]	[0.014,0.045]	[0.033,0.078]	[-0.014,0.034]	[-0.053,-0.009]	[-0.009,0.03]	[-0.025,0.008]	[0.015,0.045]	[0.031,0.076]	[-0.015,0.034]	[-0.052,-0.009]

Notes: This Table shows the estimates of the production function for cognitive skills. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets.

Table 12: Production functions for cognitive skills with two self-productivity lags (full results)

	Cognitive t+1											
	Exogenous investments						Endogenous investments					
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
TFP	-0.19	0.202	-0.056	0.44	0.422	0.483	-0.29	0.097	-0.098	0.484	0.389	0.478
	0.16	0.102	0.043	0.047	0.073	0.109	0.154	0.101	0.047	0.062	0.083	0.11
	[-0.443,0.079]	[0.1,0.426]	[-0.121,0.012]	[0.353,0.505]	[0.342,0.575]	[0.527,0.876]	[-0.52,-0.037]	[-0.016,0.326]	[-0.199,-0.044]	[0.386,0.574]	[0.298,0.565]	[0.516,0.871]
Control function	-	-	-	-	-	-	-0.22	-0.303	-0.147	0.136	-0.135	-0.077
							0.145	0.107	0.093	0.112	0.157	0.122
							[-0.423,0.036]	[-0.459,-0.124]	[-0.361,-0.066]	[-0.011,0.327]	[-0.395,0.12]	[-0.235,0.145]
AeioTu	-0.13	0.034	0.056	0.068	0.006	0.046	-0.11	0.048	0.057	0.068	0.01	0.054
	0.081	0.057	0.016	0.018	0.046	0.043	0.078	0.051	0.016	0.018	0.047	0.045
	[-0.217,0.038]	[-0.049,0.127]	[0.028,0.08]	[0.025,0.089]	[-0.061,0.085]	[-0.009,0.125]	[-0.208,0.046]	[-0.044,0.127]	[0.028,0.081]	[0.026,0.087]	[-0.055,0.087]	[-0.013,0.132]
Cognitive t	0.3	0.469	0.319	1.022	1.281	1.321	0.3	0.435	0.3	1.044	1.271	1.315
	0.067	0.124	0.069	0.124	0.092	0.178	0.067	0.125	0.071	0.133	0.098	0.181
	[0.229,0.442]	[0.379,0.741]	[0.204,0.427]	[0.808,1.215]	[1.072,1.365]	[0.69,1.211]	[0.221,0.442]	[0.348,0.707]	[0.161,0.403]	[0.834,1.27]	[1.046,1.362]	[0.683,1.213]
Cognitive t-1	-	0.046	0.155	0	-0.248	-0.507	-	0.084	0.162	0.011	-0.275	-0.514
		0.076	0.066	0.073	0.115	0.199		0.075	0.065	0.073	0.117	0.202
		[-0.094,0.134]	[0.067,0.276]	[-0.12,0.101]	[-0.365,0.019]	[-0.377,0.205]		[-0.077,0.147]	[0.071,0.279]	[-0.111,0.121]	[-0.402,-0.014]	[-0.39,0.202]
Socio-emotional t	0.08	0.161	0.049	-0.06	0.053	0.082	0.08	0.123	0.035	-0.043	0.034	0.076
	0.103	0.077	0.023	0.031	0.044	0.042	0.101	0.075	0.027	0.035	0.052	0.043
