The Economics of Human Development and Social Mobility *

James J. Heckman  
Department of Economics  
University of Chicago

Stefano Mosso  
Department of Economics  
University of Chicago

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Abstract

This paper distills and extends recent research on the economics of human development and social mobility. It summarizes the evidence from diverse literatures on the importance of early life conditions in shaping multiple life skills and the evidence on critical and sensitive investment periods for shaping different skills. It presents economic models that rationalize the evidence and unify the treatment effect and family influence literatures. The evidence on the empirical and policy importance of credit constraints in forming skills is examined. There is little support for the claim that untargeted income transfer policies to poor families significantly boost child outcomes. Mentoring, parenting, and attachment are essential features of successful families and interventions that shape skills at all stages of childhood. The next wave of family studies will better capture the active role of the emerging autonomous child in learning and responding to the actions of parents, mentors and teachers.

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James Heckman
Department of Economics
University of Chicago
1126 East 59th Street
Chicago, IL 60637
Email: jjh@uchicago.edu

Stefano Mosso
Department of Economics
University of Chicago
1126 East 59th Street
Chicago, IL 60637
Email: smosso@uchicago.edu
1 Introduction

A growing literature in economics, epidemiology, and psychology establishes the importance of attributes shaped in childhood in determining adult outcomes. At least 50% of the variability of lifetime earnings across persons results from attributes of persons determined by age 18. Childhood is the province of the family. Any investigation of how conditions in childhood affect life outcomes is a study of family influence.

This essay summarizes the recent economic literature on human development through adolescence and early adulthood, focusing on simple models that convey the essential ideas in the literature on family influence. A large literature surveyed in Heckman et al. (2006) and Rubinstein and Weiss (2006) models schooling choices and post-school on-the-job investment. The output of the models we discuss are the initial conditions of those models.

We draw from multiple sources of information: observational studies of family influence including structural models and the literature on social experiments. The early literature on family influence and the determinants of social mobility pioneered by Becker and Tomes (1979, 1986) presents multiple-generation models with one period of childhood, one period of adulthood, one-child families (with no fertility choices), and a single parent. These models are precursors to the models reviewed in this paper. They do not analyze marital sorting and family formation decisions. Parental engagement with the child is in the form of investments in educational goods analogous to firm investments in capital equipment. In the early literature on child development, the role of the child is passive and the information available to the parents is assumed to be perfect. Parental time investments in children are ignored. Investments at any stage of childhood are assumed to be equally effective in producing adult skills. The output of child quality from family investment is a scalar measure

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1 This paper draws on, updates, and substantially extends two previous papers by Cunha et al. (2006) and Cunha and Heckman (2007).

2 See, for example, Cunha et al. (2005), Huggett et al. (2011), and Keane and Wolpin (1997).
of cognition (IQ or an achievement test) or “human capital”. These notions are often used synonymously.

Recent research in the economics of human development and social mobility focuses on skills and the technology of skill formation. It establishes the importance of accounting for: (1) multiple periods in the life cycle of childhood and adulthood and the existence of critical and sensitive periods of childhood in the formation of skills, (2) multiple skills for both parents and children that extend traditional notions about the skills required for success in life, and (3) multiple forms of investment. Some of the most exciting recent research models parent-child/mentor-child, and parent-teacher-child relationships as interactive systems, involving attachment and scaffolding\(^3\) as major determinants of child learning. The recent literature also takes a more nuanced view of child investment and accounts for parental time and lack of parental knowledge about the capacities of children and effective parenting practices. It creates and implements an econometric framework that unifies the study of family influence and the consequences of external interventions in child outcomes.

There is a well-established empirical relationship between family income and child achievement. Many interpret this relationship as evidence of market restrictions including credit constraints. Although it is conceptually attractive to do so, and amenable to analysis using standard methods, the empirical evidence that credit constraints substantially impede child skill formation is not strong. Family income proxies many aspects of the family environment—parental education, ability, altruism, personality, and peers. The empirical literature suggests that unrestricted income transfers are a weak reed for promoting child skills.

This paper proceeds in the following way. Section 2 reviews recent empirical evidence on the expression and formation of capacities over the life cycle. Section 3 lays out basic concepts developed in the recent literature. Section 4 presents a bare-

\(^3\)Scaffolding is an adaptive interactive strategy that recognizes the current capacities of the child (trainee) and guides him or her to further learning without frustrating the child. Activities are tailored to the individual child’s ability so they are neither too hard or too easy in order to keep in the “zone of proximal development,” which is the level of difficulty at which the child can learn the most.
bones model of human development that capture the central features of the literature as well as some recent extensions. It also discusses evidence on the importance of family income and credit constraints in shaping child development. Section 5 amplifies the discussion of Sections 3 and 4 to demonstrate the fundamental role of dynamic complementarity in shaping life-cycle skills. It justifies policies that redistribute resources toward disadvantaged children in the early years on the grounds of efficiency without any appeal to fairness or social justice, although those too might be invoked to strengthen the argument for early intervention. Section 6 presents a dynamic state-space framework that operationalizes the theory and unifies the interpretation of the intervention literature and the literature on family influence. Section 7 presents evidence on the effectiveness of interventions over the life cycle and interprets its findings using the framework developed in this paper. Section 8 summarizes recent models of the development and expression of capacities as the outcomes of parent-child/mentor-child interactions that have common features across the life cycle. A web appendix (heckman.uchicago.edu/hum-dev) presents more formal arguments and extensive empirical evidence on each topic covered in this paper.
2 Some Facts about Skills Over the Life Cycle

Skills are multiple in nature and encompass cognition and personality, as well as health. Skills are capacities to act. They include some of the capabilities defined by Sen (1985) and Nussbaum (2011) but focus on individual attributes and not aspects of society, such as political freedoms. They shape expectations, constraints, and information. More capacities enlarge agent choice sets. The recent empirical literature has established eight important facts about the process of human development and skill formation. Each fact is extensively documented in our Web Appendix.

