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EARLY CHILDHOOD DEVELOPMENT, HUMAN CAPITAL AND POVERTY

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ABSTRACT

Children's experiences during early childhood are critical for their cognitive and socio-emotional development, two key dimensions of human capital. However, children from low income backgrounds often grow up lacking stimulation and basic investments, leading to developmental deficits that are difficult, if not impossible, to reverse later in life without intervention. The existence of these deficits are a key driver of inequality and contribute to the intergenerational transmission of poverty. In this paper, we discuss the framework used in economics to model parental investments and early childhood development and use it as an organizing tool to review some of the empirical evidence on early childhood research. We then present results from various important early childhoods interventions with emphasis on developing countries. Bringing these elements together we draw conclusions on what we have learned and provide some directions for future research.

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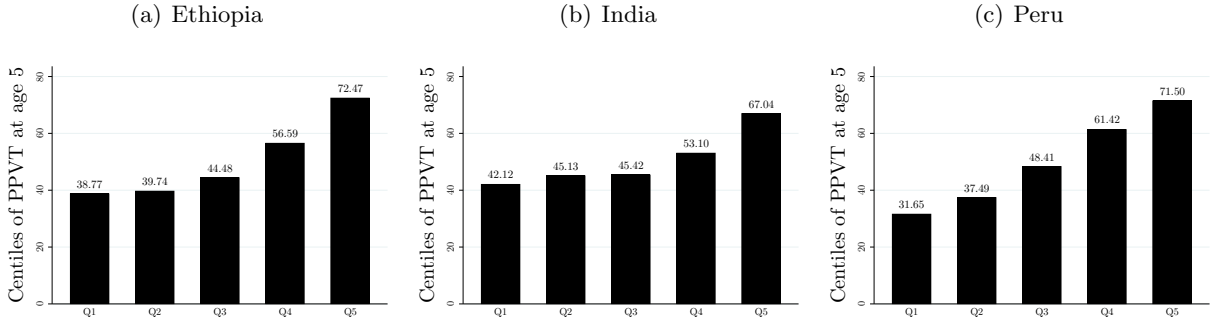
1 Introduction

The links between poverty and human capital development are multi-faceted and complex. Gaps in many dimensions of development between poorer and richer children emerge early and persist through the life-cycle. In turn, the importance of human development in determining adult outcomes means that the link between family income and human capital plays a substantial role in explaining the intergenerational transmission of poverty, observed to varying degrees across the world (Alesina, Hohmann, Michalopoulos *et al.*, 2021; Björklund and Salvanes, 2011; Black and Devereux, 2011). At the macro-level, the link between poverty and human capital development is central to understanding dynamics of productivity, growth and inequality.

The developmental deficits of children living in poverty have been documented to exist in a multitude of contexts. Figure 1 shows the relationship between a family wealth index and a well-established measure of vocabulary (the Peabody Picture Vocabulary Test) in nationally representative samples of five-year-olds in three developing countries. Although the exact shape of this relationship varies across contexts, these figures are a disheartening reminder of the developmental disadvantage that children living in poverty experience from the youngest age.

Figure 1: Language development at age 5 by family wealth quintile



Note: The figure plots the average percentile of children in the distribution of language development at age 5 for each quintile of the family wealth distribution (within each country). Language is measured with the Peabody Picture Vocabulary Test (PPVT), based on raw PPVT scores standardised for age (in months) using local linear regressions. Wealth is measured with an index constructed by latent factor analysis of indicators for whether the child's parents own the house; and whether the household has access to electricity, drinkable water, and kerosene or gar fuel for cooking; whether the household posses some durable goods (radio, fridge, bike, television, motor car or tractor, pump, phone, and sewing), and whether the house's wall, roof, and floor's main material is made of raw natural material (e.g., wood or soil, but not concrete). N = 1,860 for Ethiopia, 1,851 for India, and 1,903 for Peru.

These large inequalities in early development are ever so concerning because they are known to

map onto later ones. Figure 2 shows that children's vocabulary at age 5 is highly predictive of their vocabulary at age 15 (Panel A), which is itself highly predictive of their educational attainment at age 22 (Panel B). Although these two sets of figures are drawn from different samples, a simple imputation exercise demonstrates how strongly gaps in education measured in adulthood can be traced back to early childhood skills. While these figures obviously do not necessarily reflect a causal effect of early childhood development for later outcomes, they do reflect the long-lasting influence that early childhood inequalities have over the life-cycle.

Three series of the Lancet have addressed deficits in child development associated with poverty.[2] While these articles focused on developing counties, the issues raised are universal and not specific to poorer countries. However, understanding how we should address these developmental deficits is less well understood. To do that, a deep understanding of the fundamental reasons for these deficits is needed.

The aim of this article is to discuss recent advances in the study of the link between poverty and human development. We pay particular attention to the mechanisms through which this link operates, and what these imply for the design of appropriate interventions aimed at reducing poverty through investments in human capital. Given the importance of the early childhood period for adult human capital we focus on this period of the life-cycle, though much of our theoretical discussion about the human development process is relevant to other periods of life. The issues we touch upon here span a large variety of disciplines, and while we review evidence from a variety of disciplines, we do emphasize the insights that can be gained from interpreting the evidence through the lens of an economic framework where parents make investments decision subject to a number of constraints.

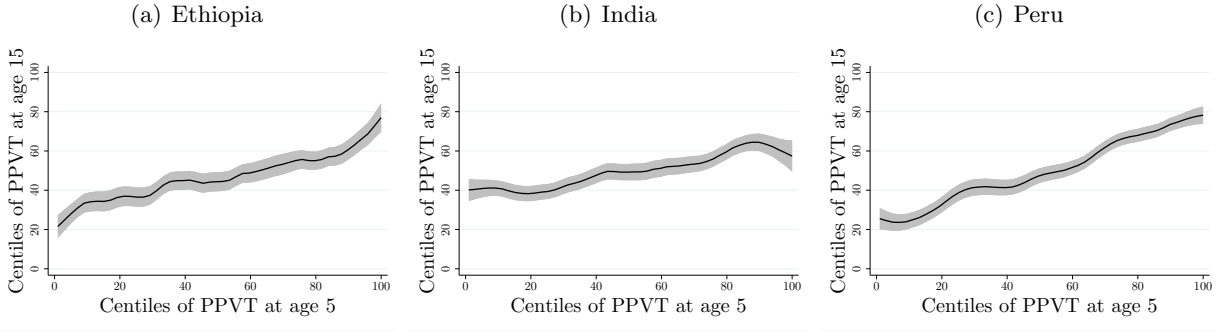
We therefore start the article by presenting a simple economic model of household behavior and child development. The model presupposes that altruistic households maximize lifetime utility, which depends on private consumption as well as the human capital of their offspring (or a function of that).[3] This household optimization problem is subject to technological constraints (the production function for child human capital), information constraints and a budget constraint. The production function models the dynamic process through which endowments and inputs (chosen by

[2] Grantham-McGregor, Cheung, Cueto *et al.* (2007); Lancet (2007, and all papers in the series)

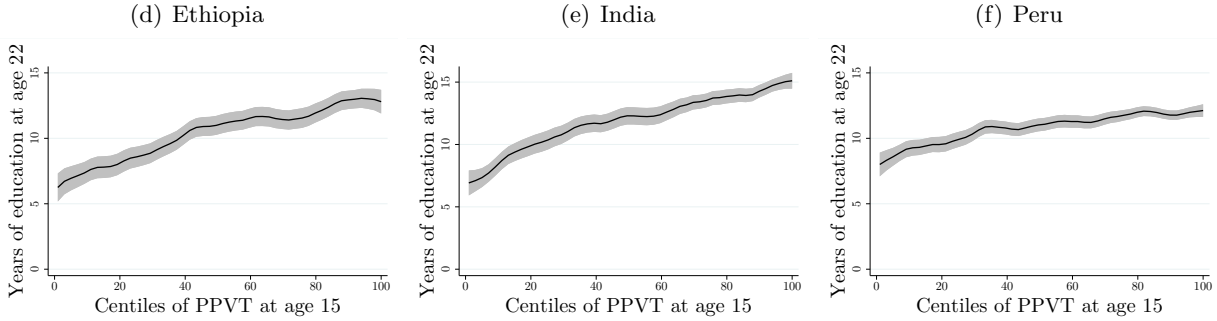
[3] It is straightforward to consider households that care about child human capital more generally and we need not constrain ourselves to Becker's altruistic model.

Figure 2: The predictive power of early childhood skills for later skills and educational attainment

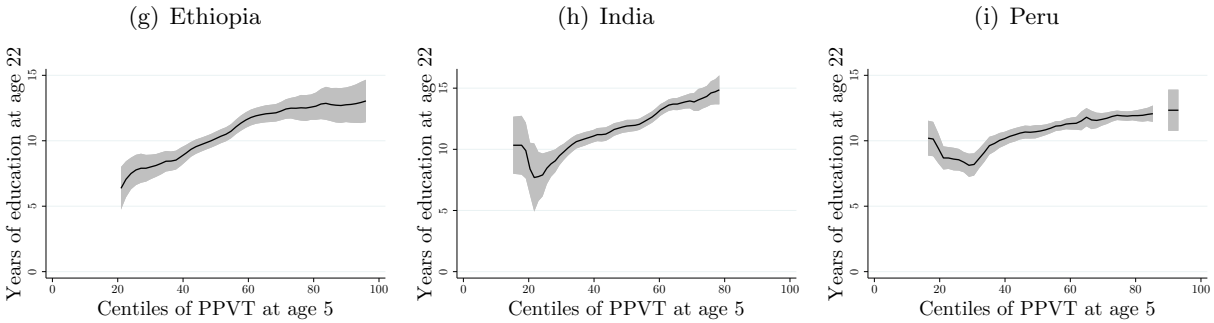
Panel A: Rank-rank relationship between PPVT at age 5 and PPVT at age 15



Panel B: Relationship between PPVT rank at age 15 and years of education at age 22



Panel C: Relationship between PPVT rank at age 5 and years of education at age 22



members of the household) determine the evolution of child human capital. The information constraints relate to the beliefs that parents have about various parameters and objects in the model, in particular their beliefs about their children's human capital and the productivity of inputs in the production function.

The model is helpful for clarifying the possible channels through which poverty can affect human development. Within the same economic environment, the socioeconomic gradient in human development can be due to gaps in parental investments and initial endowments; inequalities in parental investments can be explained by inequalities in endowments, beliefs, financial resources and preferences. We use this framework to structure our review of the evidence. First considering the process of human capital development, we discuss advances in the specification, identification, and estimation of production functions for child development. What do we know about the inputs that matter? What are the challenges to identifying the role of inputs? How should the dynamics and interactions between inputs be modeled, and why does it matter for our understanding of the link between poverty and human development?

We then turn to the drivers of parental investments. We review the evidence looking at the socio-economic gradient in parental investments and discuss the various explanations proposed in the literature. Do poor households invest less in their children only because they have less financial resources, or because they have different preferences for these investments, and/or beliefs about their returns or lack of knowledge of appropriate child rearing practices?

This evidence has some important implications for policy aimed at breaking the link between poverty and human capital development, though there are still important unknowns about *how* we should address the developmental deficits of poor children. A standard view among economists in particular has long been that those deficits are the results of a combination of preferences and resources. The focus on resources however ignores the fact that investments in early childhood do not necessarily demand important commitment of resources. In contrast, the child development literature emphasizes child stimulation through language interaction and simple games that can be based on common household materials. Just making conversation with a child, reading a book and involving them in household activities as well as simple play activities can have large effects on cognitive development. From this perspective, deficits in child development are mostly due to the lack of information and knowledge about the process, though this literature also recognizes that the stress induced by poverty could also prevent parents from engaging in these activities. Financial constraints may become more important later in childhood, but if the early years have led to deficits, even then the returns to later investments may be low.

This lack of knowledge and information, often reinforced by cultural conventions about bring-

ing up children, may be a key reason for deficits in child development and underlie the logic of parenting interventions in early childhood. These include, for example, the ABCderian program (Campbell and Ramey, 1994), the Nurse Family Partnership (Olds, Kitzman, Anson *et al.*, 2019; Olds, Kitzman, Cole *et al.*, 2004; Olds, Holmberg, Donelan-McCall *et al.*, 2014) as well as the Jamaica Home Visiting program (Grantham-McGregor, Powell, Walker *et al.*, 1991). Parenting interventions take the form of guiding parents to stimulate their children, often from just after birth. Importantly, many of these interventions do not advocate for large increases in spending or even time with children, but a change of the way these interactions should take place, from eliminating negative actions, such as corporal punishment, to introducing positive actions, such as praise, expressions of affection and introducing stimulating play activities, often based around the daily chores in a household.

In what follows we describe such interventions and present results from a number of experiments, including some designed and analyzed by the authors. The aim of this discussion is to illustrate the possibilities and the difficulties that need to be addressed if this approach becomes standard in preventing developmental deficits. The large and sustained human development impacts of parenting interventions evidenced in the literature pose an important challenge to traditional economic thinking about the nature of interventions needed to remedy developmental gaps among low-income children. Indeed, this literature suggests that, if it becomes possible to change beliefs and in some cases social norms so that parent-child attachment improves and low-income families engage in such stimulation activities, then the need for intervention will abate in the next generation. Based on empirical results on the complementarities of child development across ages (Cunha, Heckman, and Schennach (2010), Attanasio, Meghir, and Nix (2020)), it is also highly likely that an early successful intervention will increase the returns to later ones, including intervention to improve the quality of pre-school and later levels of education. And while the results are drawn from developing countries the key issues do not differ fundamentally from those that need to be addressed in pockets of poverty in wealthier countries, although the exact content and implementation model of the intervention would likely require adaptation in practice.

2 Human capital development and poverty: A general framework

This section presents a general framework to help clarify the link between poverty and the process of human capital development within and across generations. The model characterizes the dynamic process through which human capital develops throughout childhood, starting in the very first years of life, and embeds this process within a model of altruistic household behavior. This approach helps outline the mechanisms through which poverty persistently affects human capital development across generations. It also informs on the levers that might be available to policy-makers to weaken the link between poverty and human capital development. The aim of this section is to set out the key ingredients of this general framework and how they link to each other.

The framework we discuss considers an individual child, characterized by a certain initial level of development in various dimensions and a trajectory of development, from conception until a certain age at which we assume that human development no longer evolves.[4] The child is exposed to a variety of factors, ranging from the physical environment where they live to their interactions with parents, other family members, possibly teachers and other children, and to a certain number of inputs, such as nutrition, health care and formal schooling. These factors, along with shocks, determine the development of the child in periods following conception.

As proposed for instance by Todd and Wolpin (2003) and further developed in Cunha and Heckman (2008) and Cunha, Heckman, and Schennach (2010), the process of human development can be summarized by way of a set of production functions, where a vector of inputs at a given age determines an outcome or particular level of human development. In its most general form, the production function can be written as follows:

$$\mathbf{H}_{i,a} = F_a(\mathbf{H}_{i,a-1}, \mathbf{H}_{i,a-2}, ..., \mathbf{H}_{i,0}, \mathbf{X}_{i,a}, \mathbf{X}_{i,a-1}, \mathbf{X}_{i,a-2}, ..., \mathbf{X}_{i,0}, \epsilon_{i,a}) \tag{1}$$

where $\mathbf{H}_{i,a}$ is a vector which represents the human development of child i at age a and $\mathbf{X}_{i,a}$ is a vector of observable inputs. $\mathbf{H}_{i,0}$ represents the child's initial condition or endowment at conception. The function F_a represent the process of human development. It is indexed by the child's age to reflect the fact that the productivity of inputs can change with age. $\epsilon_{i,a}$ is a vector of unobserved

[4] As we mention below, the model can be extended to consider several children, incorporating both fertiliy choices (and the quality/ quantity trade-off) and the problem of resource allocation across different children.

inputs, including shocks such as incidents of ill-health. These may be observed by the parents or teachers but not by the researcher.