	[-0.007,0.335]	[0.02,0.264]	[-0.002,0.074]	[-0.088,0.014]	[-0.061,0.085]	[0.006,0.143]	[-0.014,0.326]	[-0.017,0.216]	[-0.027,0.06]	[-0.072,0.039]	[-0.096,0.067]	[-0.012,0.14]
Health t	0.39	0.213	0.269	0.006	-0.03	-0.037	0.35	0.107	0.238	0.02	-0.032	-0.041
	0.12	0.1	0.047	0.051	0.045	0.035	0.116	0.095	0.054	0.053	0.046	0.036
	[0.134,0.512]	[0.034,0.355]	[0.178,0.339]	[-0.066,0.111]	[-0.099,0.044]	[-0.095,0.015]	[0.108,0.478]	[-0.017,0.271]	[0.132,0.309]	[-0.055,0.124]	[-0.105,0.044]	[-0.1,0.018]
Parental cognition	0.02	0.016	0.092	-0.011	0.006	0.12	0	-0.006	0.045	0.026	-0.035	0.092
	0.089	0.059	0.029	0.036	0.048	0.048	0.089	0.062	0.041	0.046	0.067	0.067
	[-0.017,0.233]	[-0.01,0.161]	[0.046,0.144]	[-0.054,0.064]	[-0.065,0.096]	[-0.009,0.149]	[-0.047,0.223]	[-0.092,0.087]	[-0.038,0.094]	[-0.023,0.117]	[-0.14,0.085]	[-0.048,0.171]
Investments	0.2	0.095	0.117	0.043	-0.06	0.02	0.27	0.258	0.221	-0.058	0.036	0.072
	0.085	0.068	0.038	0.044	0.053	0.046	0.12	0.106	0.086	0.103	0.143	0.099
	[-0.017,0.28]	[-0.038,0.176]	[0.066,0.194]	[-0.068,0.083]	[-0.131,0.049]	[-0.036,0.118]	[-0.032,0.376]	[0.088,0.401]	[0.147,0.416]	[-0.275,0.042]	[-0.165,0.297]	[-0.096,0.221]
Number of children	0.01	0	0	-0.018	-0.005	0.001	0.01	0.005	0.004	-0.023	0.003	0.005
	0.016	0.009	0.006	0.009	0.013	0.012	0.016	0.009	0.006	0.009	0.013	0.011
	[-0.03,0.02]	[-0.016,0.013]	[-0.011,0.007]	[-0.029,0]	[-0.027,0.016]	[-0.016,0.023]	[-0.028,0.02]	[-0.008,0.02]	[-0.007,0.012]	[-0.032,-0.004]	[-0.021,0.021]	[-0.014,0.02]
Gender	0.08	-0.039	-0.066	-0.107	0.007	0.016	0.07	-0.045	-0.068	-0.107	0.002	0.009
	0.066	0.046	0.022	0.029	0.032	0.029	0.065	0.042	0.022	0.029	0.034	0.03
	[-0.07,0.146]	[-0.12,0.035]	[-0.093,-0.024]	[-0.141,-0.041]	[-0.059,0.05]	[-0.044,0.051]	[-0.071,0.149]	[-0.112,0.026]	[-0.096,-0.026]	[-0.138,-0.04]	[-0.066,0.05]	[-0.046,0.051]
Age	0	-0.013	0.03	0.059	-0.004	-0.039	0	-0.007	0.029	0.059	-0.004	-0.037
	0.012	0.011	0.01	0.014	0.015	0.015	0.012	0.011	0.01	0.014	0.016	0.014
	[-0.016,0.023]	[-0.033,0.001]	[0.013,0.044]	[0.033,0.077]	[-0.023,0.025]	[-0.053,-0.008]	[-0.009,0.03]	[-0.028,0.005]	[0.014,0.044]	[0.031,0.076]	[-0.023,0.028]	[-0.052,-0.008]