1. Multiple Skills Multiple skills vitally affect performance in life across a variety of dimensions. A large body of evidence shows that cognitive and noncognitive skills affect labor market outcomes, the likelihood of marrying and divorcing, the likelihood of receiving welfare, voting, and health. Comprehensive surveys are presented in Borghans et al. (2008) and Almlund et al. (2011).

2. Gaps in Skills Gaps in skills between individuals and across socioeconomic groups open up at early ages for both cognitive and noncognitive skills. Carneiro and Heckman (2003), Cunha et al. (2006), and Cunha and Heckman (2007) present evidence of early divergence in cognitive and noncognitive skills before schooling begins. Many measures show near-parallelism during the school years across children of parents from different socioeconomic backgrounds, even though schooling quality is very unequal.

3. Genes The early emergence of skill gaps might be interpreted as the manifestation of genetics: Smart parents earn more, achieve more, and have smarter children.

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4 Capacities may also shape preferences, but in this case, the interpretation placed on the benefit of enlarged choice sets is quite different.

5 See Section E in the Web Appendix.

6 Cunha et al. (2006) and Cunha and Heckman (2007) present evidence on gaps from numerous data sources. The pattern of these gaps is evident using both raw and age-adjusted scores. See Section A of our Web Appendix for an extensive analysis of gaps in cognitive and noncognitive skills.

7 See Section M of the Web Appendix. Estimates using the standard ACE model widely used to estimate heritability (see Kohler et al. (2011), for its limitations) show that, on average, 50% of child attributes are heri-
There is, however, a strong body of experimental evidence on the powerful role of parenting and parenting supplements, including mentors and teachers in shaping skills, which we document in this essay.

Genes are important, but skills are not solely genetically determined. The role of heritability is exaggerated in many studies and in popular discussions. Nisbett et al. (2012), Tucker-Drob et al. (2009), and Turkheimer et al. (2003) show that estimated heritabilities are higher in families of higher socioeconomic status. Genes need sufficiently rich environments to fully express themselves. There is mounting evidence that gene expression is itself mediated by environments. Epigenetics informs us that environmental influences are partly heritable.

4. Critical and Sensitive Periods in the Technology of Skill Formation There is compelling evidence for critical and sensitive periods in the development of a child. Different capacities are malleable at different stages of the life cycle (see Thompson and Nelson 2001, Knudsen et al. 2006 and the body of evidence summarized in Cunha et al. 2006). For example, IQ is rank stable after age 10, whereas personality skills are malleable through adolescence and into early adulthood. A substantial body of evidence from numerous disciplines shows the persistence of early life disadvantage in shaping later life outcomes. Early life environments are important for explaining a variety of diverse outcomes, such as crime, health, education, occupation, social engagement, trust, and voting. Readers are referred to Cunha et al. (2006) and Almond and Currie (2011) for reviews of numerous studies on the importance of prenatal and early childhood environments on adolescent and adult health and socioeconomic outcomes.

See, for example, Krueger and Johnson (2008), who show that parenting style affects the heritability of personality.

See the evidence in Web Appendix M.
The study of heritability not related with DNA sequencing.

See Cole et al. (2012); Gluckman and Hanson (2005, 2006); Jablonka and Raz (2009); Kuzawa and Quinn (2009); Rutter (2006).

For example, Barker (1990) and Hales and Barker (1992) propose a “thrifty phenotype” hypothesis, now widely accepted, that reduced fetal growth is associated with a number of chronic conditions later in life (Gluckman and Hanson 2005, 2006).
5. **Family Investments**  Gaps in skills by age across different socioeconomic groups have counterparts in gaps in family investments and environments. Hart and Risley (1995), Fernald et al. (2013), and many other scholars show how children from disadvantaged environments are exposed to a substantially less rich vocabulary than children from more advantaged families. At age three, children from professional families speak 50% more words than children from working-class families and more than twice as many compared to children from welfare families. There is a substantial literature summarized in Cunha et al. (2006), Lareau (2011), Kalil (2013), and Moon (2014) showing that disadvantaged children have compromised early environments as measured on a variety of dimensions. Recent evidence from Cunha et al. (2013) documents the lack of parenting knowledge among disadvantaged parents. Parenting styles in disadvantaged families are much less supportive of learning and encouraging child exploration (see Hart and Risley, 1995; Kalil, 2013; Lareau, 2011).