The model above is agnostic about the nature of inputs relevant to child development. It is also very general in allowing the whole history of inputs and prior levels human development to enter the production function. When taking this model to the data, researchers will need to make decisions about which inputs and how many lags to include in the production function. Often, these decisions will be influenced by the data available. Indeed, many of these inputs may be difficult to observe or not be observed at all, which creates issues with identification. As we discuss later, these decisions can have important implications for the estimates of the model.

The lack of a complete data on the relevant inputs to the process in equation (1), which are reflected in $\epsilon_{i,a}$, makes it difficult to estimate the effects of even those that are observed. The difficulty arises from the fact that some inputs of interest are chosen by agents with a specific stake in the outcome under study. These agents can be multiple and include parents, teachers, siblings, and the child themselves. Depending on the child's age, the relative importance of different agents will change. For example, in the early years, we would expect the primary carers of the child (and potentially the child's pre-school teachers) to have most agency. As the child grows up, the decisions of the child and of their peers would become more influential for the child's human capital development. As we primarily focus on the early childhood period in this article, we focus our discussion on the drivers of parental behavior.

During this period of the life-cycle, the family plays a prominent role, and there is broad consensus that inequalities in children's outcomes originating in early childhood are in large part determined by inequalities in how stimulating, nurturing and safe children's home environments are. There is ample correlational and causal evidence that parental behavior - both in terms of the warmth and closeness of parent-child relationship and the type of activities that parents engage in with their children - are key for cognitive and socio-emotional development of children during this age. There is also much evidence that poor parental mental health, parental stress and parental conflict are important risk factors for the development of young children (especially for their emotional and behavioral developments). This could have a direct effect on child development, or an indirect one through lower parental engagement and attachment with the child. While all these inputs are strongly correlated with family income, whether financial resources have a role per

se is disputed. In fact, much of the activities promoted by parenting interventions require very low financial resources.

Regardless of who makes investment decisions, these choices are likely to be related to elements of the developmental process that are not directly observed by the researcher. In other words, these variables are endogenous. A possible and useful strategy for the identification of such causal links is to model the endogenous variables, and therefore, in this context, model the behavior of the agents making the relevant decisions. Such an approach requires the definition of the drivers of parental and possibly teachers' behavior and choices. This might help to identify variables that can affect these choices without affecting the child's developmental outcomes directly. As is often the case, the identification of such variables can be problematic. However, without a strategy of this kind, it may be difficult, if not impossible, to identify the marginal effect of the endogenous inputs on child development.

Below we sketch a stylized model of parental investment behavior to outline key sets of drivers. Following a long tradition of models of altruistic parental behavior (e.g Becker and Tomes, 1989), we assume parents in household i maximize a function that depends on child development H^i_α at some final age α and on the path of their own consumption, $C^i_t,\ t = 1, ..., \alpha - 1$.[5] While parents choose C^i_t directly, H^i_α is the outcome of a production function, whose arguments are the level of child development $H^i_t,\ t = 1, ..., \alpha - 1$, and the path of parental investment X^i_t, and, possibly some other factors Z^i_t and ϵ^i_t, with the former being observable and the latter unobservable. The problem can then summarized as:

$$\max_{\{C^i_t, X^i_t\}_{t=1}^{\alpha}} \quad \sum_{t=1}^{\alpha} \beta^t U_i(C^i_t) + V_i(H^i_\alpha) \tag{2}$$

$$\begin{aligned} s.t. \qquad H^i_t \quad &= \tilde{f}_i(H^i_{t-1}, X^i_t, Z^i_t, \epsilon^i_t | \Omega_i) \\ A^i_{t+1} \quad &= (1 + r_i)A^i_t + Y^i_t - C^i_t - p_t X^i_t \end{aligned}$$

where Y^i_t is income, p_t is the price of parental investments and A^i_t are assets that can be used to

[5] It is possible that parents derive utility over the full trajectory of their child's human capital development. Or they could derive utility over their children's adult outcomes (e.g. earnings or well-being), which could be modeled as a function of their child's human capital at age α or as a function of their child's trajectory of human capital development.

move resources over time at the interest rate r_i. We stress that $\tilde{f}_i(.)$ is the production function as *perceived* by parents, i.e. conditional on their information set Ω_i. This information may not be fully accurate, and so the perceived production function may not correspond to the true production function outlined in equation (1) if parents have distorted beliefs over its inputs or parameters.

This model of parental behavior is highly stylized and omits a number of features, some of which we discuss in subsequent sections.[6] However, even in this simple version, it is clear that parental investment decisions depend on their preferences and three types of constraints. The first one is technological: as discussed above, the process of development follows a particularly technology that maps inputs into outputs (human development). The second one is financial: investment may be costly. and parents may be limited in their ability to borrow to finance their investment. The third type of constraint is informational, recognizing that parents make decisions subject to their perceptions of their child's level of human development and of the production function, both of which may only correspond to reality imperfectly.

While the budget constraint introduces a mechanical link between family poverty and child development, poverty may affect parental investment behavior through all other components of the model. Children born in poorer households may start with lower endowments or initial conditions H_0^i. Depending on the dynamics of the production function and parental preferences, this lower endowment may have a long-lasting effect on the child's outcomes either directly (through the production function) and/or by affecting parental investments. There is also evidence to suggest that parents from poorer backgrounds may have different information sets from parents from richer backgrounds, and they may also have different preferences over their children's outcomes. All these systematic differences across the income distribution may be responsible for creating a stubborn link between poverty and human development. We discuss them in turn in the rest of this article, starting with key features of the production function in the next section.

[6] Among others, the model assumes a unitary model of decision-making, while each parent may have a distinct set of preferences over investments and consumption. Moreover, the model assumes the family has a single child, while there could be multiple children with different initial conditions. We return to this in Section 4.2.

3 The production function for child development

The production function for child development characterizes the process of human capital accumulation over time. To be useful, the general production function in equation (1) has to be made specific, but doing so raises several important challenges. First, it is necessary to establish the dimensions of the vector $\boldsymbol{H}$. Moreover, one needs to specify the set of relevant inputs, their potential persistence, and how they interact among themselves within and across periods. We discuss these topics in turn and finish the section by providing simulation evidence that these decisions matter.

3.1 Dimensions of human capital

Economists have, for a long time, considered human capital a low dimensional variable that would enter the production function used in many models. In the simplest models, production is a function of a one-dimensional human capital, and individuals are heterogeneous in their human capital endowment. More sophisticated models considered two types of human capital, usually 'skilled' and 'unskilled', which play different roles in the production process, for example in the way they interact with other factors of production like capital and raw materials. In most of these models, these different types of human capital are mutually exclusive: individuals are endowed with one type of another (e.g. Katz and Murphy, 1992).

Over the past 20 years, the conceptualization of human capital in economic models has radically changed, both in microeconomics and macroeconomics. Human capital is now incresingly recognised as a multidimensional object, and this allows for a much richer characterization of heterogeneity across individuals.[7] While levels of human capital may be correlated across dimensions, this correlation is far from perfect. As exemplified in the important work of Heckman and co-authors on the GED, individuals with the same average level of cognitive skill but different levels of non-cognitive skills may end up with vastly different outcomes (Heckman, Humphries, and Kautz, 2014; Heckman and Rubinstein, 2001).

Modeling human capital as a multi-dimensional object is important because different dimensions of human capital play an important – and different – role in determining later outcomes. A large literature finds evidence of robust associations between various dimensions of human capital

[7] See, for instance, the survey by Acemoglu and Autor (2011) and Deming (2017).

and a range of adult outcomes, such as educational attainment, labor market outcomes, criminal engagement, healthy behaviors, teenage pregnancy and marital stability (e.g. Almlund, Duckworth, Heckman *et al.*, 2011; Carneiro, Kraftman, Mason *et al.*, 2021; Heckman and Karapakula, 2019; Heckman, Stixrud, and Urzua, 2006; Lundberg, 2017). An interesting study in Berniell, De la Mata, Bernal *et al.* (2016) reports estimates of returns to cognitive and socio-emotional skill in 10 Latin American countries, stressing that these skills might have different relevance depending on the occupational structure of the labor market. Several papers also look at the returns to different types of socio-emotional skills on a variety of outcomes. For example, Papageorge, Ronda, and Zheng (2019) find that a higher level of externalizing behavior leads to lower educational attainment,[8] but a higher wage in the labor market (conditional on education). Returns to these skills in the labor market may also change over time, for example in response to changes to the production function process (Borghans, Weel, and Weinberg, 2014; Deming, 2017).

Importantly for our discussion, different dimensions of human capital and different types of skills can interact with each other in the development of human capital over the life-cycle. These interactions, labeled 'cross-productivity' in Cunha, Heckman, Lochner *et al.* (2006), have been documented empirically in several papers. Cunha and Heckman (2008) and Cunha, Heckman, and Schennach (2010) find evidence that higher levels of early 'non-cognitive' skills boost the development of later cognitive skills. They interpret these findings as suggesting that a child more able to focus might be better able to exploit education opportunities and accumulate cognitive skills. Evidence of cross-productivity has also been found across other domains of human capital and other directions. Attanasio, Cattan, Fitzsimons *et al.* (2020) find evidence that higher levels of cognitive skill at ages 1-2 leads to higher levels of socio-emotional skills at ages 3-4. Attanasio, Meghir, and Nix (2020) find that better health at age 5 leads to higher cognitive skills at age 8.

In Table 1, we compare the main features of a selected set of papers estimating production functions for child development. While most focus on the joint development of cognitive and socio-emotional skills and/or look at their simultaneous impact on adult outcomes, very recent applied work in economics also distinguishes between socio-emotional dimensions. Using data from the British cohort studies, several papers distinguish between 'internalising' and 'externalising'

[8] Externalising behaviors are often contrasted with internalising behaviors, with the former including behaviors related to aggression and hyperactivity and the latter including behaviors related to anxiety and withdrawal and the former.

behaviors. For example, Attanasio, de Paula, and Toppeta (2020) study the evolution of these two behaviors, along with cognitive skills, and show that they interact with each other in dynamically complex ways and have long run effects on labor market outcomes. Moroni, Nicoletti, and Tominey (2019) model the development of externalising and internalising behaviors in middle childhood, allowing the productivity of a set of parental inputs to vary both across the distribution of child's socio-emotional skills in early childhood and across the input distribution.

From an economic point of view the multiple dimensions of human capital will be important if their relative price in the labor market changes over time, implying that they cannot be aggregated into one Hicks-aggregate human capital. These relative price changes may occur because of technological change and/or in response to changes in the supply of these different skills. Several papers find evidence that the return to 'non-cognitive' skills may have increased over the past decades in many economies. To explain this trend, Deming (2017) focuses on the role of individuals' ability to work in teams as a complementary skill to cognitive skill. He attributes the increase in the return to this skill to the increase in specialization in production (where individual workers contribute to a limited number of *tasks*). As the output of these very specialized tasks have to be combined to produce final outputs, the return to skills such as the ability of working in teams might increase and become as important, if not more, than cognitive skills. Thus if the labor market leads to changing valuations of alternative skills the discussion on the dimensionality of human capital becomes central to understanding important labor market issues such as changing occupational and wage structures.

3.2 Functional form of the production function

It is now widely recognized that environmental factors in the very early years have long lasting impacts on individual development and adult outcomes.[9] There is also evidence that inputs interact with each other to produce future levels of human capital. Together with the dynamics of the production function, the nature of interactions between inputs in the same period determine the extent of dynamic complementarities between investments made in different periods (Cunha, Heckman, Lochner *et al.*, 2006).

[9] See, for instance, the discussions in Cunha, Heckman, Lochner *et al.* (2006) and Elango, García, Heckman *et al.* (2016), Almond and Currie (2011).

Table 1: Comparison of main features of production functions for child development in selected set of papers

Paper	Dataset/Country	Outcomes	Inputs	Dynamics	Functional form	Treatment of endogeneity
Agostinelli and Wiswall (2020)	United States, National Longitudinal Survey of Youth	Cognition, schooling, and earnings	Parental investment	(1) One lag of the outcome	Translog	Instrumental Variables
Agostinelli, Saharkhiz, and Wiswall (2020)	United States, Early Childhood Longitudinal Study-Kindergarten Class of 1998-99	Cognitive and non-cognitive skills	Home and classroom investments	(1) One lag of the outcome	Translog	Instrumental Variables
Attanasio, Bernal, Giannola *et al.* (2020)	Colombia, the AeioTU RCT	Cognition, health, and socioemotional skills	Parental investment and skills	(2) Two lags of the cognition, health, and socioemotional skills that vary with child's age	CES, translog and Cobb-Douglas	Control function approach
Attanasio, Cattan, Fitzsimons *et al.* (2020)	Colombia, 2014 micronutrient supplementation and psycosocial stimulation RCT	Cognition and socioemotional skills	Parental material and time investments	(1) One lag of cognitive and socioemotional skills	Cobb-Douglas	Instrumental Variables
Attanasio, de Paula, and Toppeta (2020)	England, Scotland, and Wales, 1970 British Cohort Study	Internalizing and externalizing socioemotional skills, absolute mobility indexes, and cognition	Parental socioemotional skills	(1) Socioemotional and cognitive skills at age 5 for the production function at age 10, and (2) at ages 5 and 10 for the production function at age 16.	Cobb-Douglas	Controling for observed characteristics
Attanasio, Meghir, and Nix (2020)	India, Young Lives Survey	Cognition and health	Parental material investment, cognition, and health	(1) One lag of cognition and health	CES	Control function approach
Attanasio, Meghir, Nix *et al.* (2017)	Ethiopia and Peru, Young Lives Survey	Cognition and health	Parental material investment, cognition, and health	(1) One lag of cognition and health	CES	Control function approach
Caucutt, Lochner, Mullins *et al.* (2020b)	United States, Panel Study of Income Dynamics - Child Development Suplement	Cognition	Parental material and time investments	(1) One lagged outcome	Cobb-Douglas	Instrumental Variables
Chaparro, Sojourner, and Wiswall (2020)	United States, Infant Health and Development Program	Cognition and maternal-care quality	For cognition: Quantities and qualities of child care provided by the mother, the program, and others For maternal-care quality: quantities of care provided by the mother	(1) One lagged outcome	Cobb-Douglas	Instrumental Variables for the maternal care quality and controling for observed sharacteristics for cognition
Cunha and Heckman (2008)	United States, Children of the National Longitudinal Survey of Youth, 1979	Cognitive and non-cognitive skills, and earnings	Parental investment	(1) One lag of cognitive and non-cognitive skills	Cobb-Douglas	Instrumental Variables
Cunha, Heckman, and Schennach (2010)	United States, Children of the National Longitudinal Survey of Youth, 1979	Cognitive and non-cognitive skills, and earnings	Parental investment, and cognitive and non-cognitive skills	(1) One lag of cognitive and non-cognitive skills	CES	Control function approach
DelBoca, Flinn, and Wiswall (2014)	United States, Panel Study of Income Dynamics - Child Development Suplement	Cognition	Parental active and passive time investment	(1) One lag of the outcome	Cobb-Douglas	Controling for observed characteristics
Del Bono, Kinsler, and Pavan (2020)	United Kingdom, Millenium Cohort Study	Cognitive and non-cognitive skills	Child's and mother's cognitive and non-cognitive skills	(1) One lag of the outcome alone and interacted with lagged child'a and parental skills	Cobb-Douglas	Controling for observed characteristics
Helmers and Patnam (2011)	India, Young Lives Survey	Cognition, health, and non-cognitive skills	Parental material investment	(1) One lag of the outcome	Cobb-Douglas	Instrumental Variables

Even though these are crucial issues, an appropriate and exhaustive characterization of the dynamic properties of human development and substitution patterns between inputs is still unavailable. We discuss how the current literature has handled these issues and highlights the challenges to be tackled by future research.