Notes: This Table shows the estimates of the production function for cognitive skills. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets.

Table 13: Production functions for socio-emotional skills (full results)

	Socio-emotional t+1									
	Exogenous investments					Endogenous investments				
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 2	Age 3	Age 4	Age 5	Age 6
TFP	0.4	0.104	0.217	0.312	0.286	0.11	-0.12	0.054	0.09	0.236
	0.303	0.408	0.07	0.064	0.079	0.326	0.409	0.104	0.108	0.089
	[-0.143,0.812]	[-0.596,0.706]	[0.1,0.327]	[0.222,0.451]	[0.158,0.407]	[-0.483,0.597]	[-0.893,0.355]	[-0.141,0.175]	[-0.102,0.251]	[0.102,0.377]
Control function	-	-	-	-	-	-0.62	-0.471	-0.529	-0.728	-0.356
						0.279	0.263	0.237	0.273	0.348
						[-0.979,-0.097]	[-1.045,-0.244]	[-0.955,-0.241]	[-1.288,-0.368]	[-0.947,0.169]
AeioTu	-0.12	0.13	-0.007	-0.115	-0.001	-0.08	0.151	-0.006	-0.117	0.017
	0.181	0.162	0.038	0.031	0.1	0.173	0.156	0.037	0.031	0.106
	[-0.375,0.234]	[-0.305,0.219]	[-0.072,0.05]	[-0.175,-0.072]	[-0.195,0.116]	[-0.343,0.244]	[-0.25,0.218]	[-0.07,0.046]	[-0.172,-0.071]	[-0.201,0.154]
Cognitive t	-0.15	-0.007	0.216	0.099	0.217	-0.16	-0.019	0.167	-0.064	0.151
	0.131	0.206	0.076	0.078	0.088	0.133	0.206	0.088	0.129	0.118
	[-0.369,0.05]	[-0.552,0.138]	[0.062,0.319]	[-0.019,0.224]	[0.072,0.359]	[-0.391,0.035]	[-0.577,0.121]	[-0.019,0.282]	[-0.321,0.083]	[-0.044,0.33]
Socio-emotional t	0.28	0.77	0.41	0.436	0.378	0.26	0.707	0.361	0.345	0.316
	0.159	0.216	0.077	0.067	0.092	0.148	0.229	0.089	0.075	0.109
	[0.118,0.609]	[0.304,0.983]	[0.332,0.568]	[0.332,0.543]	[0.242,0.548]	[0.106,0.538]	[0.208,0.912]	[0.258,0.538]	[0.211,0.454]	[0.148,0.495]
Health t	0.42	0.09	0.156	0.242	0.103	0.31	-0.044	0.05	0.144	0.09
	0.176	0.198	0.082	0.068	0.073	0.184	0.21	0.087	0.086	0.077
	[0.122,0.685]	[-0.106,0.556]	[0.051,0.315]	[0.16,0.38]	[-0.017,0.219]	[0.012,0.605]	[-0.287,0.425]	[-0.077,0.208]	[0.022,0.296]	[-0.069,0.201]
Parental cognition	0.04	-0.021	0.083	0.115	0.206	-0.01	-0.058	-0.084	-0.079	0.088
	0.111	0.129	0.068	0.056	0.089	0.152	0.146	0.095	0.094	0.149
	[-0.071,0.291]	[-0.054,0.37]	[-0.068,0.15]	[0.03,0.217]	[0.054,0.336]	[-0.323,0.145]	[-0.309,0.103]	[-0.309,-0.007]	[-0.231,0.06]	[-0.172,0.287]
Investments	0.41	0.167	0.135	0.108	0.095	0.6	0.415	0.506	0.654	0.354
	0.163	0.137	0.068	0.083	0.099	0.232	0.246	0.203	0.243	0.286
	[0.104,0.593]	[-0.052,0.386]	[0.043,0.264]	[-0.054,0.202]	[-0.049,0.257]	[0.259,0.944]	[0.223,0.989]	[0.256,0.92]	[0.368,1.136]	[-0.049,0.869]
Number of children	0.02	0.003	-0.025	0.026	0	0.02	0.011	-0.01	0.049	0.02
	0.029	0.025	0.018	0.018	0.025	0.027	0.025	0.019	0.019	0.025
	[-0.035,0.057]	[-0.029,0.049]	[-0.053,0.005]	[-0.005,0.051]	[-0.03,0.053]	[-0.021,0.064]	[-0.015,0.066]	[-0.043,0.022]	[0.015,0.075]	[-0.006,0.073]
Gender	0.05	-0.107	-0.072	0.144	-0.15	0.03	-0.114	-0.072	0.146	-0.168
	0.154	0.136	0.06	0.053	0.081	0.147	0.131	0.06	0.054	0.085
	[-0.246,0.254]	[-0.189,0.254]	[-0.17,0.024]	[0.067,0.23]	[-0.257,0.016]	[-0.235,0.254]	[-0.18,0.246]	[-0.173,0.025]	[0.063,0.234]	[-0.278,-0.007]
Age	-0.02	-0.021	0.063	-0.051	0.076	-0.01	-0.011	0.06	-0.049	0.08
	0.029	0.029	0.026	0.027	0.035	0.029	0.029	0.027	0.028	0.035
	[-0.065,0.037]	[-0.093,0]	[0.016,0.098]	[-0.102,-0.014]	[0.01,0.129]	[-0.047,0.045]	[-0.073,0.018]	[0.013,0.1]	[-0.098,-0.01]	[0.011,0.13]