6. **Resilience and Targeted Investment**  Although early life conditions are important, there is considerable evidence of resilience and subsequent partial recovery. To our knowledge, there is no evidence of full recovery from initial disadvantage. The most effective adolescent interventions target the formation of personality, socioemotional, and character skills through mentoring and guidance, including providing information. This evidence is consistent with the greater malleability of personality and character skills into adolescence and young adulthood. The body of evidence to date shows that, as currently implemented, many later life remediation efforts are not effective in improving capacities and life outcomes of children from disadvantaged environments. As a general rule, the economic returns to these programs are smaller compared to those policies aimed at closing gaps earlier (see Cunha et al., 2006; Heck-}

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12See Table A.1 in the Web Appendix.
13A large body of evidence on this question is summarized in Section B of the Web Appendix.
14See the evidence in Web Appendix B.
15See Table I.1 in the Web Appendix.
16Rutter et al. (2010) show that Romanian orphans reared in severely disadvantaged environments but adopted out to more advantaged environments partially recover, with recovery being the greatest among those adopted out the earliest.
However, workplace-based adolescent intervention programs and apprenticeship programs with mentoring, surrogate parenting, and guidance show promising results. They appear to foster character skills, such as increasing self-confidence, teamwork ability, autonomy, and discipline, which are often lacking in disadvantaged youth. In recent programs with only short-term follow-ups, mentoring programs in schools that provide students with information that improves their use of capacities have also been shown to be effective. (See, e.g., Bettinger et al., 2012; Carrell and Sacerdote, 2013; Cook et al., 2014).

7. Parent-child/Mentor-child Interactions Play Key Roles in Promoting Child Learning

A recurrent finding from the family influence and intervention literatures is the crucial role of child-parent/child-mentor relationships that “scaffold” the child (i.e., track the child closely, encourage the child to take feasible next steps forward in his or her “proximal zone of development,” and do not bore or discourage the child). Successful interventions across the life cycle share this feature.

8. High Returns to Early Investment

Despite the generally low returns to interventions targeted toward the cognitive skills of disadvantaged adolescents, the empirical literature shows high economic returns for investments in young disadvantaged children. There is compelling evidence that high-quality interventions targeted to the early years are effective in promoting skills (Heckman and Kautz, 2014). The evidence is explained by dynamic complementarity which is discussed in the next section.

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17 Recent interventions with short-term follow-ups appear to show remarkable effects on cognitive achievement as measured by achievement tests (See Cook et al., 2014). These findings may appear to contradict the claim in the text. However, as noted by Borghans et al., 2008, Almlund et al., 2011, Heckman and Kautz, 2012, 2014, and Borghans et al., 2011b, the scores on achievement tests are heavily weighted by personality skills. Achievement tests are designed to measure “general knowledge”—acquired skills. This evidence is consistent with the evidence from the Perry Preschool Program that showed boosts in achievement test scores without raising IQ. Perry boosted noncognitive skills.

18 See Section 1.1 of the Web Appendix.
3 Skills, the Technology of Skill Formation, and the Essential Ingredients of a Life-Cycle Model of Human Development

Skills, the technology of producing skills, and parental preferences and constraints play key roles in explaining the dynamics of family influence.

3.1 Skills

We represent the vector of skills at age $t$ by $\theta_t$ over lifetime $T$. Decompose $\theta_t$ into three subvectors:

$$\theta_t = (\theta_{C,t}, \theta_{N,t}, \theta_{H,t}), \quad t = 1, \ldots, T,$$

(1)

where $\theta_{C,t}$ is a vector of cognitive skills (e.g. IQ) at age $t$, $\theta_{N,t}$ is a vector of noncognitive skills (e.g. patience, self-control, temperament, risk aversion, discipline, and neuroticism) at age $t$, and $\theta_{H,t}$ is a vector of health stocks for mental and physical health at age $t$.

Skills can evolve with age and experience $t$. The dimensionality of $\theta_t$ may also change with $t$. As people mature, they acquire new skills previously missing in their personas and sometimes shed old attributes. Skills determine in part (a) resource constraints, (b) agent information sets, and (c) expectations.$^{19}$

A key idea in the recent literature is that a core low-dimensional set of skills joined with incentives and constraints generates a variety of diverse outcomes, although both the skills and their relationship with outcomes may change with the stage of the life cycle.

Age-specific outcome $Y_{j,t}$ for action (task) $j$ at age $t$ is

$$Y_{j,t} = \psi_{j,t}(\theta_t, e_{j,t}, X_{j,t}), \quad j \in \{1, \ldots, J_t\} \quad \text{and} \quad t \in \{1, \ldots, T\},$$

(2)

$^{19}$They may also shape preferences.
where \( X_{jt} \) is a vector of purchased inputs that affect outcomes. Effort \( e_{jt} \) is characterized by the supply function:

\[
e_{jt} = \delta_{j}(\theta_{t}, A_{t}, X_{jt}, R_{jt}^{e}(I_{t-1}) | u),
\]

where \( I_{t-1} \) is the information set, on the basis of which the agent evaluates outcomes; \( R_{jt}^{e}(I_{t-1}) \) is the anticipated reward per unit effort in activity \( j \) in period \( t \); \( A_{t} \) represents other determinants of effort; and \( u \) represents a vector of parameters characterizing preferences.  