3.2.1 Input substitution within and across periods

As shown in Table 1, researchers have used various functional forms for equation (1) that allow for more or less flexible interactions between inputs. Several studies specify a Cobb-Douglas (CD) specification, which implies a unit elasticity of substitution among different inputs (e.g. Attanasio, Cattan, Fitzsimons *et al.*, 2020; Cunha and Heckman, 2008; DelBoca, Flinn, and Wiswall, 2014). The CD specification imposes very strong restrictions on the substitutability among different inputs, an assumption that may be particularly severe when considering several inputs. Some studies, such as Cunha, Heckman, and Schennach (2010) or Attanasio, Cattan, Fitzsimons *et al.* (2020), generalize the CD specification to consider a Constant Elasticity of Substitution (CES) specification, which encompasses the CD form as a special case. While the CES is less restrictive than the CD specification, it still imposes strong assumptions on the pattern of substitutability of different inputs. In particular, it implies that any pair of inputs has the same elasticity of substitution.

In turn, some papers have sought to relax this assumption by considering a nested CES specification, which allows different groups of inputs to have different elasticities of substitution. Caucutt, Lochner, Mullins *et al.* (2020a) use a nested CES where they define parental investment as a function of parental time inputs and market childcare. The aggregate investment is then interacted with other inputs on the basis of a CD production function to generate child outcomes. Another example is Attanasio, Meghir, Nix *et al.* (2017), who estimate a nested CES function to model health and cognitive development at ages 8, 12 and 15 using data from Peru and Ethiopia. They aggregate the initial conditions within the lower nest of the CES, which is then aggregated with investment and other background variables. They strongly reject the restrictions implied by the standard CES for a sample of Ethiopian children collected as part of the Young Lives Survey.

One disadvantage of both the CES and nested CES is that the relationship between the relevant variables and the outcomes of interest can be highly non linear, therefore involving considerable econometric challenges. Moreover, the requirement that the function be concave restricts the

substitution patterns. An attractive alternative is to consider a translog production function, where the output is modeled as a second order polynomial in the (log) of prior achievement, investment and other background variables. Such a specification preserves linearity in parameters while allowing a considerable amount of flexibility. This functional form is used in Attanasio, Bernal, Giannola *et al.* (2020).

These different patterns of substitutability across inputs can have important implications for the process of child development and therefore for the design of policies. Attanasio, Meghir, Nix, and Salvati (2017) present some simulations plotting the impulse response function of human development to an exogenous change in parental investment at age 5. In the first scenario, this shift in investment occurs while holding baseline health constant. In the second scenario, it is accompanied by an increase in the child's initial health level at age 5. This exercise aims to capture how the dynamics of the interactions between different inputs (in this case parental investment and initial health) vary depending on the exact specification of the production function (here, CES or nested CES).

The exercise shows that, as expected, an early shift in investments has a large positive effect on the evolution of cognition over time. However, both the magnitude of the impact and the interaction between the shift in investment and initial health status are, in some contexts, quite different across the two specifications of the production function. The exercise also shows that the extent to which increasing initial health boosts the effect of the early shift in investments on cognition over time also varies between the CES and nested CES production function. These differences come from the fact that a) the estimates of the marginal product of investment at different ages are quite different when one allows for the flexibility implied by the nested model, and b) the complementarities between health, cognition and investments also differ between the CES and nested CES specifications.

3.2.2 Dynamics

While the prevailing consensus is that the process of human capital formation is inherently dynamic, the exact nature of these dynamics is still relatively unknown. The dynamics are important in two ways. On the one hand, the parameters that characterize the production function can change substantially with age. On the other hand, the persistence of lagged skills can be very different across dimensions of skill considered. Equation (1) is most general in that it allows human capital at

age a to be a function of the whole history of inputs and previous levels of human capital. However, identifying such function empirically involves important data requirements (both in terms of the frequency with which data is collected and in terms of the length of the panel), which exceed the features of most available datasets.

As we let the production function in equation (1) be age specific, the process is intrinsically non-stationary. This means that the productivity of certain inputs may vary with age. Moreover, the exact nature of this non-stationarity may determine the existence of *windows of opportunity* for intervention aimed to bolster the development of children with early developmental delays. This would be the case if certain dimensions of human development in one period have direct persistent effects on later outcomes (i.e. over and beyond their effect on skills in the next period working through *self-productivity*).

As is reflected in Table 1, it is common practice in empirical studies to assume that the human capital accumulation process follows a first order Markov process, i.e. outcomes at age a only depend on outcomes at age $a-1$, given we condition on current inputs. Formally, if $\boldsymbol{H}_{i,a}$ is the vector that represents the level of development of child i in its various dimensions at age a, then a first order Markov process describing the evolution of $\boldsymbol{H}_{i,a}$ with age can be expressed as:

$$\boldsymbol{H}_{i,a+1} = g_a(\boldsymbol{H}_{i,a}, \boldsymbol{X}_{i,a}, \boldsymbol{\epsilon}_{i,a+1}) \tag{3}$$

where $\boldsymbol{X}_{i,a}$ is a vector of observable (exogenous and endogenous) variables determined at age a. More generally, we note that in equation (3) we let the function $g_a(.)$ vary with age. The important point we want to stress here is that, conditional on $\boldsymbol{H}_{ia}$, previous level of development, such as $\boldsymbol{H}_{i,a-j}, \quad j>0$, are assumed irrelevant for $\boldsymbol{H}_{i,a+1}$.[10]

Such a model, while convenient from the analyst's point of view, might have a hard time to explain certain empirical observations, such as the fade-out and subsequent re-emergence of the impacts of certain interventions. There are several ways in which this Markov assumption can be relaxed. First, it is possible that the dynamics of the process are more complex that that described

[10] One could think of the unobservable term $\epsilon_{i,a+1}$ as being composed of a time-invariant component $\boldsymbol{\eta}_i$ and of a time-varying component $\boldsymbol{\upsilon}_{i,a+1}$, which is possibly correlated over time. Even if $\boldsymbol{\upsilon}_{i,a+1}$ is not serially correlated, the presence of $\boldsymbol{\eta}_i$ creates a source of persistence in the unobservable in the production function, to be distinguished from state dependence working through $\boldsymbol{H}_{i,a}$.

in equation (3). A simple extension, for instance, would be to consider a model of the type:

$$\boldsymbol{H}_{i,a+1} = \tilde{g}_a(\boldsymbol{H}_{i,a}, \boldsymbol{H}_{i,a-1}, \boldsymbol{X}_{i,a}, \boldsymbol{\epsilon}_{i,a+1}) \tag{4}$$

An alternative possible violation of the Markovian assumption embedded in equation (3) is that there exist some critical age, possibly very early in the life cycle, when development is key for subsequent development, in a way that is not summarized by subsequent attainment levels. Define such age as α^*. It is then possible that the right model is:

$$\boldsymbol{H}_{i,a+1} = \hat{g}_a(\boldsymbol{H}_{\alpha^*}, \boldsymbol{H}_{i,a}, \boldsymbol{X}_{i,a}, \boldsymbol{\epsilon}_{i,a+1}), \quad \forall \;\; a > \alpha^* - 1 \tag{5}$$

One important fact, which has been observed in several studies and which speaks against the simple first-order Markov assumption, is the long run impacts of some early child development interventions on adult outcomes, even when no impacts are apparent at intermediate ages (Bailey, Duncan, Odgers *et al.*, 2017). One well known example is the Perry Pre-School Program, where early impacts of the intervention on IQ disappeared, only to re-emerge in other domains, including socio-emotional skills (Heckman, Moon, Pinto *et al.*, 2010). Another example is the Jamaican Home Visiting Program, which provided psychosocial stimulation to children aged 9-24 months old. There, large impacts on cognition at the end intervention decreased in magnitude over time and were no longer statistically significant when children were 7-8 years of age (Grantham-McGregor, Walker, Chang *et al.*, 1997). However, the intervention was found to have improved a variety of adult outcomes, including earnings and criminal behavior, measured about 20 years after the end of the intervention (Gertler, Heckman, Pinto *et al.*, 2014).

Ultimately the distinction between equations (3), (4), and (5) is an empirical matter. However, distinguishing among them is hindered by the scarcity of appropriate longitudinal data covering a sufficiently long period. Moreover, the measures used to capture development throughout childhood are often different, making longitudinal links difficult and depending on the specific anchoring one chooses (Agostinelli and Wiswall, 2016; Cunha, Heckman, and Schennach, 2010). In practice, the dynamics of the empirical specifications of equations such as (3) or (4) are driven by the frequency at which data are observed, as reflected in Table 1.

A few recent papers have modeled the process of child development using data from developing countries and focused on the dynamics of the process. In particular, Attanasio, Bernal, Giannola *et al.* (2020) use a high frequency data set, which contains information on child development and other outcomes, collected on a sample of Colombian children observed from birth to 7 years, roughly at an annual frequency.[11] They model child development in three dimensions: cognition, socio-emotional skills and health. They find evidence of several interactions across skills, and for cognition they find that incorporating more than one lag of development is important for explaining future outcomes at certain ages.

More generally, Attanasio, Bernal, Giannola *et al.* (2020) find that the production function changes considerably over time, both in the impact of different inputs and in the level of persistence each dimension exhibits. In the case of cognition, for example, the level of persistence increases considerably with age, and the productivity of parental investment is significant until age 4 and then declines considerably. In the case of socio-emotional development, the productivity of parental investment becomes important after age 4. For health, persistence is very high from very early on in the life-cycle.[12]

While there is still too little evidence available to know whether the patterns found in Attanasio, Bernal, Giannola *et al.* (2020) are specific to the context they study or whether they are more general, the dynamic properties of the process of human capital development have crucial implications for when and how long it is best to intervene to promote human development. For example, if indeed persistence in cognition is lower in the first two years of life than it is in the next two, but the marginal productivity of parental investment is higher earlier than it is later, this would suggest that an optimal policy would be to intervene very early but sustain investments until an age where depreciation (or fade-out) is unlikely. To date, still too little is known about the dynamics of the process of human capital development across subsequent, short periods of the life-cycle. We see this as an important research priority going forward.

[11] The data is an unbalanced panel of 5 waves, containing children of different ages.
[12] We note that health specific investment data are not available in this dataset.

4 The determinants of parental investments

The model we sketched in section 2 provides a framework for understanding the factors that influence child development and ultimately can offer a structural approach for identifying the causal effects of investments in children on adult outcomes. The production function represented in equation (1) is central to the model and its characterization is key to establish what policies could child development among disadvantaged children. The main difficulty in such characterization is to quantify the causal links between certain inputs, such parental investment, which are chosen by agents with a certain objective (as illustrated in equation (2). As can be seen in the last column of Table 1, the literature has adopted various approaches to this issue, ranging from ignoring it to making different assumptions to deal with the endogeneity of parental choices. Most approaches, however, rely on a model of parental behavior, which in turns motivates the choices of a set of instrumental variables (or the construction of a control function).

In this section, therefore, we discuss the main determinants of parental investment. Within the relatively stylized structure we sketched in Section 2, we identified the main drivers of parental behavior and investment: (i) resource constraints; (ii) tastes and preferences; and (iii) the (perceived) process of child development. We now discuss them in turn.

4.1 Resource constraints

As set out in the model in section 2, a first reason why parents make different investments in their children's human capital is because they have different financial resources available to do so. The lower the resources available (or the higher the price of investments), the less parents would be predicted to invest in their children's human capital. If the imperfection arises from the inability of transferring resources from the future to the present (liquidity constraints - which are not fully explicit in the model we presented) a positive effect could be obtained by increasing current parental income and/or subsidizing investments (e.g., Becker and Tomes, 1986; Dahl and Lochner, 2012).[13]

Evidence on the causal effect of increasing family income - in the sense of a pure income effect - is rare to find. This is because most reforms that have been used to identify the effect of

[13] Carneiro, García, Salvanes *et al.* (2021) examine the importance of timing of parental income over the lifecycle for child outcomes.

family income on children's outcomes (or investments in their human capital) do not only increase family income, but also change other inputs that may also affect child development. In particular, most cash transfer policies, such as PROGRESA in México and other similar programs (many of which have been rigorously evaluated in many low-income contexts), make transfers *conditional on parental investments in children*, such as schooling or health care (Attanasio, Meghir, and Schady, 2010; Fernald, Gertler, and Neufeld, 2008). Welfare reforms, such as the Earned Income Tax Credit (EITC), which have been used in Dahl and Lochner (2012) to study the impact of family income on children's outcomes, increase family income *as well as* maternal labor supply. The policy therefore changes the allocation of parental time and the quality of the care provided to the child, which may affect children's outcomes holding family income constant (Agostinelli and Sorrenti, 2018).

Although the vast literature on cash transfers has mostly considered conditional cash transfers,[14] important insights can be obtained from the handful of papers that have evaluated the impact of unconditional cash transfers. Macours, Schady, and Vakis (2012), for instance, show that an unconditional cash transfer in Nicaragua lead to improvements in early childhood development: children in households that were randomized into an intervention called *Atención a Crisis* had significantly higher levels of development than children in the control group nine months after transfers were started. Furthermore, these impacts persisted two years after the program had been discontinued and the transfers ended. While this evidence is consistent with an important role for financial resources in determining children's outcomes, the authors bring other evidence to bear to suggest that other program features, such as the social marketing that accompanied the transfers, or the fact that transfers were made to women, were likely to be important in explaining the results.[15]

Another issue that has received recent attention is the fact that the lack of appropriate financial resources, coupled with a stressful environment and a lack of social support system, may induce a considerable amount of strain on parents and prevent them from performing even simple parenting tasks to stimulate their child's development.[16] Within this context, a set of programs that consists in transferring assets (and possibly training) to ultra-poor household are particularly interesting.

[14] See the surveys by Bastagli, Samman, Both *et al.* (2020), De Walque, Fernald, Gertler *et al.* (2017), and Molina-Millan, Macours, Maluccio *et al.* (2020) on long-term effects of such transfers. The literature on Conditional Cash Transfers is extensive - see Fiszbein, Schady, Ferreira *et al.* (2009) for a review.

[15] Maluccio and Flores (2005) study the same program in Nicaragua, and Paxson and Schady (2010) ask a similar question for a program in Ecuador.

[16] On the effect of stress on different types of performance, see, for instance, Mani, Mullainathan, Shafir *et al.* (2013)

These programs, first tried in Bangladesh, and subsequently replicated and validated in a number of ow and Middle Income Countries (LMICs) have received considerable attention. The studies reviewed in Banerjee, Duflo, Goldberg *et al.* (2015) have shown, in most places, a considerable impact on individual incomes and more generally well-being. In doing so, these programs might help households to escape *poverty traps*. Unfortunately, information on child development has not been collected in studies evaluating these programs. Such an analysis would be particularly pertinent, as many of the asset and skill transfers that have been analyzed are targeted to women and, therefore, more likely to change women's labor supply and bargaining power within the household.

4.2 Parental tastes and preferences

The simple model above posits that parental preferences depend on child development (H) and own consumption (C). In the most basic form of the model, heterogeneity in preferences over H and C across households could lead to observing different investment behaviors across households. Any correlation between such heterogeneity in preferences and family income could create a socio-economic gradient in investment (which would contribute to the gap in child development).

To be made more realistic, however, the model could be enriched in a variety of ways. First, one could distinguish between different types of investment (e.g. material and time investments), and allowing parents to have preferences over performing certain activities with their children. Second, parents may also be heterogeneous in their preferences for different domains of child development. For example, some parents may care about their children's cognitive development more than they care about other dimensions of development, while others may value socio-emotional development and health more. This type of heterogeneity could help explain differential patterns of investments observed across different demographic groups, defined by socio-economic status, cultural or religious norms.[17] Some authors argue that this heterogeneity in preferences could be driven by heterogeneity in beliefs over the returns to various skills. For example, Kohn (1963) argues that mothers from lower socio-economic backgrounds have stronger preferences toward the development of their children's socio-emotional skills because they believe obedience and conformity have high labor market returns.