Notes: This Table shows the estimates of the production function for socio-emotional skills. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets.

Table 14: Production functions for socio-emotional skills with two self-productivity lags (full results)

	Socio-emotional t+1									
	Exogenous investments					Endogenous investments				
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 2	Age 3	Age 4	Age 5	Age 6
TFP	0.4	0.03	0.175	0.316	0.31	0.11	-0.079	0.06	0.107	0.272
	0.303	0.535	0.076	0.065	0.078	0.326	0.508	0.102	0.106	0.088
	[-0.143,0.812]	[-0.997,0.783]	[0.034,0.271]	[0.226,0.438]	[0.195,0.452]	[-0.483,0.597]	[-1.126,0.534]	[-0.133,0.177]	[-0.053,0.268]	[0.159,0.424]
Control function	-	-	-	-	-	-0.62	-0.258	-0.447	-0.683	-0.242
						0.279	0.243	0.25	0.268	0.347
						[-0.979,-0.097]	[-0.747,0.012]	[-0.935,-0.127]	[-1.228,-0.303]	[-0.749,0.369]
AeioTu	-0.12	0.147	0.035	-0.1	0.01	-0.08	0.158	0.012	-0.105	0.021
	0.181	0.15	0.038	0.033	0.097	0.173	0.148	0.039	0.034	0.102
	[-0.375,0.234]	[-0.222,0.24]	[-0.034,0.093]	[-0.158,-0.05]	[-0.18,0.125]	[-0.343,0.244]	[-0.217,0.271]	[-0.058,0.062]	[-0.16,-0.059]	[-0.191,0.142]
Cognitive t	-0.15	-0.041	0.212	0.093	0.17	-0.16	-0.04	0.173	-0.059	0.133
	0.131	0.272	0.077	0.081	0.094	0.133	0.266	0.088	0.124	0.116
	[-0.369,0.05]	[-0.721,0.182]	[0.051,0.31]	[-0.032,0.23]	[-0.003,0.312]	[-0.391,0.035]	[-0.716,0.138]	[-0.018,0.282]	[-0.286,0.1]	[-0.064,0.313]
Socio-emotional t	0.28	0.728	0.39	0.338	0.314	0.26	0.702	0.36	0.275	0.282
	0.159	0.211	0.085	0.076	0.103	0.148	0.224	0.09	0.078	0.111
	[0.118,0.609]	[0.245,0.918]	[0.293,0.557]	[0.193,0.448]	[0.149,0.484]	[0.106,0.538]	[0.173,0.887]	[0.248,0.534]	[0.116,0.369]	[0.099,0.46]
Socio-emotional t-1	-	0.087	0.171	0.114	0.164	-	0.066	0.075	0.088	0.139
		0.246	0.093	0.079	0.119		0.246	0.096	0.078	0.125
		[-0.265,0.61]	[0.034,0.3]	[0.054,0.283]	[0.013,0.393]		[-0.243,0.588]	[-0.081,0.215]	[0.015,0.242]	[-0.024,0.383]
Health t	0.42	0.078	0.118	0.263	0.093	0.31	0.005	0.05	0.166	0.086
	0.176	0.203	0.083	0.071	0.072	0.184	0.21	0.085	0.087	0.074
	[0.122,0.685]	[-0.121,0.555]	[0.003,0.268]	[0.162,0.397]	[-0.025,0.205]	[0.012,0.605]	[-0.246,0.468]	[-0.073,0.203]	[0.031,0.318]	[-0.043,0.196]
Parental cognition	0.04	-0.024	0.065	0.111	0.178	-0.01	-0.044	-0.066	-0.07	0.102
	0.111	0.112	0.066	0.055	0.088	0.152	0.122	0.097	0.09	0.144
	[-0.071,0.291]	[-0.097,0.249]	[-0.084,0.13]	[0.016,0.203]	[0.007,0.302]	[-0.323,0.145]	[-0.256,0.101]	[-0.28,0.018]	[-0.227,0.062]	[-0.148,0.312]
Investments	0.41	0.173	0.044	0.082	0.081	0.6	0.311	0.409	0.6	0.259
	0.163	0.15	0.071	0.089	0.095	0.232	0.22	0.22	0.247	0.28
	[0.104,0.593]	[-0.029,0.45]	[-0.042,0.199]	[-0.101,0.171]	[-0.067,0.245]	[0.259,0.944]	[0.087,0.843]	[0.204,0.895]	[0.222,1.072]	[-0.189,0.697]
Number of children	0.02	-0.004	-0.032	0.02	0.007	0.02	0.002	-0.016	0.042	0.02
	0.029	0.031	0.018	0.018	0.026	0.027	0.031	0.018	0.018	0.023
	[-0.035,0.057]	[-0.061,0.039]	[-0.059,0.001]	[-0.011,0.045]	[-0.021,0.064]	[-0.021,0.064]	[-0.045,0.049]	[-0.043,0.015]	[0.005,0.069]	[-0.004,0.064]
Gender	0.05	-0.122	-0.105	0.117	-0.143	0.03	-0.125	-0.087	0.125	-0.157
	0.154	0.123	0.059	0.055	0.077	0.147	0.122	0.058	0.056	0.08
	[-0.246,0.254]	[-0.203,0.177]	[-0.201,-0.009]	[0.037,0.21]	[-0.243,-0.003]	[-0.235,0.254]	[-0.189,0.178]	[-0.182,0.015]	[0.042,0.215]	[-0.253,-0.007]
Age	-0.02	-0.02	0.075	-0.03	0.075	-0.01	-0.014	0.066	-0.033	0.077
	0.029	0.031	0.024	0.029	0.034	0.029	0.03	0.026	0.03	0.033
	[-0.065,0.037]	[-0.092,0.013]	[0.027,0.107]	[-0.08,0.013]	[0.01,0.124]	[-0.047,0.045]	[-0.079,0.017]	[0.023,0.102]	[-0.08,0.015]	[0.015,0.124]