An active body of research investigates the role of skills in producing outcomes (see Almlund et al., 2011; Borghans et al., 2008; Bowles et al., 2001; Dohmen et al., 2010). In general, each outcome is differentially affected by components of the (possibly age-dependent) capacity vector \( \theta_{t} \). Schooling, for example, depends more strongly on cognitive abilities, whereas earnings are equally affected by cognitive capacities and noncognitive capacities such as conscientiousness. Scores on achievement tests depend on both cognitive and noncognitive capacities. Evidence that achievement tests predict outcomes better than measures of personality or IQ alone miss the point that achievement tests capture both. As the mapping of capacities to outputs differs among tasks, people with different levels of capacities will also have comparative advantages in performing different tasks.

Equation (2) emphasizes that there are many ways to achieve a level of performance in any given activity. One can compensate for a shortfall in one dimension through greater strength in another. For example, for some tasks deficiencies in cognitive ability can be compensated by greater motivation, determination, and effort. Grades in school depend more on personality traits than pure cognition.

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20 In models of parent-child interactions, the utility functions of the parent and the child govern effort.
21 See Appendix E, Table E.1 for the definition of the Big Five attributes used in personality psychology. They have been called the “latitude and longitude of personality.”
22 See Borghans et al. (2008) and Heckman and Kautz (2012, 2014). This point is confused in a literature that equates cognition with scores on achievement tests.
23 For a recent example of this confusion, see Duckworth et al. (2012).
24 One version of this is the Roy model of occupational choice. See e.g. Heckman and Sédlacek (1985).
25 See Borghans et al. (2011a).
Equation (2) informs a recurrent debate about the relative importance of the “person” versus “the situation” that is alive and well in modern behavioral economics: Are outcomes due to attributes of the individual ($\theta_t$), the situation ($A_t$) or the effort evoked by the interaction among $\theta_t$, $A_t$, and the incentives to attain a given result ($R_{jt}$)? Thaler et al. (2008) and many behavioral economists (e.g., Mullainathan and Shafir, 2013) treat actions of agents as largely the outcomes of situations and incentives in situations. Extreme views claim that there is no stable construct associated with personality or preferences. Almlund et al. (2011) review a large body of empirical evidence that refutes this claim. Stable personality and other capacities play empirically important roles in shaping performance in a variety of tasks apart from the effects of incentives in situations.

Equation (2) has important implications for the use of psychological constructs in the economics of human development and social mobility. Economists routinely use test scores developed by psychologists to capture IQ, achievement, and personality. Psychologists offer their measures as independent indicators of attributes that can be used to predict behaviors. As discussed by Almlund et al. (2011), and Heckman and Kautz (2012, 2014), all tests are just measures of performance on some tasks (i.e., some other behaviors). The tasks usually differ across tests. A large body of evidence shows that effort on test-taking tasks can be incentivized and the response to incentives varies depending on other capabilities. Scores on IQ tests can be substantially boosted by directly rewarding successful answers. The elasticity of response to rewards depends on levels of conscientiousness. The less conscientious are more sensitive to rewards (see Borghans, Duckworth, Heckman, and ter Weel, 2008; Borghans, Meijers, and ter Weel, 2008). Incentivized boosts in achievement have not been shown to persist when the incentives are removed.27

Taking a test is just one of many tasks in life. Behaviors are also as informative about skills as tests are. This insight is the basis for the empirical strategy employed

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26 See Borghans et al. (2008).

27 A literature in psychology by Deci and Ryan (1985; Ryan and Deci, 2000) suggests that the performance is actually lower in the baseline after incentives are removed.
in the recent literature using early behaviors as measures of child attributes (see Heckman et al., 2014; Jackson, 2013; Piatek and Pinger, 2010). Any distinction between tests (or “assessments”) and behaviors is intrinsically arbitrary even though it is enshrined in the literature in psychology and often uncritically adopted by economists.

Equation (2) reveals an important identification problem. To use any set of measurements of outcomes to identify capacities, one needs to control for incentives and the situations that generate performance on a task (see Almlund et al., 2011; Heckman and Kautz, 2012, 2014). The system of equations (2) does not isolate $\theta_t$ unless outcomes are standardized for incentives and environments. Even then, equations in the system (2), which are in the form of nonlinear factor models, are not identified, even in the linear case, unless certain normalizations are imposed that associate a particular factor with a specific set of measurements.\(^{28}\) At best we can identify factors normalized relative to each other (see Almlund et al., 2011; Borghans et al., 2008; Cunha et al., 2010; Heckman and Kautz, 2012, 2014).

A proper understanding of the relevant skills and how they can be modified allows for a unification of the findings from the treatment effect literature for interventions and the more economically motivated family economics literature. Using the empirically specified system of equations (2), and the technology of skill formation in equation (4) exposited below, one can characterize how different interventions or different family influence variables affect $\theta_t$ and hence outcomes ($Y_t$) and make comparisons across those literatures (see Cunha and Heckman, 2007).

Outcomes studied include earnings, crime, health, education, trust, and health behaviors. By accounting for multiple skills, their mutual interactions, and evolution over time, the recent literature goes well beyond saying that schooling is the principal determinant of individual productivity, that measures of cognition are the principal predictors of child outcomes, or that only early health affects adult health.