[17] For example, Lynd and Lynd (1929, 1937) reported that working-class mothers ranked "strict obedience" as their most important child-rearing goal more frequently than mothers from higher socio-economic backgrounds did.

The recent work by Doepke and Zilibotti (2017), Doepke and Zilibotti (2019) and Doepke, Sorrenti, and Zilibotti (2019) looks at how parents choose their parenting style, based on their specific set of preferences and their perception of the returns different parenting styles will have for child development (and future outcomes). In their model, two types of preferences are important in driving such behavior: altruism, which determines how much parents care about their children's utility; and paternalism, which which determines how much parents care about their children's actions in ways that potentially conflict with the children's own preferences. More generally, heterogeneity in preferences (and/or beliefs about the developmental process - which we discuss below) might be behind the remarkable differences in parental investment across households from different backgrounds. Dotti Sani and Treas (2016), for instance, report that across many countries more educated parents (whose time in the job market should be more valuable) spend more time with their children than less educated ones.

The model we have discussed so far assumes a single child and omits fertility choices, which in developing countries have been an important consideration, in particular when thinking about the quantity/quality trade-offs that poor parents might face. The model could be extended in this direction without much difficulty. Such considerations, however, would introduce a number of other important dimensions to the parents problem. Indeed, for families with several children, preferences will also have to incorporate a taste for equality among children that parents might have, another dimension that can be added to the basic model. How resources (and eventual outcomes) are distributed across children will play an important role in driving investment decisions. If children are born with (or develop in the early years) different skills and endowments parents might face a trade-off between efficiency (that is maximizing the total level of development of their children) and possible equity concerns. As discussed in Almond and Mazumder (2013), parental investment strategies might attempt to compensate for perceived differences in initial conditions or strategically reinforce them, depending on the features of the perceived process of child development and on their preferences. Marginal returns to investments and, consequently, chosen levels of investment may also be affected by the characteristics of the child. Differences in ability across children may therefore affect how investments are allocated across and within households (e.g. Aizer and Cunha, 2012; Behrman, Pollak, and Taubman, 1982).

How parents distribute resources and investment across different children matters. Giannola

(2021) reports that, in many countries, inequality among siblings accounts for a substantial fraction of total inequality in earnings among individuals. Furthermore, he shows that, while average outcomes across siblings in various dimensions decline with family size, the best outcome among siblings does not vary with family size. This result is robust to a number of considerations and indicates that parental investment has an important role in determining inequality among siblings.[18]

A number of recent papers empirically explore these questions in developing country contexts. For example, Adhvaryu and Nyshadham (2016) use data from Tanzania and exploit variation in initial conditions induced by a randomly allocated pre-birth intervention. They argue that "parents reinforced endowment increases by making health investments in children who were exposed to the campaign while *in utero*", a finding in accordance with those in Giannola (2021). Using data on twins from China, Yi, Heckman, Zhang *et al.* (2015) argue instead that the family acts as a net equaliser in response to early health shocks across children. Berry, Dizon-Ross, and Jagnani (2020) explore this question with a lab-in-the-field experiment to identify parental preferences for the total amount of development across siblings and how parents trade this off with inequalities in outcome or inputs. They show that while parents do care about average earnings, they also have a strong preference for equality in inputs. They do not find evidence that parents care about equality in outcomes.

Finally, another important aspect of preferences, which can be of particular relevance in some contexts, is that of gender-specific preferences. In other words, parental preferences may lead to allocations that depend on gender and gender composition.[19] In the simple model considered so far, the decision units are the parents considered as a monolithic block with well-defined preferences. However, maternal and paternal preferences might be different, which implies that parental investment decisions will depend on both sets of preferences as well as on the nature of the decision process *within the household.* There is vast empirical evidence that is consistent with this hypothesis. For example, Thomas (1994), Hoddinott and Haddad (1995), Doss (2006), and Schady and Rosero (2008) show that income controlled by women is associated with higher expenditures on food. Macours and Vakis (2010) show non-experimental evidence on the positive impact of mother's seasonal migration on children's cognitive development. Lundberg, Pollak, and Wales (1997) and

[18] He also finds that parents in the slums in a city in India reinforce differences.
[19] Fertility choices have also been shown to depend on the gender of existing children, (Butcher and Case, 1994).

Ward-Batts (2008) present quasi-experimental evidence from the United Kingdom to argue that income is more likely to be spent on clothing for women and children when it is controlled by women than when it is controlled by men.

Models of intra-household decision making have received considerable attention in recent years, with their implications for parental investment decisions being the focus of more recent research.[20] In a recent paper, Almås, Attanasio, and Jervis (2021) model parental investment in a semi-structural fashion using data elicited to measure bargaining power within couples in Tanzania.[21] In their application, parental behavior depends, as in the model sketched above, on tastes, bargaining power and beliefs about the process of child development.

The discussion so far should make it clear that parental preferences can be complex and reflect different sources of heterogeneity that lead to different types of parenting practices and, ultimately, differences in child development. Attempts to directly measure drivers of individual behavior, including preferences, can be valuable for establishing the causal links between parental investment and child development. Some of the papers cited above undertake this strategy and are important in paving the way for further work in this direction.

4.3 Informational constraints

In standard economic models, parents are assumed to be rational and to know the production function of human development. If that is the case, variation in parental investment can only be explained by variation in tastes and variation in resources. The past decade has seen a burgeoning of evidence pointing to the importance of relaxing this assumption to consider the role of informational imperfections in determining investments in human capital.

The literature discusses two particular sources of information friction. The first one is around parents' perceptions of their children's abilities. The second one is around parents' perceptions of the technology of human capital formation. Both may be incorrect, and the extent to which they are distorted may be correlated with socio-economic status. This in turn could be another mechanism through which poverty is linked to lower human capital investments (and hence lower

[20] The literature on intra-household decision making is too vast to cite exhaustively here. The *collective* model of Chiappori (1988) has motivated much of this work. Reviews can be found in Bourguignon and Chiappori (1992) and Chiappori and Meghir (2015).

[21] The measure used to measure bargaining power with a couple is the one designed by Almås, Armand, Attanasio *et al.* (2018).

children's outcomes).

Parental perceptions of children's abilities. Parents might misperceive the ability of their children, either in absolute or in relative terms. This issue has been studied both in developed (see, for instance, Kinsler and Pavan, 2021) and developing countries. For the latter, Dizon-Ross (2019) provides evidence from Malawi, showing that misperceptions are more common among the poorest parents and that providing information to parents can change parental choices substantially. Parental misperceptions may also be compounded by misperceptions about the returns to different education choices (by parents or youths). Several studies have used observational data to show that students' beliefs about their own abilities predict their decisions, such as college major choice or college dropout.[22] These findings also complement a recent information experiment performed in Mexico by Bobba and Frisancho (2020) who test predictions about the differential roles of the mean and variance of beliefs on educational decisions.

Parental perceptions about the production function. Another potential source of information imperfections, which is particularly relevant in our context, relates to parental beliefs about the effect that parental investment have on child development. The salience of these imperfections can be different for parents from different SES backgrounds.[23] For example, while all parents might care equally about the development and well-being of their children, low-income parents might not be aware (or as aware as high-income parents) of the importance that some specific activities, such as talking to and interacting in specific ways with a young child, might have for their development. As Lareau (2003) argues, this may because they believe that child development follows a *natural growth* process, thus under-estimating the extent to which the brain is malleable and shaped by early stimulation.

To explain the relationship between parental investment and family income, Caucutt, Lochner, and Park (2017) propose a model where parents misperceive the child development production function, and especially the usefulness of early years investment. Other types of studies elicit *direct information* on parental beliefs about the process of child development. Cunha, Elo, and Culhane

[22] See Arcidiacono, Hotz, and Kang (2012); Chevalier, Gibbons, Thorpe *et al.* (2009); Stinebrickner and Stinebrickner (2014, 2012).

[23] See, for instance Lareau (2003) and Putnam (2015).

(2013) and Cunha, Elo, and Culhane (2020) design innovative instruments that allow direct elicitation of quantitative measures of individual perceptions and find evidence of such misperceptions in a sample of disadvantaged mothers in the US.[24]

Attanasio, Cunha, and Jervis (2019) further develop these methods to measure parental beliefs about the productivity of investments in the context of an early parenting intervention for low-income families in Colombia (We return to this in Section 5). They show that mothers in their sample underestimate the productivity of parental investment substantially. Moreover, they find that mothers tend to view parental investment as more useful for children with relatively low levels of development than children with higher levels of development. Estimates of the production function in the same sample suggest that parental investment complements baseline levels of skills, which contradicts the latter set of maternal beliefs. Finally, Attanasio, Cunha, and Jervis (2019) show that their measures are meaningful: parental investment is positively correlated with parental beliefs about its productivity.[25]

Despite mounting evidence about the importance of parental investments for child development, there are still important gaps in our understanding of the drivers of parental behavior and of the link between family income and the quantity and quality of parental investments. Though the role of financial constraints cannot be under-estimated, the evidence reviewed so far suggests a strong role for the lack of information and knowledge about the process of child development in explaining deficits in child development.

This lack of knowledge and information, often reinforced by cultural conventions about bringing up children, underlie the logic of early childhood parenting interventions. These focus on demonstrating good practice for stimulating children and strengthening the way parents interact with their children. In the next section, we discuss the large literature evaluating these interventions and interpret the evidence through the lens of the economic framework underpinning the article. The discussion illustrates the possibilities and difficulties that need to be addressed if this approach becomes standard in preventing developmental deficits. While the results are drawn from develop-

[24] Distorted beliefs can also be important for education choices beyond the early years, as discussed, in Boneva and Rauh (2018) and Attanasio, Boneva, and Rauh (2020) among others.

[25] In a recent paper, Giannola (2021) combines data from a survey collecting data on parental investments and parental beliefs with data from a lab in the field experiment in India showing that parents do not seem to have a strong taste for equality in outcomes among siblings.

ing countries the key issues do not differ fundamentally from those that need to be addressed in pockets of poverty in wealthier countries, although some of the details may differ in practice.

5 Evidence on parenting interventions

There is broad consensus that inequalities in children's outcomes originating in early childhood are in large part determined by inequalities in family environments and home stimulation. It has also been argued that economic circumstances might be only one, and not even the most important, determinant of child development, with the family playing a prominent role and stimulation being possible and effective even with limited resources. Against this background, parenting interventions are a promising direction for mitigating or even reversing such early developmental inequalities between poorer and richer children. These policies support caregivers to enrich the home environment and the quality of their interactions with children in order to provide greater stimulation and strengthen the emotional bond between children and their parents.

Many early childhood parenting interventions have been tried in developing countries over the last few decades. One of the best known is *Care for Development* (CfD), which has been promoted extensively by the WHO and UNICEF.[26] An intervention somewhat similar in spirit to CfD is the Jamaica Home Visiting (JHV) program, which was first implemented in the seventies and, unlike others, rigorously and continuously evaluated, culminating in a seminal study described in a series of papers including Grantham-McGregor, Powell, Walker *et al.* (1991) and Grantham-McGregor, Walker, Chang *et al.* (1997). The JHV was not the first home-visiting intervention ever implemented in developing countries,[27] but it is one of the few interventions where participants have been repeatedly followed up to evaluate long-term impacts. Quite remarkably, the latest study on this intervention, Gertler, Heckman, Pinto *et al.* (2014), shows that the labor market earnings of

[26] There exist several reviews of stimulation interventions. For a review of such interventions in LMICs see, for instance, Baker-Henningham and López Bóo (2010); Engle, Fernald, Alderman *et al.* (2011); Richter, Black, Britto *et al.* (2019).

[27] In addition to the CfD program we also note of the existence of two early childhood interventions for children suffering from malnutrition implemented in Colombia in the 1970s which inspired the JHV program. One is an experimental study conducted in Cali between 1971 and 1974, which evaluated the impact of high-quality preschool program providing integrated health, nutritional and educational activities (McKay, Sinisterra, McKay *et al.* (1978)). The second one was a nutritional and psychosocial stimulation program implemented between 1973 and 1976 in Bogota, Colombia (Super, Herrera, and Mora (1990)). This study randomized children into four groups, including one that received the nutritional component only, one that received the psychosocial stimulation program only, one that received both, and a fourth one that received neither.

the treated group improved by 25% by the time children were 22 years old.

As we discuss in this section, these results are remarkable in that they defy the notion that remediating developmental deficits of poor children must require much financial resources. Indeed, some of these interventions (as those we focus on in this section) have been shown to be low cost, relative to early years interventions implemented in the US, which have been shown to deliver long-term impacts (such as the Perry Pre-School Program, the ABCdarian program, and Family Nurse Partnership). Moreover, and importantly for their scalability, they can be implemented by local, non-specialist staff. This last aspect is not only relevant for the financial cost of running such interventions, which is obviously key in low-resource settings, but also for their ability to change behavioral patterns in disadvantaged communities.

However, despite the promise that these interventions hold to promote child development in the early years among disadvantaged families, there remains important questions about how they can be successfully adapted and targeted to yield significant and long-term impacts, especially at scale. At what age should this type of program start? How long and how frequently should parents be solicited by the program? What dimensions of development (language, cognition, socioemotional skills) should they mostly target at different ages? How should these interventions be delivered at scale so that they do not lose their effectiveness? And how can we ensure that the short-term impacts of these interventions do not fade out over time? All these are important questions for researchers and policy-makers alike to scale-up and refine the design of these promising interventions.

In what follows, we review the body of evidence surrounding the Jamaica Home Visiting (JHV) program and the interventions that were modeled after it and experimentally evaluated in Bangladesh, Colombia, and India. We focus specificatlly on the JHV program because it has, since then, been adapted in its content and mode of delivery in a variety of contexts. Its curriculum, now registered under the name of 'The Reach up Early Childhood Parenting program', has been used as the core of several efficacy and effectiveness trials in, among other places, Bangladesh, China, Colombia, and India, and as the basis of a universal early childhood program in Peru. While what follows is not an exhaustive review of the literature on parenting interventions, we argue that the evidence surrounding this single parenting program (which shares many common features with other such programs) provides a remarkable opportunity to reflect on the factors behind its effectiveness in the short- and long-term. In turn, this analysis can help inform how to target and

deliver the program better so that they achieve maximum cost-effectiveness and scalability in the future.

5.1 The Reach Up Early Childhood Parenting program

The "Reach Up Early Childhood Parenting programme" (henceforth "Reach Up") is based on the Jamaica Home Visit (JHV) intervention, described for instance in Grantham-McGregor, Powell, Walker *et al.* (1991). The program works by trying to build a positive relationship between parents and children and by strengthening parenting skills through a number of home visits occurring at regular intervals for an extended period, between 9 months and two years in the available studies. Each visit starts with a review of the activities introduced in previous weeks. The home visitor then introduces a new set of activities for the parent to perform with the child during the coming week and discusses how these can be included in daily routines. Each activity is designed to address a separate developmental domain, such as cognitive (puzzles), language (stories, songs, books etc.) and motor skills. The activities are supported by materials, including picture books, story cards and toys, typically made by waste materials such as plastic bottles and cloth so as to help affordability and encourage the caregiver to produce her own.

The intervention is a highly structured and somewhat prescriptive curriculum that can be delivered by a well-trained home visitor who does *not* necessarily have formal qualifications. The activities to be performed during the visits are precisely described in the curriculum manual the visitor uses. Such activities become progressively more complex as children grow. While each visit is mapped to a certain age in weeks, during the training the visitors are encouraged to use earlier or later visits to match the level of complexity to the developmental stage of the child. Moreover, the program requires very low levels of resources. No materials are given to the parents, although some are left in the household for a week and then exchanged with the new materials used for progressing with the intervention. In other words there is no element of subsidy implicitly related to the program. Taken together, this means that the program is feasible in low-income settings and potentially scalable.