Notes: This Table shows the estimates of the production function for socio-emotional skills. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets.

Table 15: Production functions for health (full results)

	Health t+1											
	Exogenous investments						Endogenous investments					
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
TFP	0.1	0.382	0.347	0.38	0.331	0.496	-0.06	0.402	0.368	0.353	0.35	0.497
	0.145	0.062	0.017	0.021	0.026	0.026	0.135	0.071	0.021	0.025	0.033	0.027
	[-0.14,0.319]	[0.252,0.449]	[0.323,0.379]	[0.338,0.407]	[0.305,0.391]	[0.455,0.538]	[-0.288,0.166]	[0.235,0.47]	[0.341,0.409]	[0.307,0.391]	[0.323,0.425]	[0.455,0.539]
Control function	-	-	-	-	-	-	-0.33	0.042	0.067	-0.09	0.132	0.033
							0.116	0.061	0.037	0.046	0.137	0.098
							[-0.473,-0.119]	[-0.102,0.106]	[0.015,0.128]	[-0.13,0.011]	[-0.012,0.433]	[-0.061,0.236]
AeioTu	-0.03	0.004	0.005	0.005	0.069	0.105	0	0.002	0.005	0.005	0.062	0.102
	0.061	0.042	0.005	0.007	0.032	0.028	0.05	0.041	0.005	0.007	0.032	0.03
	[-0.104,0.086]	[-0.069,0.059]	[-0.002,0.016]	[-0.009,0.014]	[0.004,0.105]	[0.05,0.137]	[-0.076,0.076]	[-0.068,0.06]	[-0.002,0.016]	[-0.01,0.014]	[-0.005,0.097]	[0.04,0.133]
Cognitive t	-0.02	0.061	0.002	-0.13	-0.1	-0.122	-0.03	0.062	0.008	-0.151	-0.075	-0.117
	0.063	0.1	0.022	0.033	0.038	0.033	0.062	0.098	0.022	0.036	0.049	0.036
	[-0.108,0.096]	[-0.043,0.268]	[-0.037,0.037]	[-0.191,-0.086]	[-0.152,-0.031]	[-0.177,-0.072]	[-0.108,0.093]	[-0.043,0.26]	[-0.03,0.044]	[-0.214,-0.093]	[-0.126,0.026]	[-0.171,-0.05]
Socio-emotional t	-0.01	0.069	0.026	0.042	-0.037	-0.035	-0.02	0.075	0.032	0.031	-0.014	-0.032
	0.098	0.052	0.011	0.014	0.036	0.027	0.087	0.05	0.014	0.016	0.049	0.028
	[-0.1,0.225]	[0.003,0.18]	[0.006,0.041]	[0.009,0.055]	[-0.088,0.028]	[-0.085,0.005]	[-0.1,0.187]	[0.006,0.169]	[0.012,0.057]	[-0.005,0.052]	[-0.07,0.079]	[-0.078,0.021]
Health t	0.77	0.892	0.95	1.107	1.196	1.237	0.71	0.904	0.963	1.095	1.202	1.239