Using these notions, analysts of human development can draw on frontier production theory (Fried et al., 2008) and define the set of possible actions for people—their

\(^{28}\) See Anderson and Rubin (1956) and Williams (2012).
action spaces. This is closely related to the space of “functionings” in Sen’s capability theory. A fundamental notion in that literature is that of maximum possible flexibility. As noted by [Foster (2011)], this conceptualization is in turn closely related to Kreps’s (1979) notion of flexibility in choice sets that gives agents options to act, whatever their preferences may turn out to be. One goal of many parents is to allow children to be able to be the best that they want to be.29

3.2 Technology

An important ingredient in the recent literature is the technology of skill formation (Cunha 2007; Cunha and Heckman 2007), where the vector $\theta_t$ evolves according to a law of motion affected by investments broadly defined as actions specifically taken to promote learning, and parental skills (environmental variables):

$$\theta_{t+1} = f^{(t)}(\theta_t, I_t, \theta_p, \text{self productivity and cross effects, investments, parental skills}).$$ (4)

$f^{(t)}$ is assumed to be twice continuously differentiable, increasing in all arguments and concave in $I_t$. As noted above, the dimension of $\theta_t$ and $f^{(t)}$ likely increases with the stage of the life cycle $t$, as does the dimension of $I_t$. New skills emerge along with new investment strategies. The technology is stage-specific, allowing for critical and sensitive periods in the formation of capabilities and the effectiveness of investment.30

This technology accommodates the family formation of child preferences, as in Becker and Mulligan (1997), Becker et al. (2012), Bisin and Verdier (2001), and Doepke and Zilibotti (2012).

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29However, as noted by Doepke and Zilibotti (2012) and in the large literature they cite, parenting styles differ, and some parents are paternalistic, seeking to shape child preferences and choices (see, e.g., Chan and Koo 2011).

30The technology is a counterpart to the models of adult investment associated with Ben-Porath (1967) and its extensions (see, e.g., Browning et al., 1999 and Rubinstein and Weiss, 2006). It is more general than the Ben-Porath model and its extensions, because it allows for multiple skill outputs ($\theta_t$) and multiple inputs ($I_t$), where inputs at one stage of the life cycle can be qualitatively different from investments at other stages of the life cycle. Cunha et al. (2006) compare technology (4) with the Ben-Porath model.
The first term in equation (4) captures two distinct ideas: (a) that investments in skills do not fully depreciate within a period and (b) that stocks of skills can act synergistically (cross partials may be positive). For example, higher levels of noncognitive skills promote higher levels of cognitive skills, as shown in the econometric studies of Cunha and Heckman (2008) and Cunha et al. (2010).

A crucial concept emphasized in the recent literature is complementarity between skills and investments at later stages \((t > t^*)\) of childhood:

\[
\frac{\partial^2 \theta_{t+1}}{\partial \theta_t \partial I_t'} > 0, \quad t > t^*\]  \(31\)

The empirical literature reviewed below is consistent with the notion that investments and endowments are direct substitutes (or at least weak complements) at early ages,

\[
\frac{\partial^2 \theta_{t+1}}{\partial \theta_t \partial I_t'} \leq 0, \quad t < t^*, \quad \left(\text{or } \epsilon > \frac{\partial^2 \theta_{t+1}}{\partial \theta_t \partial I_t'} > 0, \text{ for “small” } \epsilon\right)\]

but that complementarity increases with age:

\[
\frac{\partial^2 \theta_{t+1}}{\partial \theta_t \partial I_t'} \uparrow t \uparrow 32
\]

Growing complementarity with the stage of the life cycle captures two key ideas. The first is that investments in adolescents and adults with higher levels of capacity \(\theta_t\) tend to be more productive. This is a force for the social disequalization of investment. It is consistent with evidence reported by Cameron and Heckman (2001), Cunha et al. (2006), Carneiro et al. (2013), and Eisenhauer et al. (2014) that returns to college are higher for more able and motivated students. The second idea is that complementarity tends to increase over the life cycle. This implies that compensatory investments tend to be less effective the later the stage in the life cycle. This feature is

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31 There are other notions of complementarity. For a discussion with reference to the technology of skill formation, see Cunha et al. (2006).
33 See, e.g., Table G.1 Web Appendix.
consistent with a large body of evidence reviewed below that later life remediation is generally less effective than early life prevention and investment (Cunha et al., 2006; Heckman and Kautz, 2014; Knudsen et al., 2006; Sroufe et al., 2005). The dual face of later life complementarity is that early investment is most productive if it is followed up with later life investment.

Complementarity coupled with self-productivity leads to the important concept of dynamic complementarity introduced in Cunha and Heckman (2007, 2009). Because investment produces greater stocks of skills, $I_t \uparrow \Rightarrow \theta_{t+1} \uparrow$, and because of self-productivity, $\theta_{t+s} \uparrow \Rightarrow \theta_{t+s} \uparrow$, $s \geq 1$, it follows that:

$$\frac{\partial^2 \theta_{t+s+1}}{\partial I_t \partial I_{t+s}} > 0, \quad s \geq 1.$$ 

Investments in period $t+s$ and investments in any previous period $t$ are always complements as long as $\theta_{t+s}$ and $I_{t+s}$ are complements, irrespective of whether $I_t$ and $\theta_t$ are complements or substitutes in some earlier period $t$.

It is not inconsistent with the notion that later life investments may have substantial effects and may be cost-effective. It is also consistent with the notion that later life information and guidance can enhance the effectiveness of a given stock of skills.