Since its initial use in Jamaica in the 1970s and 1980s, the program has been adapted for and trialed in various cultural contexts, including Colombia, India, and Bangladesh. Focusing on those interventions that have been experimentally evaluated, Table 2 compares several of their features

as well as impacts on child development. Although all these interventions are based on the same curriculum and hence on the same developmental and pedagogical approach, there are important differences in terms of the population they target and the ways in which they deliver the 'Reach Up' curriculum. For example, the Jamaican and Bangladeshi interventions focus on undernourished or severely undernourished (stunted) children Grantham-McGregor, Powell, Walker *et al.* (1991); Hamadani, Mehrin, Tofail *et al.* (2019); Hamadani, Huda, Khatun *et al.* (2006); Nahar, Hossain, Hamadani *et al.* (2012); Tofail, Hamadani, Mehrin *et al.* (2013). In contrast, the Colombia and Indian interventions focus on low-income populations, but do not require children to show signs of undernourishment. Specifically, in Colombia, the intervention was offered to families who were eligible to receive the Colombia Conditional Cash Transfer program known as 'Familias en Action' (Attanasio, Fernández, Fitzsimons *et al.*, 2014)). In India, one intervention targeted migrants living in the slums in Cuttack (Andrew, Attanasio, Augsburg *et al.*, 2019), and the other targeted poor children living in rural areas of Odisha (Grantham-McGregor, Adya, Attanasio *et al.*, 2020).

Another key difference between these different adaptations of the same curriculum is in the way the curriculum was delivered. The JHV and and several of its adaptations (Colombia, Cuttack, and two of the four Bangladeshi trials) implemented it via home visits. The others implemented it via group sessions. Importantly, the Odisha study was the only one to implement, within the same trial, both home visits and group sessions so that their relative effectiveness can be compared. We return to this below when discussing issues of scalability.

Although the program was never delivered by child development specialists, the background and qualifications of home visitors differed depending on location and context: health para-professionals in Jamaica, female local community leaders in Colombia,[28] community workers associated with Pratham, an existing and well-established NGO in India, and local women and health workers in Bangladesh. The choice of who delivered the intervention was directly related to the program's scalability and sustainability: the emphasis on local women with no specific qualifications, but a strong training on the curriculum delivery clearly solves any problem of scarcity of human resources and has the potential to make the program culturally more acceptable within their communities.

[28] These women, called 'Madres Lideres', are in charge of the local administration of the CCT.

Table 2: Summary of experimentally evaluated interventions following the JHV or Reach Up programme

Country	Intervention	Delivery mode of psychostimulation	Duration	Target population	Age at baseline	RCT	Sample size	Horizon	Impacts (only reported if p_i0.1)	Reference
Jamaica (1986 to 1987)	Psychosocial stimulation and/or nutritional supplementation	Weekly home visits delivered by community health aides	24 months	Stunted children (HAZ<-2)	9 to 24 months old	Individual-level (1: stim; 2: nutrition; 3: stim + nutrition, 4: control)	129 children	Endline	COG: 0.91 stim, 0.76 nutrition LC: 0.49 stim, 0.59 nutrition LANG: 0.59 stim H&E: 0.80 stim PRF: 0.63 stim, 0.53 nutrition	Grantham-McGregor, Powell, Walker *et al.* (1991)
							122 children	Four years after intervention end	M: 0.61 stim, 1.07 nutrition, 0.81 stim + nutrition	Grantham-McGregor, Walker, Chang *et al.* (1997)
							105 children	Twenty years after intervention end	WAGE: 35%	Gertler, Heckman, Pinto *et al.* (2014)
Colombia (2010 to 2012)	Psychosocial stimulation and/or nutritional supplementation	Weekly home visits by local female community leaders ('Madre Lideres')	18 months	Beneficiaries of Colombia conditional cash transfer ('Families en Accion')	12 to 24 months old	Cluster-level (1: stim; 2: nutrition; 3: stim + nutrition, 4: control)	96 towns 1420 children	Endline	COG: 0.26 RL: 0.22	Attanasio, Fernández, Fitzsimons *et al.* (2014)
								Two years after intervention end	No significant impact	Andrew, Attanasio, Fitzsimons *et al.* (2018)
India (Cuttack) (2013 to 2015)	Psychosocial stimulation	Weekly home visits by community workers	18 months	Migrants living in urban slums	12 to 24 months old	Cluster-level	54 slums 378 children	Endline	COG: 0.35 RL: 0.22 EL:0.19	Andrew, Attanasio, Augsburg *et al.* (2019)
India (Odisha) (2015 to 2017)	Psychosocial stimulation or nutritional supplementation	Weekly home visits or group sessions	24 months	Children living in rural areas	7 to 16 months old	Cluster-level (1: stim via home visits; 2: stim via groups; 3: nutrition, 4: control)	192 villages 1400 children	Midline and endline	COG: 0.32 home visits, 0.28 group sessions LANG: 0.24 home visits, 0.30 groups sessions	Grantham-McGregor, Adya, Attanasio *et al.* (2020)
	Enhanced pre-school experience	Training of the pre-school (Anganwadi) staff	18/24 months		31 to 40 months old	Cluster-level (children from trial above re-randomized into enhanced or basic pre-school)		Trial in progress		
Bangladesh (Monohordani)	Psychosocial stimulation	Weekly group sessions and twice weekly home visits by local women	12 months	Children with moderate and sever undernutrision (WAZ_i-2)	6 to 24 months old	Cluster-level	20 community nutrition centers 193 children	One year after intervention end	COG: 0.27 SE: 0.28 COOP: 0.41 VOC: 0.30	Hamadani, Huda, Khatun *et al.* (2006)
Bangladesh (Dhaka)	Psychosocial stimulation and/or nutritional supplementation	Twice weekly parenting sessions (1-3 dyads) delivered by local women	6 months	Children with sever undernutrision (WAZ_i-3)	6 to 24 months old	Individual-level (1: stim; 2: nutrition; 3: stim + nutrition, 4: clinic control, 5: hospital control)	504 children	Endline	COG: 0.33 strim + nutrition WAZ: 0.27 stim + nutrition LAZ: 0.30 stim + nutrition	Nahar, Hossain, Hamadani *et al.* (2012)
Bangladesh (Monohordani)	Psychosocial stimulation	Weekly group sessions delivered by health workers	9 months	Children with iron deficiency anemia and children who were neither anemic nor iron deficient	6 to 24 months old	Cluster-level	30 villages 434 children	Endline	COG: 0.38	Tofail, Hamadani, Mehrin *et al.* (2013)
Bangladesh (Narsingdi) (2015 to 2016)	Psychosocial stimulation	Weekly group sessions delivered by health workers	12 months	Children with moderate and sever undernutrision (WAZ_i-2)	5 to 24 months old	Cluster-level	90 community clinics 687 children	Endline	COG: 1.13 LANG: 0.87 FM: 1.02 SE: 0.89	Hamadani, Mehrin, Tofail *et al.* (2019)

All impacts but Grantham-McGregor, Walker, Chang *et al.* (1997)'s are expressed in standard deviations of the control group. Grantham-McGregor, Walker, Chang *et al.* (1997)'s impacts are expressed in standard deviations of the whole sample. COG: cognitive development, LANG: language, RL and EL: receptive and expressive language, respectively, M: motor development, FM: fine motor, H&E: hand-eye coordination, SE: socioemotional development, PRF: behaviour performance, COOP: cooperation with test procedures, VOC: vocalization, WAZ: weight-for-age z-score, and LAZ: length-for-age z-score. The impacts reported all have p-values < 0.1. Some but not all studies adjust p-values for multiple testing.

5.2 Heterogeneity in short-term impacts across and within studies

The experimental evaluations of these interventions point to their overall effectiveness in improving children's cognitive development(see Column 10 of Table 2). Nevertheless, impact sizes (measured in units of standard deviations of the control group) do vary, sometimes quite dramatically, across studies of the same core intervention. For example, in the Colombia study, stimulation improved cognitive development by 26% of a standard deviation (SD) (RW[29] p-value 0.002) and receptive language by 22% SD (RW p-value 0.032) (Attanasio, Fernández, Fitzsimons *et al.*, 2014). In the Cuttack study, the program led to a 36% SD (RW p-value 0.016) increase in cognition, 26% SD (RW p-value 0.058) increase in receptive language, and 21% SD (RW p-value 0.079) increase in expressive language (Andrew, Attanasio, Augsburg *et al.*, 2019).[30] In contrast, the original JHV evaluation found that the program led a 90% SD improvement in cognitive and 60% SD improvement in language (all p-values < 0.01) (Grantham-McGregor, Powell, Walker *et al.*, 1991). Even greater impacts were found in the Bangladeshi adaptations of 'Reach Up' (e.g. Hamadani, Huda, Khatun *et al.*, 2006; Nahar, Hossain, Hamadani *et al.*, 2012).

This observation motivates two comments. First, comparing intervention impacts across studies is inherently challenging (Bond and Lang, 2013). In the case of the 'Reach Up' intervention, most studies used the same development scale as primary outcomes. While this obviously facilitates comparison of impacts across studies, it does not remove all the challenges associated with comparing impacts across settings. Indeed, two interventions may generate the same impact, but the practice of standardizing impacts with respect to the SD of the control group will make the same impact look a lot bigger in a very homogeneous population (with a small SD) than in a more heterogeneous population (with a larger SD). As proposed by Bond and Lang (2013), Cunha and Heckman (2008) and Cunha, Heckman, and Schennach (2010), a solution to this is to anchor the impact of the intervention to a long-term outcome, such as years of education or wages, which are measured in more meaningful units. Often however, this anchoring is hard to achieve given the scarcity of long-term follow-ups from these interventions.[31] Another way to achieve a more meaningful comparison

[29] RW refers to the p-values adjusted for multiple testing using the Romano and Wolf (2005, 2016) step down procedure.

[30] We report results when the (adjusted) p-value is less than 0.1. If the study does not adjust the p-value for multiple testing we uuse the p-value reported in the paper.

[31] One could use an auxiliary dataset to perform this anchoring. This would still require the existence of longitudinal panels containing the same developmental measures as those used to measure the impact of the intervention. These

of interventions is to measure impacts in terms of the gap in development between well defined groups in the population (e.g. bottom and top quartile of the income distribution). This approach requires access to external, ideally nationally representative datasets containing the developmental measures used as primary outcomes. These are strong data requirements, but weaker than those necessary for anchoring impacts to long-term outcomes.

Putting aside those methodological considerations for the moment, the fact that impacts of the same intervention were greater in the Jamaican and Bangladeshi contexts than in the other studies could suggest that the program is truly more effective in some populations than in others. As mentioned above, children in the Jamaica and Bangladeshi studies were only eligible to the program if they were undernourished or severely undernourished, measured by the degree of stunting. The interventions in Colombia and India have generally targeted the poor but not necessarily the children suffering from long term malnutrition. For example, in Colombia the target group were the beneficiaries for the Familias en Acción conditional cash transfer program. There was little or no stunting in that population, although the children's BMI was high. The Cuttack intervention targeted slum-dwellers, while the rural Odisha intervention targeted village dwellers without any further screening. In both cases the stunting rate was about 30%. In the production function framework we have discussed in Sections 2 and 3, this would suggest that the marginal productivity of the inputs provided by the intervention (mostly increased stimulation) may depend negatively on the health endowment of children at baseline. In other words, stimulation may be a substitute for baseline health and cognition.[32] And indeed, in the Cuttack study, impacts were considerably larger (and in line with impacts found in the JHV and Bangladeshi studies at about 0.8 SD for cognition) for children that were stunted at baseline (Andrew, Attanasio, Augsburg *et al.*, 2019). From a policy perspective, this would suggest the importance of targeting these interventions with the lowest levels of development, and/or of adapting their content so that even children who start the program with higher levels of development receive appropriate stimulation from it.

It is interesting to put these findings about heterogeneity of average impacts *across* studies in perspective with findings about heterogeneity of impacts *within* studies. For example, in the Cuttack study, the intervention was twice as effective in increasing cognitive development for those

datasets are extremely rare in developing countries or anywhere else.

[32] These results echo the findings of Bitler, Hoynes, and Domina (2014) in the context of the HeadStart study, who find that the impacts of the program were stronger for those children at the bottom of the developmental distribution.

whose mother had higher levels of education (0.38 SD with RW p-value of 0.04 versus 0.19 SD with RW p-value of 0.31), and the entire impact on receptive language was driven by this group as well (0.37SD with RW p-value of 0.035) (Andrew, Attanasio, Augsburg *et al.*, 2019). At first, this complementarity between the program and maternal education may seem contradictory with the fact that the program may be more effective for children with the lowest levels of development at baseline (since those are also likely to have less educated mothers). But it could also suggest that, in this context, more educated mothers are more likely than less educated mothers to adjust their parenting practices in response to the program (either because they believe in the importance of these practices more or because they have more time and/or less stress in their environment to implement them). While this hypothesis (and, more broadly, the issue of impact heterogeneity across and within interventions) warrants much further investigation, these findings do suggest that any production function used to interpret intervention impacts must be flexible enough to allow for complex interactions between the inputs provided by the intervention and baseline characteristics of children and their primary carers.

5.3 Mechanisms

Making sense of these patterns requires an understanding of the mechanisms through which this type of intervention generates impacts, and the economic framework set out earlier can be helpful to do that. Within the framework, this type of intervention can be conceptualised in different (though not mutually exclusive) ways. First, it could be modeled as a transfer in kind. Standard economic reasoning would imply that some parental activities and or expenditures could be crowded out as a result. For example, more time and resources could be shifted to other children in the family unit and/or to the parents themselves. Second, this intervention could be modeled as a shift of parental beliefs about the value of investments and the best manner to achieve them (such as implementing the various activities promoted by the program). If this were the case, the model would predict that the program leads parents to increase their investments. Third, the program could also be modeled as an intervention that shifts other inputs (outside of parental investments), especially maternal mental health. These effects could arise because of the regular contacts between the mother and the home visitor and/or because the mother feels increased confidence in her parenting. If maternal mental health and parental investments are complementary, the program could deliver even larger

impacts by working through those two channels.

Impacts of these interventions on parental investments and the quality of the home learning environment, as well as on maternal mental health, are helpful to suggest which mechanisms are likely to operate. In all studies where these data were collected, the psychosocial stimulation program was found to significantly increase the quality of the home learning environment and of child-rearing practices.[33] This is important as it suggests that the intervention does not crowd out parental resources. The Cuttack study and one of the Bangladeshi studies (Hamadani, Mehrin, Tofail *et al.*, 2019) also found evidence of an improvement in maternal mental health, though this finding was not replicated in the other cases. In the Cuttack study, maternal depressive symptoms measured by a shortened version of the Center for Epidemiological Studies-Depression (CES-d) scale decreased by 0.22 SD (p-value 0.04). In the Bangladeshi study of Hamadani, Mehrin, Tofail *et al.* (2019), they decreased by 0.3 SD (p-value 0.05).

However, this evidence is not sufficient to show that the effect of the intervention only operated through shifting parental behavior and investments. To investigate this, one needs to perform the kind of mediation analysis Attanasio, Cattan, Fitzsimons *et al.* (2020) performed for the Colombian study, which also allows for confounding factors by accouting for the endogeneity of investments. This exercise requires estimating the parameters of the production function (or a set of production functions), such as the following:

$$logQ_{i,t} = \gamma_0 logQ_{i,t-1} + \gamma_1 T_i + \gamma_2' logI_{i,t} + \gamma_3' x_{i,t} + v_{i,t} \tag{6}$$

where the output $Q_{i,t}$ denotes cognitive development, and inputs include: baseline levels of child development $Q_{i,t-1}$ (to measure 'self-productivity' and 'cross-productivity' in the case of a multi-dimensional output), the intervention T_i, inputs that could be shifted by the intervention $I_{i,t}$ (e.g parental investments and maternal mental health) and other inputs $x_{i,t}$, which may be less likely to be shifted by the intervention but could nevertheless be important in the process of child development (e.g. maternal education or the number of siblings living in the household). For simplicity, we assume one endogenous mediating factor $I_{i,t}$, though the model could be extended

[33] Time investments are usually measured by the number and frequency of activities, such as reading and playing, parents engage with the child; Material investments are measured by as the number of play materials (books, toys) around the house (and excluding the materials left by the home visitor)

to accommodate several ones and indeed was extended to consider material investments and time investments in Attanasio, Cattan, Fitzsimons *et al.* (2020). In the framework, the input T_i can be thought of as the direct in-kind transfer provided by the program (i.e. the stimulation provided to the child by the home visitor during the weekly visit).