	0.107	0.155	0.028	0.034	0.043	0.034	0.097	0.162	0.03	0.034	0.045	0.036
	[0.533,0.872]	[0.543,1.036]	[0.914,1.009]	[1.051,1.164]	[1.103,1.249]	[1.173,1.291]	[0.495,0.822]	[0.522,1.056]	[0.925,1.022]	[1.047,1.159]	[1.11,1.263]	[1.181,1.301]
Parental cognition	0	-0.006	-0.023	0.029	-0.017	-0.071	-0.03	-0.002	-0.002	0.005	0.027	-0.06
	0.071	0.029	0.015	0.02	0.035	0.032	0.058	0.031	0.018	0.023	0.063	0.049
	[-0.017,0.189]	[-0.026,0.062]	[-0.047,0.003]	[-0.013,0.052]	[-0.075,0.031]	[-0.123,-0.017]	[-0.062,0.095]	[-0.028,0.062]	[-0.03,0.03]	[-0.04,0.036]	[-0.049,0.16]	[-0.118,0.034]
Investments	0.27	-0.017	0.045	-0.048	-0.043	-0.009	0.37	-0.039	-0.002	0.02	-0.139	-0.031
	0.073	0.045	0.019	0.022	0.04	0.035	0.083	0.064	0.034	0.041	0.13	0.082
	[0.061,0.301]	[-0.061,0.082]	[0.01,0.069]	[-0.059,0.014]	[-0.102,0.023]	[-0.053,0.061]	[0.18,0.443]	[-0.117,0.099]	[-0.063,0.046]	[-0.038,0.101]	[-0.401,0.006]	[-0.196,0.061]
Number of children	0	0.001	0.002	-0.011	-0.01	-0.013	0.01	0	0	-0.008	-0.018	-0.014
	0.013	0.005	0.003	0.004	0.007	0.008	0.013	0.006	0.003	0.003	0.009	0.007
	[-0.022,0.019]	[-0.007,0.011]	[-0.002,0.007]	[-0.013,-0.001]	[-0.021,0]	[-0.024,0.001]	[-0.017,0.023]	[-0.008,0.012]	[-0.004,0.006]	[-0.011,0]	[-0.034,-0.006]	[-0.027,-0.004]
Gender	0.01	0.012	0.011	-0.011	-0.058	-0.085	0	0.013	0.011	-0.011	-0.051	-0.082
	0.049	0.037	0.009	0.011	0.026	0.019	0.042	0.037	0.009	0.011	0.028	0.02
	[-0.081,0.073]	[-0.039,0.076]	[-0.008,0.023]	[-0.023,0.013]	[-0.086,0.001]	[-0.105,-0.043]	[-0.07,0.061]	[-0.04,0.076]	[-0.009,0.024]	[-0.023,0.013]	[-0.076,0.01]	[-0.1,-0.034]
Age	0.01	0	-0.004	0.007	0.028	-0.016	0.01	-0.001	-0.003	0.007	0.026	-0.017
	0.009	0.006	0.005	0.006	0.011	0.009	0.01	0.006	0.005	0.006	0.012	0.009
	[-0.009,0.02]	[-0.006,0.016]	[-0.012,0.004]	[-0.005,0.012]	[0.002,0.042]	[-0.032,-0.004]	[-0.001,0.029]	[-0.006,0.015]	[-0.011,0.004]	[-0.005,0.012]	[-0.002,0.039]	[-0.035,-0.006]