Dynamic complementarity is a consequence of static complementarity in later life periods. Because future capacities are increasing in current investments and future investments are complements with future capacities, current and future investments tend to be complements the stronger the static complementarity in future periods. Consider the following specification for the technology with scalar $\theta_t$ and $I_t$:

$$\theta_{t+1} = f^{(t)}(\theta_t, I_t).$$

Denoting by $f^1_t$ and $f^2_t$ the derivatives with respect to the first and second argument, respectively,

$$s_i \left\{ \frac{\partial^2 f^{(t+s)}(\theta_{t+s}, I_{t+s})}{\partial I_{t+s} \partial I_t} \right\} = s_i \left\{ f^{(t+s)}_{21} \right\}$$

independently of the sign of $f^{(t+s)}_{21}$, for $s \geq 1$. To prove the claim, note that

$$\frac{\partial^2 f^{(t+s)}(\theta_{t+s}, I_{t+s})}{\partial I_{t+s} \partial I_t} = f^{(t+s)}_{21} \left( \prod_{j=1}^{s-1} f^{(t+j)}_{11} \right) f^{(t)}_{21} \text{ for } s \geq 1.$$ 

(We keep the arguments of the right-hand-side expressions implicit to simplify the notation.) The extension to the vector case is straightforward. See Section L of the Web Appendix.

Empirical evidence (Cunha, 2007; Cunha and Heckman, 2008; Cunha et al., 2010) shows that in multi-period models, $\cdots > f^{(3)}_{12} > f^{(2)}_{12} > f^{(1)}_{12}$. Moreover, the elasticity of substitution in the first stage between capabilities and investments is greater than 1, making these gross substitutes, whereas they are gross com-
enhances later life investment, even if early investment substitutes for early stage capabilities.

These properties of the technology of skill formation show why investment in disadvantaged young children can be both socially fair and economically efficient, whereas later-stage investments in disadvantaged (low-$\theta_t$) persons, although fair, may not be economically efficient. Building the skill base of disadvantaged young children makes them more productive at later ages. Dynamic complementarity also shows why investments in disadvantaged adolescents and young adults who lack a suitable skill base are often less effective.

These properties of the technology explain, in part, why more advantaged children were the first to respond in terms of college attendance to the rising returns to education (see Cunha et al., 2006). They had the necessary skill base to benefit from more advanced levels of schooling as the returns increased. These properties also explain the failure of tuition subsidy policies in promoting the educational participation of disadvantaged adolescents (see Heckman, 2008). Dynamic complementarity also suggests that limited access to parenting resources at early ages can have lasting lifetime consequences that are difficult to remediate at later ages.

Parental skills also play a disequalizing role as they enhance the productivity of investments ($\frac{\partial^2 \theta_{t+1}}{\partial \theta_p \partial I_t} > 0$). There is evidence that more educated parents, by engaging their children more, increase the formative value of investments such as sports or cultural activities (Lareau, 2011).

Public investments are usually thought to promote equality. Whether they do so depends on the patterns of substitutability with private investments and parental skills. If more skilled parents are able to increase the productivity of public investments as they are estimated to do with private ones, or if public investments crowd

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Supplementary note: For further discussion see Cunha et al., 2006.
out private investments relatively more among disadvantaged families, then public investments will also play a role towards disequalization.\footnote{This is an argument against the universal provision of policies to promote the equality of outcomes. The evidence supporting the complementarity hypothesis is mixed. See Pop-Eleches and Urquiola (2013) and Gelber and Isen (2013). See Web Appendix J.}

### 3.3 Other Ingredients

In addition to the functions linking outcomes to skills and the technology of capability formation, a fully specified model of family influence considers family preferences for child outcomes. Parents have different beliefs about “proper” child rearing, and can act altruistically or paternalistically (see, e.g., Baumrind 1968, Bisin and Verdier 2001, and Doepke and Zilibotti 2012).\footnote{Altruistic parents care about the utility of their child and therefore evaluate their child’s actions using the child’s utility function. Paternalistic parents, on the other hand, potentially disapprove of their child’s actions, as these are evaluated through the lenses of the parents’ utility function. As discussed below, the literature is divided in terms of its specification of parental preferences, and the evidence on the precise form of parental preferences for child outcomes is scant.} A fully specified model also includes family resources broadly defined, such as parental and child interactions with financial markets and external institutions. This includes restrictions (if any) on transfers across generations, restrictions on transfers within generations (parental lifetime liquidity constraints), and the public provision of investments in children.

Such constraints are traditional. Less traditional, but central to the recent literature are other constraints on parents: (a) information on parenting practices and parental guidance; (b) gene; and (c) the structure of households, including assortative matching patterns.

### 3.4 The Empirical Challenge

There is a substantial empirical challenge facing the analyst of family influence. Influences at different stages of the life cycle build on each other. Evidence of early family influence on adult outcomes is consistent with strong initial effects that may be attenuated at subsequent stages of the life cycle or weak initial effects that are amplified at later stages of the life cycle. The empirical challenge is to sort out the
relative importance of the different causal influences on adult outcomes and stages of the life cycle where they are most influential. This paper reviews the evidence on these links.
4 A Bare-Bones Model of Parenting as Investment

To focus ideas, we present a simple model of family investment and skill development based on Cunha (2007) and Cunha and Heckman (2007). Section D of the Web Appendix provides much greater detail on these and more general models. This model extends the traditional literature on human capital accumulation and parental investments (Aiyagari et al., 2002; Becker and Tomes, 1986; Loury, 1981). It has multiple periods of productive investments and dynamic complementarity in the process of skill accumulation and incorporates family transactions with financial markets. We show how intergenerational links between parental and child skills emerge, even in the absence of life-cycle credit constraints.