The question asked is whether the intervention affects Q_{it} both directly ($\gamma_1 \neq 0$) and indirectly through shifting investments ($\gamma_2 \neq 0$) or alternatively whether only one channel matters (say, the increase in investment). The fundamental difficulty with identifying the mediation channels is the classic economics problem of endogeneity, expressed here by a correlation between u_{it} and v_{it}. For example, suppose parents compensated for negative shocks to their child's cognition (a negative realization of v_{it}) by increasing investments. Estimating equation (6) by OLS thereby ignoring such a phenomenon would lead to underestimating the effects of investments (a downward bias in γ_2) and potentially overestimating the direct effect of the intervention.

To solve this standard identification problem we can either assume that the errors are not correlated, which is the classic mediation analysis used in Heckman, Pinto, and Savelyev (2013), or we need an instrument, denoted z_{it}, which can be plausibly assumed not to have a direct effect on cognition. The latter approach, which is the one followed in Attanasio, Cattan, Fitzsimons *et al.* (2020), requires specifying a first-stage equation, which is a reduced form version of a parental decision rule for investment in the child of the following form:

$$logI_{it} = \beta_0 + \beta_1 T_i + \beta_2' x_{it} + \beta_3 z_{it} + u_{it} \tag{7}$$

By not relying on the exact optimal decision rule this semi-structural approach avoids imposing the restriction that parents know and understand the process of child development, as reflected here in the production function for cognitive skills. This is particularly important given that the intervention may be shifting parental beliefs about the productivity of investing/stimulating children.

In addition to being necessary for the identification of γ_2, the first-stage equation is of interest because it reveals how resources are allocated to children. In this sense, it informs on the origins of inequality in investments and on how the intervention affects investments decisions. In the case of the Colombian study, the treatment effect on investments (measured by β_1) is strong and positive.

A zero or a negative value would have been completely consistent with the behavior of a Becker-type altruistic household, but here the evidence shows that far from crowding out parental resources the intervention causes parents to invest more. Beyond this result, the estimates of the first-stage reveal additional important information about the drivers of investment decisions: children who score higher in cognition at the ages of 1-2 years old (at baseline) receive larger investments, consistent with the idea that these are complementary in the production of cognition. And holding the child's baseline level of cognitive development constant, mothers with higher cognition themselves invest more in their children. This could reflect better levels of understanding of child development, improved availability of resources and/or a more stable lifestyle. Finally, the presence of other (older children) reduces investments in the subject child (who is the youngest in most cases). The latter may reflect the usual quality-quantity trade-off.

The estimates of the production function are of key importance for understanding the mechanisms through which these intervention operate: in the context of the Colombia intervention, these imply that the entire impact of the intervention operates by increasing parental investment, which in turn improves cognitive development. The direct effect of the treatment is zero, once investments are controlled for. Another noteworthy finding is that the production function is estimated to be Cobb-Douglas, which implies complementarity between maternal education and parental investments. This could be a reason explaining why impacts of these interventions are often found to be higher among children with more highly educated mothers - not only do these mothers invest more in their children, but the marginal productivity of their investments is also higher.

The broad implications of this analysis is that interventions are capable of reversing the effects of poverty, at least to an extent, but the findings raise the deeper question as to why poorer parents are investing less than richer parents, when these investments are not (financially) costly. As alluded earlier, one hypothesis that is consistent with much of the evidence around these interventions is that they work by shifting parental beliefs over the value of investments. Attanasio, Cunha, and Jervis (2019) provide direct evidence that, in the case of the Colombian study at least, the intervention precisely did that. They use direct measure of parental beliefs over the productivity of investments for children endowed with different levels of skills. With those data, they show that treated parents believe that investments are more productive than parents in the control group. They estimate a structural model to show that this shift in parental beliefs is enough to explain

the intervention impacts on parental investments.

5.4 Sustainability of impacts over time

As mentioned earlier, the JHV program achieved remarkably strong impacts into adulthood both in cognition and earnings (Gertler, Heckman, Pinto *et al.*, 2014). Among the other evaluations of 'Reach Up' interventions, the only one that has so far collected data some time after the end of the intervention is the study in Colombia. Two years after the intervention ended, none of the benefits that had been immediately observed were visible any more (Andrew, Attanasio, Fitzsimons *et al.*, 2018).

The production function framework and evidence on its empirical features can suggest a number of reasons why the effects of the Colombian intervention would fade out over time. As discussed in Section 3.2.2, in a model where dynamics follow a Markov process, persistence of impacts could occur either through the 'self-productivity' or 'cross-productivity' channels, and/or because impacts on inputs occurring during the intervention are sustained over time. If this is an accurate characterization of the process of child development, then fade out could occur either because the intervention's initial impacts were too small (given a particular level of self-productivity) and/or because increases in parental investments were not sustained. In the case of the Colombian intervention, both of these factors were likely to be at play.

Initial impacts of the Colombia trial were much smaller than in the Jamaica trial, and estimates of self-productivity in the production function for cognition is well below 1 (Attanasio, Cattan, Fitzsimons *et al.*, 2020). Moreover, when measured two years after the end of the intervention, parental investments among the treated group had returned to the same level of investment as that of the control group (although they had significantly shifted during the intervention). If indeed parental investments had shifted because of a change in parental beliefs about the productivity of investments (as discussed above), this evidence does suggest that such change in beliefs may be too narrow or age-specific to ensure sustained changes in environments over time. This would suggest that sustaining impacts in the longer run requires to find ways to preserve parental engagement and possibly continue with further interventions in pre-school and later.[34]

[34]This is one of the hypotheses being tested in current work in the Odisha study where children are re-randomised at the end of the parenting program to an enhanced pre-school program or to the status quo.

5.5 Scalability of parenting interventions

While efficacy trials, such as the Jamaican study, show the potential of interventions for mitigating and even reversing the effects of poverty on child development, a key challenge lies in designing the intervention to be scalable. Holding the target population constant, scalability is a matter of resource availability and cost, and there are two crucial parameters that affect the cost of the intervention: the human capital of the personnel delivering the intervention and its duration. There is a practical trade-off between achieving strong benefits from interventions and reducing the implementation cost to the extent that governments would be willing to make the investments.

The first issue to consider is the human resources problem. It would be prohibitively expensive to hire college graduates to act as home visitors. However, this may not be necessary. One idea at the core of the interventions discussed above is to use women drawn from the local community (or men if the local norms allow them to operate in a household setting). These home visitors would have to be trained in delivering the program as designed and act as mentors for the mothers. However, an important advantage of recruiting home visitors from within the community is their understanding of the local culture and ability to introduce households to the new practices in a culturally appropriate way. Moreover, if properly chosen to be influential and trusted individuals, these individuals may act as role models and help promote the new practices in the entire community. The difficulty of course relates to training and supervising the home visitors appropriately to ensure they can deliver the intervention, offer support and encouragement to mothers effectively.

An alternative model to individual home visits is to deliver the intervention in groups. The mothers and their children can attend a group session once a week, and a group facilitator can introduce activities, which the group of mother and children practice together. There are several potential advantages to such an approach. First, it comes at a fraction of the cost of delivering home visits. Second, in some contexts, group sessions can enhance the formation of networks of otherwise isolated women, thus reinforcing the adoption and improving the acceptability of new parenting practices (Andrew, Attanasio, Augsburg *et al.*, 2020).

To date, there is little systematic evidence about which delivery model (group vs. home visits) is most cost-effective, and which individuals should be optimally chosen to deliver it (as mentors and supervisors), though the answer to these questions is naturally likely to greatly vary depending

on contexts and cultural norms. One of the few exceptions is the Odisha study, which implemented group sessions in one treatment arm and home visits in another. Quite strikingly, Grantham-McGregor, Adya, Attanasio *et al.* (2020) report that after two years of intervention, group sessions were equally effective as individual home visits with approximately 30% of a standard deviation improvement in cognition and language. These findings are quire remarkable, particularly since implementing group sessions cost less than 30% as much as home visits. The interventions do differ in their compliance and attendance rates, with those being much lower among those assigned group sessions than those assigned individual home visits. This implies that the impact of treatment on the treated (i.e. the ITT effect scaled up to account for compliance) is much higher for groups than home visits, although the compliers for the two intervention types may be different populations. Moreover, the cost of implementing groups may in fact be higher if we factor in the extra effort required to attract families that did not attend.

The second key parameter underlying the intervention's implementation cost is the length of the intervention. Among the JHV and the various implementations 'Reach Up', implementation length varied between 18 and 24 months long. To our knowledge, there is no experimental evidence to show how effectiveness depends on the intervention's duration. Though not definitive, some insight can be gained from the Odisha study, where outcome data were collected half way through the intervention, at 12 months. After one year of intervention, both group and home visits experienced cognitive gains of about 30% SD (with p-values of 0.018 for group sessions and 0.006 for home visits). Children attending groups also show a 31% SD (p-value 0.006) significant improvement in language, while the home visits showed half that improvement, which is not significant (although the two point estimates are not significantly different from each other). After two years of intervention it remains the case that group modality is as effective as individual home visits with approximately 30% SD (p-values of 0.007 for group sessions and 0.001 for home visits) improvement in cognition and language. Children in both treatment arms were found to have made strong and highly significant improvements in language in the second year, with now an impact of 24% SD (p-value 0.009) in language for home visits. A surprising finding therefore is that no further benefit relative to the control group was achieved for cognition in either intervention and for language in the group sessions. Given results on fadeout that we have seen from other experiments, including in the JHV and the Colombia study, the second year may have prevented fadeout and as such it may be

particularly important. However, the lack of further progress with respect to the control group in the second year is troubling and challenging, although it has been observed in other contexts as well (Grantham-McGregor and Smith, 2016; McKay, Sinisterra, McKay *et al.*, 1978; Yousafzai, Rasheed, Rizvi *et al.*, 2014). What causes this plateau in progress and how can it be overcome? These are questions that remain unanswered but are of key importance if we are to understand better the process of human capital accumulation and how this interacts with poverty and intervention.

5.6 The production function and policy interventions

The optimal timing and duration of policy interventions depend crucially on the process of child development, which economists describe using production functions. While we have learned a lot over the recent years, the more we learn the more questions open up. At stake is the design of coherent policies towards interventions to improve investments in children, in particular those from lower income and, broadly defined, deprived backgrounds, so as to address inequality and the intergenerational transmission of poverty.

From the available evidence we know that the early impacts of several interventions tend to fade out, although there is some evidence of re-emergence later in some cases (Bailey, Duncan, Odgers *et al.*, 2017). An implication of these patterns and in particular of the re-emergence of impacts is that the first order Markov assumption, where all the past can be captured by the current development level of the child and it is often used in current studies, may not be fully accurate. Furthermore the short run evaluation of interventions may only provide a partial and over-pessimistic picture of their effects.

Many estimates of the effect of parental investments on child development imply that early investments are the most potent. However, this evidence mostly captures only the impact of parental investments and does not account for the effects of schools or peers and the dynamic interactions that parental investment (and their effect on several dimensions of development) has with these subsequent inputs. Investments in later childhood and adolescence are likely to be very important and interact with early parental investments but these effects have not been measured appropriately, at least by economists. This view would imply that we need sequences of programs that last and complement each other throughout childhood, while adapting to the demands of each age.

Finally, existing estimates of production function covering several developmental periods suggest that developmental measures, such as cognition, are increasingly persistent with age. An implication of this evidence, coupled with the fact that the 'productivity' of parental investment changes as children age, could be the existence of opposing forces defining when the right time to intervene should be, or more accurately, how the intensity and duration of intervention should vary throughout childhood. On the one hand, investments at a very young age seem to be highly effective in the short run, but the low persistence implies their impact fades out. A better understanding of the complex dynamics and interactions between different inputs in the process of child development is necessary for the design of effective policies.

6 Conclusion and directions for future research

Human capital research has dominated economics ever since Becker pushed it to the forefront with his seminal work (Becker, 1964) linking human capital to individual income growth, inequality, and intergenerational mobility. While economists were working out the implications of Becker's theory, including how individuals and families decide to invest in human capital and what the implications of such investments are, medical, psychological and neuroscience researchers were working out how the brain develops and establishing the plasticity of intelligence and the importance of the environment in defining outcomes for individuals. Through these efforts, they uncovered the importance of early childhood in defining cognitive and socio-emotional development and the way early childhood interact with later developmental stages, including adolescence, to form adult skills and capabilities.

To use economic language, these discoveries have taught us a lot about the production process of human capital and its complexities. Perhaps some of its most important lessons relate to the plasticity of the human brain and the link between poverty and early developmental deficits, which could be at the origins of the perpetuation of poverty across generations. The literature in child development, neuro-science and economics are now converging and leading to an important interdisciplinary field in which economists and child development specialists interact to reach a better understanding of human development and suggest how to design policies that best promote child development from the earliest days of life. This research and policy agenda involves bringing

together the lessons from medical research and neuroscience with our understanding as economists of how families make decisions and react to incentives and constraints when investing in their children's development.

While much progress has been made in recent years, there are still a number of open challenges and research questions, ranging from the details of the process of human development to a full understanding of the behavior of actors involved. The design of effective policies requires a good understanding of how and when the process of human development changes with age, so as to identify where "windows of opportunities" for effective interventions might be. Another key element for the development and deployment of effective policies is a good understanding of the behaviors of key actors such as parents or teachers. The accumulating evidence is forcing economists to re-evaluate and modify models of human capital investments that assume full information of the development process on the part of key actors. In a context where some of these investments are simple and cheap in nature (such as talking, playing or reading with them), it is indeed very hard to understand the huge and widening developmental disparities between the poor and the middle class if we assume full information and a complete understanding of the production function of human capital.

This is where interdisciplinarity offers the strongest support to our understanding: while child development specialists need to know about concepts including crowding out, resource and time constraints affecting parental behavior, economists are sure to fail in policy design and advice without an understanding of developmental complexities and an appreciation of our limited understanding of the returns to child investments in various childhood stages across the income distribution. Moreover, if we are to understand and possibly remedy the disparities across the income distribution, we need to develop a richer model of household behaviour than the one which assumes full information on the part of parents and teachers. And we need more research on the formation of beliefs about the human capital production function and how this process differs by income and wealth.

In this review, we discussed the economics literature on the dynamic production functions for human capital and how they have been used in the literature to learn directly from the data the process of human development and the productivity of investments in children at various ages. In doing so, we highlighted some of the important challenges and open questions, including the

identification of causal links between inputs and outputs in the process of human capital formation when the former are determined endogenously as the product of individual choices. By using data on actual child development, under ideal circumstances at least, this empirical work is intended to reveal the "true" production function reflecting the productivity of the various inputs at different childhood stages. We also discussed extensively the important but as yet unresolved issue of the dimensions of human capital. Following the lead of Heckman and his co-authors, most of the economics literature currently focuses on two dimensions: cognitive and socio-emotional skills (often called 'non-cognitive' skills in the economics literature). But is that sufficient? Or is it a product of the limited data at our disposal?

These issues are important in the child development literature and have become central to economics as well, with the increased focus on multi-dimensional skills in the labor market and the role these play in understanding the effects of automation and indeed understanding gender disparities (Bernatzky-Koehli, 2021). Of course from an economic point of view, the question is not just whether there are are multiple dimensions to intelligence (a key developmental question), but also whether they can be Hicks-aggregated when studying the labor market and the resulting wages. The ability to aggregate skills into, say, one index transforms what is a complex problem in child development into a much simpler one for its economic implications. Nevertheless, the recent economic literature has shown that the relative price of the various skills has been changing over time together with their relative importance as technology changes, implying that the simplification of aggregation is not available.