Notes: This Table shows the estimates of the production function for health. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets.

Table 16: Production functions for health with two self-productivity lags (full results)

	Health t+1											
	Exogenous investments						Endogenous investments					
	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
TFP	0.1	0.394	0.298	0.256	0.076	0.376	-0.06	0.407	0.318	0.222	0.08	0.371
	0.145	0.065	0.026	0.072	0.095	0.059	0.135	0.068	0.028	0.079	0.097	0.062
	[-0.14,0.319]	[0.252,0.472]	[0.261,0.347]	[0.298,0.53]	[-0.022,0.28]	[0.306,0.486]	[-0.288,0.166]	[0.249,0.479]	[0.282,0.369]	[0.266,0.517]	[-0.003,0.3]	[0.301,0.498]
Control function	-	-	-	-	-	-	-0.33	0.034	0.06	-0.1	0.204	-0.032
							0.116	0.07	0.038	0.048	0.12	0.099
							[-0.473,-0.119]	[-0.112,0.101]	[0.002,0.12]	[-0.13,0.018]	[0.027,0.411]	[-0.125,0.184]
AeioTu	-0.03	0.004	0.009	0.001	0.028	0.074	0	0.003	0.009	0.001	0.014	0.076
	0.061	0.042	0.006	0.007	0.03	0.029	0.05	0.042	0.006	0.007	0.03	0.03
	[-0.104,0.086]	[-0.068,0.058]	[0.002,0.02]	[-0.008,0.014]	[-0.026,0.068]	[0.029,0.121]	[-0.076,0.076]	[-0.069,0.059]	[0.002,0.021]	[-0.008,0.014]	[-0.034,0.061]	[0.027,0.119]
Cognitive t	-0.02	0.05	0.012	-0.092	-0.032	-0.092	-0.03	0.054	0.017	-0.113	0.012	-0.096
	0.063	0.084	0.023	0.042	0.041	0.033	0.062	0.082	0.023	0.043	0.048	0.036
	[-0.108,0.096]	[-0.069,0.212]	[-0.031,0.047]	[-0.22,-0.077]	[-0.091,0.042]	[-0.157,-0.045]	[-0.108,0.093]	[-0.062,0.203]	[-0.025,0.054]	[-0.24,-0.094]	[-0.054,0.095]	[-0.158,-0.044]
Socio-emotional t	-0.01	0.067	0.025	0.038	-0.007	-0.01	-0.02	0.072	0.031	0.025	0.031	-0.012
	0.098	0.051	0.012	0.014	0.039	0.029	0.087	0.049	0.014	0.017	0.045	0.028
	[-0.1,0.225]	[0.002,0.168]	[0.005,0.041]	[0.008,0.056]	[-0.058,0.063]	[-0.068,0.032]	[-0.1,0.187]	[0.005,0.153]	[0.008,0.053]	[-0.004,0.054]	[-0.03,0.113]	[-0.063,0.028]
Health t	0.77	0.857	1.051	1.472	1.752	1.546	0.71	0.876	1.06	1.47	1.815	1.554
	0.107	0.233	0.066	0.215	0.208	0.152	0.097	0.248	0.067	0.217	0.206	0.16
	[0.533,0.872]	[0.381,1.119]	[0.955,1.175]	[0.639,1.327]	[1.278,1.97]	[1.26,1.744]	[0.495,0.822]	[0.334,1.132]	[0.965,1.186]	[0.654,1.335]	[1.323,2.006]	[1.226,1.743]