The deliberately simplified model with a scalar skill and scalar investment presented in this section misses key implications of richer models with multiple skills and multiple investments, which we discuss after presenting the basic model. It also fails to capture the change in the dimensionality of $\theta_t$ with $t$ and the associated change in the dimensions of $f(t) (\cdot)$ and $I_t$.

4.1 The Problem of the Parent

Life is assumed to last four periods: two periods as a passive child who makes no economic decisions (and whose consumption is ignored) but who receives investment in the form of goods and two periods as a parent. When the parent dies, she is replaced by the generation of her grandchild. Denote by $\theta_1$ the initial capability level of a child drawn from the distribution $J(\theta_1)$.

The evolution of child skills depends on parental investments in the first and second period, $I_1$ and $I_2$. The productivity of parental investment depends on parental human capital, $\theta_P$. (For notational simplicity, we set $\theta_{P,1} = \theta_P$.) We follow conventions in the literature and equate scalar human capital with skill for both parents and children. Denoting by $\theta_3$ the human capital of the child when he reaches adulthood, recursive substitution of the technology of skill accumulation.
formation using a CES specification gives the following representation:

\[ \theta_3 = \delta_2 \left[ \theta_1, \theta_P, \left( \gamma (I_1)^\phi + (1 - \gamma) (I_2)^\phi \right)^\frac{\phi}{\gamma} \right] , \]  

(5)

for \( 0 < \rho \leq 1, \phi \leq 1 \) and \( 0 \leq \gamma \leq 1 \), \( \gamma \) is a skill multiplier.

To develop intuition about the representation in equation (5), consider the following parameterization of the stage-specific production functions:

\[ \theta_{t+1} = \delta_t \left\{ \gamma_{1,t} \theta_t^{\phi_t} + \gamma_{2,t} I_t^{\phi_t} + \gamma_{3,t} \theta_P^{\phi_t} \right\}^{\frac{\phi_t}{\gamma_t}} \]

with \( 0 < \gamma_{1,t}, \gamma_{2,t}, \) and \( \gamma_{3,t} \leq 1; \phi_t \leq 1; \) and \( \sum_{k=1}^{3} \gamma_{k,t} = 1 \). Substitute recursively. If \( T = 2, \rho_1 = \rho_2 = 1, \delta_1 = 1, \) and \( \phi_1 = \phi_2 = \phi \leq 1 \), skills at adulthood, \( \theta_3 = \theta_{T+1} \), can be expressed as

\[ \theta_3 = \delta_2 \left[ \gamma_{1,2} \gamma_{1,1} \theta_1^{\phi_1} + \gamma_{1,2} \gamma_{2,1} I_1^{\phi_1} + \gamma_{2,2} I_2^{\phi_1} + (\gamma_{3,2} + \gamma_{1,2} \gamma_{3,1}) \theta_P^{\phi_1} \right]^{\frac{\phi_1}{\gamma_2}} \]

The multiplier is \( \gamma = \gamma_{1,2} \gamma_{2,1} \). It arises from the conjunction of self-productivity \( (\gamma_{2,1} \neq 0) \) and the productivity of investment \( (\gamma_{1,2} \neq 0) \). Self-productivity joined with the productivity of investment generates dynamic complementarity. \( \gamma_{2,1} \) characterizes how much of the investment in period \( t = 1 \) propagates into skills at adulthood, \( \theta_3 \).

The parameter \( \phi \) captures the substitutability/complementarity of investments. If \( \phi = 1 \), investments at different periods are (almost) perfect substitutes. They are perfect substitutes if \( \gamma_{1,2} \gamma_{2,1} = \gamma_{2,2} \), in which case the timing of investment in skills does not matter for the developmental process. This is the only circumstance in which collapsing childhood into one period as in Becker–Tomes is without loss of generality. The polar opposite case is \( \theta_3 = \delta_2 (\theta_1, \theta_P, \min (I_1, I_2)) \), which is closer to the empirical truth than perfect substitution. In that case, complementarity has a dual face. Early investment is essential but ineffective unless later investments are also made. In this extreme case, there is no possibility of remediation. If parents are poor and unable to
borrow against the future earnings of their children and, as a result, $I_1$ is low, there is no amount of investment at a later age, $I_2$, that can compensate for early neglect.

The parameters of the technology determine whether early and later investments are complements or substitutes\textsuperscript{39}. Given $\rho$, the smaller $\phi$, the harder it is to remediate low levels of early investment $I_1$ by increasing later investments. At the same time, the stronger the complementarity (the lower $\phi$), the more important it is to follow high volumes of early investments with high volumes of late investments to achieve high levels of production of adult human capital.

The parent decides how to allocate resources across household consumption in both periods of the child’s life, $c_1$ and $c_2$; early and late investments, $I_1$ and $I_2$; and bequests, $b'$. Assets at the end of the first period, period $a$, may be constrained to be non-negative. Bequests are received when entering adulthood and may be positive or negative. The state variables for the parent are her initial wealth, $b$; human capital level, $\theta_P$; and the initial skill level of the child, $\theta_1$. Human capital is rewarded in the labor market according to the wage rate, $w$. The economy is characterized by one risk-free asset with return $r$.