The other big question, unresolved as far as we are concerned, relates to how we should model parental decisions to invest in children and, in particular how we should incorporate the role of distorted beliefs. We argue more should be done to incorporate insights from the child development literature around the appropriate characterization and measurement of parental investments. Few datasets used by economists working in this space have more than coarse measures of resources and time, which seem inadequate to capture important differences across families of various socio-economic backgrounds and cultures.

Finally, we discussed policy interventions that seek directly to change parental behavior towards child rearing and child investments. These have generally been shown to be successful in achieving short-run gains. In some, but not all, cases the gains have been shown to be long lasting. While

generally we understand how to structure such interventions to achieve positive effects, there are still important challenges relating to the scaling up of these interventions and the sustainability of their impacts. First, scalability does not only refer to the financial cost of running these interventions but also to the ownership and acceptability of the intervention by the community that is targeted. How should interventions be designed and delivered to take account of this important distinction? Second, we need to identify ways to improve outcomes further and to ensure that these improvements are sustained in the longer run: if scaled-up interventions are not capable of producing the kind of outcomes we have seen in the Jamaica intervention and in a few other places, it may be the case that we need to prolong the intervention period and/or complement the early intervention with other ones in later periods of childhood.

Third, we need to ensure that the intervention can produce benefits both for the hard-to-reach and the less disadvantaged who have better prior outcomes. As we have discussed earlier in the article, a crucial distinction between the Jamaican and Bangladeshi interventions on the one hand, and the Colombian and Indian interventions on the other is the fact that, while the latter generally targeted the poor, they did not necessarily target children suffering from long-term malnutrition. An important question therefore is whether the design of this intervention is better suited for the ultra-poor and whether modifications could be performed to obtain benefits for less deprived groups. Despite the urgency to improve development for a relatively broad range of initial deficits, it is unlikely that one size fits all. How do we then adapt parenting interventions that have been shown to succeed to obtain benefits for a broad range of baseline abilities and levels of deprivation? This question is key for scaling up where the heterogeneity of the children is likely to be even higher than it was in the interventions discussed earlier. To our knowledge, little is known about this, though it constitutes an important research priority.

Improving child development among the poor is a key challenge for breaking the cycle of poverty. This will require continued research bringing economists and child development specialists together with more fieldwork and ever improved and creative approaches. However, from a growth policy perspective it is important to place this in a broader context. Human capital policies are just one element of a set of policies that can promote growth and indeed reduce poverty. For example, without policies that promote entrepreneurship and capital investment, human capital policies may lead to very little because economic opportunity will be absent even for the better educated and

skilled. However, absent human capital policies starting at the very beginning of life, growth is likely to be stunted and inequitable.

References

Acemoglu, D. and Autor, D. (2011). 'Skills, Tasks and Technologies: Implications for Employment and Earnings.' In D. Card and O. Ashenfelter, eds., *Handbook of Labor Economics*, vol. 4B, chap. 12, pages 1043–1171. Elsevier.

Adhvaryu, A. and Nyshadham, A. (2016). 'Endowments at Birth and Parents' Investments in Children.' *The Economic Journal*, vol. 126(593):pages 781–820.

Agostinelli, F., Saharkhiz, M., and Wiswall, M. J. (2020). 'Home and School in the Development of Children.' NBER Working Paper 26037, National Bureau of Economic Research.

Agostinelli, F. and Sorrenti, G. (2018). 'Money vs. Time: Family Income, Maternal Labor Supply, and Child Development.' Working Papers 2018-017, Human Capital and Economic Opportunity Working Group.

Agostinelli, F. and Wiswall, M. (2016). 'Identification of Dynamic Latent Factor Models: The Implications of Re-Normalization in a Model of Child Development.' Working Paper 22441, National Bureau of Economic Research.

Agostinelli, F. and Wiswall, M. (2020). 'Estimating the Technology of Children's Skill Formation.' NBER Working Paper 22442, National Bureau of Economic Research.

Aizer, A. and Cunha, F. (2012). 'The Production of Human Capital: Endowments, Investments and Fertility.' NBER Working Paper 18429.

Alesina, A., Hohmann, S., Michalopoulos, S., and Papaioannou, E. (2021). 'Intergenerational Mobility in Africa.' *Econometrica*, vol. 89(1):pages 1–35.

Almlund, M., Duckworth, A. L., Heckman, J., and Kautz, T. (2011). 'Personality Psychology and Economics.' In E. A. Hanushek, S. Machin, and L. Woessmann, eds., *Handbook of the Economics of Education*, vol. 4, pages 1–181. Elsevier.

Almond, D. and Currie, J. (2011). 'Human capital development before age five.' In O. Ashenfelter and D. Card, eds., *Handbook of Labor Economics, Volume 4b*. Elsevier Science, Amsterdam.

Almond, D. and Mazumder, B. (2013). 'Fetal Origins and Parental Responses.' *The Annual Review of Economics*, vol. 5(3):pages 1–20.

Almås, I., Armand, A., Attanasio, O., and Carneiro, P. (2018). 'Measuring and Changing Control: Women's Empowerment and Targeted Transfers.' *The Economic Journal*, vol. 128(612):pages F609–F639.

Almås, I., Attanasio, O., and Jervis, P. (2021). 'Economics and Measurment. New measures to model decision making.' In progress.

Andrew, A., Attanasio, O., Augsburg, B., Behrman, J., Day, M., Jervis, P., Meghir, C., and Phimister, A. (2020). 'Mothers' Social Networks and Socioeconomic Gradients of Isolation.' *NBER Working paper 28049*.

Andrew, A., Attanasio, O., Augsburg, B., Day, M., Grantham-McGregor, S., Meghir, C., Mehrin, F., Pahwa, S., and Rubio-Codina, M. (2019). 'Effects of a scalable home-visiting intervention on child development in slums of urban India: Evidence from a randomised controlled trial.' *Journal of Child Psychology and Psychiatry*.

Andrew, A., Attanasio, O., Fitzsimons, E., Grantham-McGregor, S., Meghir, C., and Rubio-Codina, M. (2018). 'Impacts 2 years after a scalable early childhood development intervention to increase psychosocial stimulation in the home: A follow-up of a cluster randomised controlled trial in Colombia.' *PLoS medicine*, vol. 15(4):page e1002556.

Arcidiacono, P., Hotz, V. J., and Kang, S. (2012). 'Modeling college major choices using elicited measures of expectations and counterfactuals.' *Journal of Econometrics*, vol. 166(1):pages 3–16.

Attanasio, O., Bernal, R., Giannola, M., and Nores, M. (2020). 'Investment and the Changing Dynamics of Different Dimensions.' NBER Working Paper 27812.

Attanasio, O., Boneva, R., and Rauh, C. (2020). 'Parental Beliefs about Returns to Different Types of Investments in School Children.' *Journal of Human Resources*.

Attanasio, O., Cattan, S., Fitzsimons, E., Meghir, C., and Rubio-Codina, M. (2020). 'Estimating the Production Function for Human Capital: Results from a Randomized Controlled Trial in Colombia.' *American Economic Review*, vol. 110(1):pages 48–85.

Attanasio, O., Cunha, F., and Jervis, P. (2019). 'Subjective Parental Beliefs. Their Measurement and Role.' Working Paper 26516, National Bureau of Economic Research.

Attanasio, O., Meghir, C., and Nix, E. (2020). 'Human Capital Development and Parental Investment in India.' *The Review of Economic Studies*, vol. 87(6):pages 2511–2541. ISSN 0034-6527.

Attanasio, O., Meghir, C., Nix, E., and Salvati, F. (2017). 'Human Capital Growth and Poverty: Evidence from Ethiopia and Peru.' *Review of Economic Dynamics*, vol. 25:pages 234–259.

Attanasio, O., Meghir, C., and Schady, N. (2010). 'Mexico's conditional cash transfer programme.' *Lancet*, vol. 375(9719):page 980.

Attanasio, O., de Paula, A., and Toppeta, A. (2020). 'The Persistence of Socio-Emotional Skills: Life Cycle and Intergenerational Evidence.' NBER Working Paper No. 27823.

Attanasio, O. P., Fernández, C., Fitzsimons, E. O. A., Grantham-McGregor, S. M., Meghir, C., and Rubio-Codina, M. (2014). 'Using the infrastructure of a conditional cash transfer program to deliver a scalable integrated early child development program in Colombia: Cluster randomized controlled trial.' *British Medical Journal*, vol. 349:page g5785.

Bailey, D., Duncan, G. J., Odgers, C. L., and Yu, W. (2017). 'Persistence and Fadeout in the Impacts of Child and Adolescent Interventions.' *Journal of research on educational effectiveness*, vol. 10:pages 7–39.

Baker-Henningham, H. and López Bóo, F. (2010). 'Early Childhood Stimulation Interventions in Developing Countries: A Comprehensive Literature Review.' IZA Discussion Papers 5282, Institute of Labor Economics (IZA).

Banerjee, A., Duflo, E., Goldberg, N., Karlan, D., Osei, R., Parienté, W., Shapiro, J., Thuysbaert, B., and Udry, C. (2015). 'A multifaceted program causes lasting progress for the very poor: Evidence from six countries.' *Science*, vol. 348(6236). ISSN 0036-8075.

Bastagli, F., Samman, E., Both, N., Evans, M., Sepúlveda, M., Yang, L., Walker, R., Salomon, H., and Orton, I. (2020). 'Universal child benefits: Policy issues and options.' Tech. rep., UNICEF-ODI, London and New York, NY.

Becker, G. S. (1964). *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education*. New York: National Bureau of Economic Research.

Becker, G. S. and Tomes, N. (1986). 'Human Capital and the Rise and Fall of Families.' *Journal of Labor Economics*, vol. 4(3):pages S1–39.

Behrman, J., Pollak, R., and Taubman, P. (1982). 'Parental Preferences and Provision for Progeny.' *Journal of Political Economy*, vol. 90(1):pages 52–73.

Bernatzky-Koehli, M. (2021). 'Labor Market Behavior and Fertility of Highly Educated Women.' Yale University mimeo.

Berniell, L., De la Mata, D., Bernal, R., Camacho, A., Barrera-Osorio, F., Álvarez, F., and Vargas, J. (2016). *RED 2016. More Skills for Work and Life: The contributions of Families, Schools, Jobs, and the Social Environment*. Caracas: CAF.

Berry, J., Dizon-Ross, R., and Jagnani, M. (2020). 'Not Playing Favorites: An Experiment on Parental Fairness Preferences.' NBER Working Paper 26732, National Bureau of Economic Research.

Bitler, M., Hoynes, H., and Domina, T. (2014). 'Experimental Evidence on Distributional Impacts of Head Start.' NBER Working Paper 20434.

Björklund, A. and Salvanes, K. G. (2011). 'Education and Family Background: Mechanisms and Policies.' In E. A. Hanushek, S. Machin, and L. Woessmann, eds., *Handbook of the Economics of Education*, vol. 3, chap. 3, pages 201–247. Elsevier.

Black, S. E. and Devereux, P. J. (2011). 'Recent Developments in Intergenerational Mobility.' In D. Card and O. Ashenfelter, eds., *Handbook of Labor Economics*, vol. 4, chap. 16, pages 1487–1541. Elsevier.

Bobba, M. and Frisancho, V. (2020). 'Self-Perceptions about Academic Achievement: Evidence from Mexico City.' TSE Working Papers 20-1070, Toulouse School of Economics (TSE).

Bond, T. N. and Lang, K. (2013). 'The Evolution of the Black-White Test Score Gap in Grades K-3: The Fragility of Results.' *The Review of Economics and Statistics*, vol. 95(5):pages 1468–1479.

Boneva, T. and Rauh, C. (2018). 'Parental Beliefs about Returns to Educational Investments—The Later the Better?' *Journal of the European Economic Association*, vol. 16(6):pages 1669–1711.

Borghans, L., Weel, B. T., and Weinberg, B. A. (2014). 'People skills and the labor-market outcomes of underrepresented groups.' *ILR Review*, vol. 67(2):pages 287–334. ISSN 00197939, 2162271X.

Bourguignon, F. and Chiappori, P.-A. (1992). 'Collective models of household behavior: An introduction.' *European Economic Review*, vol. 36(2):pages 355–364. ISSN 0014-2921.

Butcher, K. F. and Case, A. (1994). 'The Effect of Sibling Sex Composition on Women's Education and Earnings*.' *The Quarterly Journal of Economics*, vol. 109(3):pages 531–563. ISSN 0033-5533.

Campbell, F. A. and Ramey, C. T. (1994). 'Effects of Early Intervention on Intellectual and Academic Achievement:A Followup Study of Children from Low Income Families.' *Child Development*, vol. 65,684-6.

Carneiro, P., García, I. L., Salvanes, K. G., and Tominey, E. (2021). 'Intergenerational Mobility and the Timing of Parental Income.' *Journal of Political Economy*, vol. 129(3).

Carneiro, P., Kraftman, L., Mason, G., Moore, L., Rasul, I., and Scott, M. (2021). 'The Impacts of a Multifaceted Prenatal Intervention on Human Capital Accumulation in Early Life.' *American Economic Review*, vol. 111(8):pages 2506–49.

Caucutt, E., Lochner, L., Mullins, J., and Park, Y. (2020a). 'Child skill production: Accounting for parental and market-based time and goods investments.' *University of Western Ontario, mimeo*.

Caucutt, E. M., Lochner, L., Mullins, J., and Park, Y. (2020b). 'Child Skill Production: Accounting for Parental and Market-Based Time and Goods Investments.' NBER Working Paper 27838, National Bureau of Economic Research.

Caucutt, E. M., Lochner, L., and Park, Y. (2017). 'Correlation, Consumption, Confusion, or Constraints: Why Do Poor Children Perform so Poorly?' *Scandinavian Journal of Economics*, vol. 119(1):pages 102–147.

Chaparro, J., Sojourner, A., and Wiswall, M. J. (2020). 'Early Childhood Care and Cognitive Development.' Working Paper 26813, National Bureau of Economic Research.

Chevalier, A., Gibbons, S., Thorpe, A., Snell, M., and Hoskins, S. (2009). 'Students' academic self-perception.' *Economics of Education Review*, vol. 28(6):pages 716–727.

Chiappori, P.-A. (1988). 'Rational Household Labor Supply.' *Econometrica*, vol. 56(1):pages 63–90. ISSN 00129682, 14680262.

Chiappori, P.-A. and Meghir, C. (2015). 'Intrahousehold Inequality.' In A. B. Atkinson and F. Bourguignon, eds., *Handbook of Income Distribution*, vol. 2, chap. 16, pages 1369–1418. Elsevier.

Cunha, F., Elo, I., and Culhane, J. (2013). 'Eliciting Maternal Expectations about the Technology of Cognitive Skill Formation.' NBER Working Papers 19144, National Bureau of Economic Research, Inc.

Cunha, F., Elo, I., and Culhane, J. (2020). 'Maternal subjective expectations about the technology of skill formation predict investments in children one year later.' *Journal of Econometrics*. ISSN 0304-4076.

Cunha, F. and Heckman, J. (2008). 'Formulating, Identifying and Estimating the Technology of Cognitive and Noncognitive Skill Formation.' *Journal of Human Resources*, vol. 43(4):pages 738–782.

Cunha, F., Heckman, J., Lochner, L., and Masterov, D. (2006). 'Interpreting the evidence on life cycle skill formation.' In E. Hanushek, S. Machin, and L. Woessmann, eds., *Handbook of the Economics of Education, Volume 1*. Elsevier Science, Amsterdam.

Cunha, F., Heckman, J., and Schennach, S. (2010). 'Estimating the technology of cognitive and non-cognitive skill formation.' *Econometrica*, vol. 78(3):pages 883–931.

Dahl, G. B. and Lochner, L. (2012). 'The Impact of Family Income on Child Achievement: Evidence from the Earned Income Tax Credit.' *American Economic Review*, vol. 102(5):pages 1927–56.