Health t-1	-	0.041	-0.117	-0.385	-0.698	-0.396	-	0.03	-0.113	-0.397	-0.766	-0.409
		0.144	0.06	0.223	0.252	0.176		0.149	0.061	0.228	0.249	0.191
		[-0.178,0.272]	[-0.214,-0.021]	[-0.219,0.491]	[-0.976,-0.155]	[-0.626,-0.066]		[-0.192,0.286]	[-0.208,-0.02]	[-0.229,0.488]	[-1.005,-0.193]	[-0.635,-0.018]
Parental cognition	0	-0.006	-0.019	0.034	0.012	-0.063	-0.03	-0.003	0	0.007	0.082	-0.074
	0.071	0.033	0.016	0.02	0.036	0.033	0.058	0.032	0.019	0.023	0.056	0.045
	[-0.017,0.189]	[-0.026,0.079]	[-0.041,0.011]	[-0.015,0.05]	[-0.053,0.056]	[-0.116,-0.008]	[-0.062,0.095]	[-0.028,0.063]	[-0.027,0.034]	[-0.038,0.036]	[-0.015,0.172]	[-0.119,0.014]
Investments	0.27	-0.009	0.047	-0.068	-0.027	0.015	0.37	-0.029	0.005	0.007	-0.174	0.036
	0.073	0.053	0.019	0.028	0.037	0.038	0.083	0.081	0.034	0.042	0.109	0.081
	[0.061,0.301]	[-0.069,0.095]	[0.01,0.073]	[-0.065,0.025]	[-0.089,0.028]	[-0.039,0.076]	[0.18,0.443]	[-0.119,0.141]	[-0.059,0.053]	[-0.035,0.107]	[-0.382,-0.037]	[-0.122,0.122]
Number of children	0	0.001	0.002	-0.012	0	-0.009	0.01	0	0.001	-0.009	-0.011	-0.007
	0.013	0.005	0.003	0.004	0.007	0.008	0.013	0.006	0.003	0.004	0.008	0.007
	[-0.022,0.019]	[-0.008,0.011]	[-0.002,0.007]	[-0.013,0]	[-0.012,0.009]	[-0.019,0.005]	[-0.017,0.023]	[-0.007,0.012]	[-0.004,0.006]	[-0.011,0.001]	[-0.026,0]	[-0.021,0.002]
Gender	0.01	0.011	0.005	-0.012	-0.028	-0.055	0	0.012	0.005	-0.012	-0.015	-0.057
	0.049	0.036	0.009	0.011	0.024	0.02	0.042	0.036	0.009	0.011	0.025	0.02
	[-0.081,0.073]	[-0.042,0.075]	[-0.013,0.019]	[-0.024,0.013]	[-0.059,0.015]	[-0.084,-0.02]	[-0.07,0.061]	[-0.041,0.075]	[-0.014,0.019]	[-0.024,0.012]	[-0.051,0.031]	[-0.084,-0.02]
Age	0.01	0	0	0.009	0.025	-0.028	0.01	-0.001	0	0.01	0.023	-0.028
	0.009	0.006	0.005	0.006	0.011	0.009	0.01	0.006	0.005	0.006	0.012	0.009
	[-0.009,0.02]	[-0.006,0.016]	[-0.008,0.009]	[-0.006,0.012]	[0.003,0.039]	[-0.039,-0.011]	[-0.001,0.029]	[-0.006,0.015]	[-0.008,0.009]	[-0.006,0.012]	[-0.003,0.038]	[-0.041,-0.01]

Notes: This Table shows the estimates of the production function for health. The left panel considers investments as exogenous, while the right panel allows investments to be endogenous. 90% confidence intervals based on 200 bootstrap replications are reported in square brackets.