De Walque, D., Fernald, L., Gertler, P., and Hidrobo, M. (2017). *Cash Transfers and Child and Adolescent Development*, chap. 23, pages 325–342. The International Bank for Reconstruction and Development / The World Bank.

Del Bono, E., Kinsler, J., and Pavan, R. (2020). 'Skill Formation and the Trouble with Child Non-Cognitive Skill Measures.' IZA Discussion Papers 13713, Institute of Labor Economics (IZA).

DelBoca, D., Flinn, C., and Wiswall, M. (2014). 'Household Choices and Child Development.' *Review of Economic Studies*, vol. 81:pages 137–185.

Deming, D. J. (2017). 'The Growing Importance of Social Skills in the Labor Market*.' *The Quarterly Journal of Economics*, vol. 132(4):pages 1593–1640. ISSN 0033-5533.

Dizon-Ross, R. (2019). 'Parents' Beliefs about Their Children's Academic Ability: Implications for Educational Investments.' *American Economic Review*, vol. 109(8):pages 2728–65.

Doepke, M., Sorrenti, G., and Zilibotti, F. (2019). 'The Economics of Parenting.' *Annual Review of Economics*, vol. 11(1):pages 55–84.

Doepke, M. and Zilibotti, F. (2017). 'Parenting With Style: Altruism and Paternalism in Intergenerational Preference Transmission.' *Econometrica*, vol. 85(5):pages 1331–1371.

Doepke, M. and Zilibotti, F. (2019). *Love, Money, and Parenting*. Princeton University Press.

Doss, C. (2006). 'The Effects of Intrahousehold Property Ownership on Expenditure Patterns in Ghana.' *Journal of African Economies*, vol. 15(1):pages 149–180. ISSN 0963-8024.

Dotti Sani, G. M. and Treas, J. (2016). 'Educational Gradients in Parents' Child-Care Time Across Countries, 1965–2012.' *Journal of Marriage and Family*, vol. 78(4):pages 1083–1096.

Elango, S., García, J., Heckman, J., and Hojman, A. (2016). 'Early Childhood Education.' In R. A. Moffitt, ed., *Economics of Means-Tested Transfer Programs in the United States*, vol. 2, chap. 4. University of Chicago Press, Chicago, IL.

Engle, P. L., Fernald, L. C., Alderman, H., Behrman, J., O'Gara, C., Yousafzai, A., de Mello, M. C., Hidrobo, M., Ulkuer, N., Ertem, I., and Iltus, S. (2011). 'Strategies for reducing inequalities and improving developmental outcomes for young children in low-income and middle-income countries.' *The Lancet*, vol. 378(9799):pages 1339–1353. ISSN 0140-6736.

Fernald, L., Gertler, P., and Neufeld, L. (2008). 'Role of Cash in Conditional Cash Transfer Programmes for Child Health, Growth, and Development: An analysis of Mexico's Oportunidades.' *Lancet*, vol. 371:pages 828–37.

Fiszbein, A., Schady, N., Ferreira, F., Grosh, M., Keleher, N., Olinto, P., and Skoufias, E. (2009). *Conditional Cash Transfers: Reducing Present and Future Poverty*. The World Bank.

Gertler, P., Heckman, J., Pinto, R., Zanolini, A., Vermeerch, C., Walker, S., Chang, S., and Grantham-McGregor, S. (2014). 'Labor Market Returns to an Early Childhood Stimulation Intervention in Jamaica.' *Science*, vol. 344:pages 998–1001.

Giannola, M. (2021). 'Parental Investments and Intra-household Inequality in Child Human Capital: Theory, Measurement, and Evidence from a Lab-in-the-Field Experiment.' University College London.

Grantham-McGregor, S., Adya, A., Attanasio, O., Augsburg, B., Behrman, J., Caeyers, B., Day, M., Jervis, P., Kochar, R., Makkar, P., Meghir, C., Phimister, A., Rubio-Codina, M., and Vats, K. (2020). 'Group Sessions or Home Visits for Early Childhood Development in India: A Cluster RCT.' *Pediatrics*, vol. 146:page e2020002725.

Grantham-McGregor, S., Cheung, Y. B., Cueto, S., Glewwe, P., Richter, L., and Strupp, B. (2007). 'The International Child Development Steering Group. Developmental potential in the first 5 years for children in developing countries.' *Lancet*, vol. 369.

Grantham-McGregor, S., Powell, C., Walker, S., and Himes, J. (1991). 'Nutritional supplementation, psychosocial stimulation, and mental development of stunted children: The Jamaican Study.' *Lancet*, vol. 338(758):pages 1–5.

Grantham-McGregor, S. and Smith, J. A. (2016). 'Extending the Jamaican early childhood development intervention.' *Journal of Applied Research on Children*, vol. 7(2):4.

Grantham-McGregor, S., Walker, S., Chang, S., and Powell, C. (1997). 'Effects of early childhood supplementation with and without stimulation on later development in stunted Jamaican children.' *The American journal of clinical nutrition*, vol. 66(2):page 247—253. ISSN 0002-9165.

Hamadani, J., Mehrin, F., Tofail, F., Hasan, I., Huda, S., Baker-Henningham, H., Ridout, D., and Grantham-McGregor, S. (2019). 'Integrating an early childhood development programme into Bangladeshi primary health-care services: An open-label, cluster-randomised controlled trial.' *The Lancet Global Health*, vol. 7(3):pages 366–375.

Hamadani, J. D., Huda, S. N., Khatun, F., and Grantham-McGregor, S. M. (2006). 'Psychosocial Stimulation Improves the Development of Undernourished Children in Rural Bangladesh.' *The Journal of Nutrition*, vol. 136(10):pages 2645–2652. ISSN 0022-3166.

Heckman, J., Moon, S. H., Pinto, R., Savelyev, P., and Yavitz, A. (2010). 'Analyzing social experiments as implemented: A reexamination of the evidence from the HighScope Perry Preschool Program.' *Quantitative Economics*, vol. 1(1):pages 1–46.

Heckman, J., Pinto, R., and Savelyev, P. (2013). 'Understanding the mechanisms through which an influential early childhood program boosted adult outcomes.' *American Economic Review*, vol. 103(6):pages 2052–86.

Heckman, J. J., Humphries, J. E., and Kautz, T. (2014). *The Myth of Achievement Tests: The GED and the Role of Character in American Life*. University of Chicago Press, Chicago, IL and London.

Heckman, J. J. and Karapakula, G. (2019). 'The Perry Preschoolers at Late Midlife: A Study in Design-Specific Inference.' NBER Working Paper 25888, National Bureau of Economic Research.

Heckman, J. J. and Rubinstein, Y. (2001). 'The Importance of Noncognitive Skills: Lessons from the GED Testing Program.' *American Economic Review*, vol. 91(2):pages 145–149.

Heckman, J. J., Stixrud, J., and Urzua, S. (2006). 'The Effects of Cognitive and Noncognitive Abilities on Labor Market Outcomes and Social Behavior.' *Journal of Labor Economics*, vol. 24(3):pages 411–482.

Helmers, C. and Patnam, M. (2011). 'The formation and evolution of childhood skill acquisition: Evidence from India.' *Journal of Development Economics*, vol. 95(2):pages 252–266. ISSN 0304-3878.

Hoddinott, J. and Haddad, L. (1995). 'Does Female Income Share Influence Household Expenditures? Evidence from Cote d'Ivoire.' *Oxford Bulletin of Economics and Statistics*, vol. 57(1):pages 77–96.

Katz, L. F. and Murphy, K. M. (1992). 'Changes in Relative Wages, 1963-1987: Supply and Demand Factors.' *The Quarterly Journal of Economics*, vol. 107(1):pages 35–78. ISSN 00335533, 15314650.

Kinsler, J. and Pavan, R. (2021). 'Local Distortions in Parental Beliefs over Child Skill.' *Journal of Political Economy*, vol. 129(1):pages 81–100.

Kohn, M. L. (1963). 'Social Class and Parent-Child Relationships: An Interpretation.' *American Journal of Sociology*, vol. 68(4):pages 471–480.

Lancet (2007). 'Early Child Development in Developing Countries.' *Lancet*.

Lareau, A. (2003). *Unequal Childhoods: Class, Race, and Family Life*. University of California Press, 1 ed.

Lundberg, S. (2017). 'Noncognitive Skills as Human Capital.' In C. R. Hulten and V. A. Ramey, eds., *Education, Skills, and Technical Change: Implications for Future US GDP Growth*, chap. 6, pages 219–243. niversity of Chicago Press.

Lundberg, S. J., Pollak, R. A., and Wales, T. J. (1997). 'Do Husbands and Wives Pool Their Resources? Evidence from the United Kingdom Child Benefit.' *Journal of Human Resources*, vol. 32(3):pages 463–480. ISSN 0022166X.

Lynd, R. S. and Lynd, H. M. (1929). *Middletown : A study in contemporary American culture*. Harcourt, Brace and Company, New York.

Lynd, R. S. and Lynd, H. M. (1937). *Middletown in transition : A study in cultural conflicts*. Harcourt, Brace and Company, New York.

Macours, K., Schady, N., and Vakis, R. (2012). 'Cash Transfers, Behavioral Changes, and Cognitive Development in Early Childhood: Evidence from a Randomized Experiment.' *American Economic Journal: Applied Economics*, vol. 4(2):pages 247–273.

Macours, K. and Vakis, R. (2010). 'Seasonal Migration and Early Childhood Development.' *World Development*, vol. 38(6):pages 857–869.

Maluccio, J. A. and Flores, R. (2005). 'Impact evaluation of a conditional cash transfer program: The Nicaraguan Red de Protecciońn Social.' Research reports 141, International Food Policy Research Institute (IFPRI).

Mani, A., Mullainathan, S., Shafir, E., and Zhao, J. (2013). 'Poverty Impedes Cognitive Function.' *Science*, vol. 341(6149):pages 976–980. ISSN 0036-8075.

McKay, H., Sinisterra, L., McKay, A., Gomez, H., and Lloreda, P. (1978). 'Improving Cognitive Ability in Chronically Deprived Children.' *Science*, vol. 200(4339):pages 270–278. ISSN 00368075, 10959203.

Molina-Millan, T., Macours, K., Maluccio, J. A., and Tejerina, L. (2020). 'Experimental long-term effects of early-childhood and school-age exposure to a conditional cash transfer program.' *Journal of Development Economics*, vol. 143:page 102385. ISSN 0304-3878.

Moroni, G., Nicoletti, C., and Tominey, E. (2019). 'Child Socio-Emotional Skills: The Role of Parental Inputs.' IZA Discussion Papers 12432, Institute of Labor Economics (IZA).

Nahar, B., Hossain, M. I., Hamadani, J., Ahmed, T., Huda, S., Grantham-McGregor, S., and Åke Persson, L. (2012). 'Effects of a community-based approach of food and psychosocial stimulation on growth and development of severely malnourished children in Bangladesh: A randomised trial.' *European journal of clinical nutrition*, vol. 66(6):pages 701–709.

Olds, D., Kitzman, H., Anson, B., Smith, J., Knudtson, M., Miller, T., Cole, R., Hopfer, C., and Conti, G. (2019). 'Prenatal and Infancy Nurse Home Visiting Effects on Mothers: 18-Year Follow-up of a Randomized Trial.' *Pediatrics*, vol. 144(6):page e20183889.

Olds, D., Kitzman, H., Cole, R., Robinson, J., Sidora-Arcoleo, K., Luckey, D., Henderson, C., Hanks, C., Bondy, J., and Holmberg, J. (2004). 'Effects of Nurse Home-Visiting on Maternal Life Course and Child Development: Age 6 Follow-Up Results of a Randomized Trial.' *Pediatrics*, vol. 114(6):pages 1550–1559.

Olds, D. L., Holmberg, J. R., Donelan-McCall, N., Luckey, D. W., Knudtson, M. D., and Robinson, J. (2014). 'Effects of Home Visits by Paraprofessionals and by Nurses on Children: Follow-up of a Randomized Trial at Ages 6 and 9 Years.' *JAMA Pediatrics*, vol. 168(2):pages 114–121. ISSN 2168-6203.

Papageorge, N. W., Ronda, V., and Zheng, Y. (2019). 'The Economic Value of Breaking Bad: Misbehavior, Schooling and the Labor Market.' Working Paper 25602, National Bureau of Economic Research.

Paxson, C. and Schady, N. (2010). 'Does Money Matter? The Effects of Cash Transfers on Child Development in Rural Ecuador.' *Economic Development and Cultural Change*, vol. 59(1):pages 187–229.

Putnam, R. D. (2015). *Our Kids: The American Dream in Crisis*. Simon & Schuste.

Richter, L., Black, M., Britto, P., Daelmans, B., Desmond, C., Devercelli, A., Dua, T., Fink, G., Heymann, J., Lombardi, J., Lu, C., Naicker, S., and Vargas-Barón, E. (2019). 'Early childhood development: an imperative for action and measurement at scale.' *British Medical Journal Global Health*, vol. 4(4).

Romano, J. P. and Wolf, M. (2005). 'Stepwise Multiple Testing as Formalized Data Snooping.' *Econometrica*, vol. 73:pages 1237 – 1282.

Romano, J. P. and Wolf, M. (2016). 'Efficient computation of adjusted p-values for resampling-based stepdown multiple testing.' *Statistics & Probability Letters*, vol. 113:pages 38–40. ISSN 0167-7152.

Schady, N. and Rosero, J. (2008). 'Are cash transfers made to women spent like other sources of income?' *Economics Letters*, vol. 101(3):pages 246–248.

Stinebrickner, R. and Stinebrickner, T. R. (2014). 'A Major in Science? Initial Beliefs and Final Outcomes for College Major and Dropout.' *The Review of Economic Studies*, vol. 81(1 (286)):pages 426–472. ISSN 00346527, 1467937X.

Stinebrickner, T. R. and Stinebrickner, R. (2012). 'Learning about Academic Ability and the College Dropout Decision.' *Journal of Labor Economics*, vol. 30(4):pages 707–748. ISSN 0734306X, 15375307.

Super, C. M., Herrera, M. G., and Mora, J. O. (1990). 'Long-Term Effects of Food Supplementation and Psychosocial Intervention on the Physical Growth of Colombian Infants at Risk of Malnutrition.' *Child Development*, vol. 61(1):pages 29–49.

Thomas, D. (1994). 'Like Father, like Son; Like Mother, like Daughter: Parental Resources and Child Height.' *Journal of Human Resources*, vol. 29(4).

Todd, P. E. and Wolpin, K. I. (2003). 'On the Specification and Estimation of the Production Function for Cognitive Achievement.' *The Economic Journal*, vol. 113(485):pages F3–F33.

Tofail, F., Hamadani, J. D., Mehrin, F., Ridout, D. A., Huda, S. N., and Grantham-McGregor, S. M. (2013). 'Psychosocial Stimulation Benefits Development in Nonanemic Children but Not in Anemic, Iron-Deficient Children.' *The Journal of Nutrition*, vol. 143(6):pages 885–893. ISSN 0022-3166.

Ward-Batts, J. (2008). 'Out of the Wallet and into the Purse: Using Micro Data to Test Income Pooling.' *Journal of Human Resources*, vol. 43(2):pages 325–351. ISSN 0022166X.

Yi, J., Heckman, J. J., Zhang, J., and Conti, G. (2015). 'Early Health Shocks, Intra-household Resource Allocation and Child Outcomes.' *The Economic Journal*, vol. 125(588):pages F347–F371.

Yousafzai, A. K., Rasheed, M. A., Rizvi, A., Armstrong, R., and Bhutta, Z. A. (2014). 'Effect of integrated responsive stimulation and nutrition interventions in the Lady Health Worker programme in Pakistan on child development, growth, and health outcomes: a cluster-randomised factorial effectiveness trial.' *Lancet*, vol. 384(9950):page 1282–1293.