Denoting parental financial assets by $a$ and allowing parental labor market productivity to grow at exogenous rate $g$, one can represent the stage-of-childhood-specific budget constraints by

$$c_1 + I_1 + \frac{a}{1+r} = w\theta_P + b$$

and

$$c_2 + I_2 + \frac{b'}{1+r} = w(1+g)\theta_P + a$$

We allow for the possibility of borrowing constraints $a \geq a$ (intragenerational) and $b' \geq 0$ (intergenerational). When $g$ is high (high income in the second stage of the child’s life), parents might hit the constraint $a \geq a$. In the absence of these con-

\textsuperscript{39}“Direct” complementarity for equation (5) holds if $\rho > \phi$, whereas substitutability holds otherwise. Another definition of complementarity in the literature distinguishes (in the case of $\rho = 1$) whether $\phi > 0$ (gross substitutes; the elasticity of substitution is greater than 1) or $\phi < 0$ (gross complements; the elasticity of substitution is less than 1) so that Cobb-Douglas ($\phi = 0$) is the boundary case.
straints, one simple lifetime budget constraint governs parental choices of investment in children.

Let $u(\cdot)$ denote the parental utility function, $\beta$ the discount factor, and $\upsilon$ the parental altruism given by the weight assigned to the utility of future generations. Letting $\theta_1'$ be the uncertain initial endowment of the child’s child, the goal of the parent is to optimize

$$V(\theta_p, b, \theta_1) = \max_{c_1, c_2, I_1, I_2} \{ u(c_1) + \beta u(c_2) + \beta^2 \upsilon \mathbb{E}[V(\theta_3, b', \theta_1')] \} \tag{8}$$

subject to (5), (6) and (7).

In models of paternalism, parental preferences are defined over specific outcomes and not necessarily the adult utility of children.

### 4.2 Implications of the Model

A model with multiple periods of childhood is essential for understanding investment dynamics and rationalizing the empirical evidence on the effectiveness of programs targeted toward promoting human capital at different ages. The earlier literature [Becker and Tomes, 1986], as well as some recent work [Lee and Seshadri, 2014], limits itself to a one-period model of childhood. Inputs at any age are implicitly assumed to be perfect substitutes, contrary to the evidence discussed below. Application of the one-period model supports the widely held, but empirically unfounded, intuition that diminishing returns make investment in less advantaged adolescents more productive. The assumed magnitudes of the substitution ($\phi$), multiplier ($\gamma$), and scale ($\rho$) parameters play key roles in shaping policy.

If no intra- and intergenerational credit constraints are assumed, a key property of the Becker and Tomes (1986) model persists in this framework. There is no role for initial financial wealth $b$, parental income, parental utility, or the magnitude of parental altruism $\upsilon$ (above zero) in determining the optimal level of investment be-

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40One can interpret this specification of preferences as excluding any utility from child consumption or else as assuming that $c_1$ and $c_2$ are pure public goods, and parent and child utilities are identical.

41See, for example, Del Boca et al. (2012).
cause parents can borrow freely in the market to finance the wealth-maximizing level of investment.\footnote{Even if the altruism parameter is zero ($v = 0$), if the parents can make binding commitments, selfish parents ($v = 0$) will still invest in the child, as long as the economic return in doing so is positive.}

However, even in this setup, returns to parental investments depend on parental skills, $\theta_P$, as they affect the productivity of investments. The returns to investments are higher for children of parents with higher $\theta_P$. These children will receive higher levels of investment. This is a type of market failure due to the “accident of birth” that induces a correlation of human capital and earnings across generations even in the absence of financial market imperfections. The initial condition $\theta_1$ also affects investments. It creates a second channel of intergenerational dependence due to the “accident of birth” if it is genetically related to parental endowments, as considerable evidence suggests.\footnote{Becker and Tomes (1986) discuss the importance of children’s initial endowments. A third channel is parental paternalism. If parents value the child’s $\theta_3$ for itself, they may subsidize child education, even if the investment is economically inefficient.}

Imperfect credit markets create another channel of intergenerational dependence. One possible constraint is the impossibility of borrowing against the child’s future earnings (Becker and Tomes 1986). This constraint likely emerges because children cannot credibly commit to repay the loans parents would take out on their behalf. Because $b' \geq 0$, parental wealth matters in this model when this constraint binds. Children coming from constrained families will have lower early and late investments. Carneiro and Heckman (2003) show that permanent income has a strong effect on child outcomes. However, even with $b' \geq 0$, the ratio of early to late investment is not affected.\footnote{The constraint binds uniformly across periods within generations.}

A second type of constraint arises when parents are prevented from borrowing fully against their own future labor income ($a \geq q > -\infty$). In this case, investments are not perfect substitutes ($-\infty < \phi < 1$), $\rho = 1$, and parental utility is given by
\[ u(c) = \left( c^\lambda - 1 \right) / \lambda \]

the ratio of early to late investment is

\[ \frac{I_1}{I_2} = \frac{\gamma}{(1-\gamma)(1+r)} \]

\[ \frac{[\beta(1+r)]^{1-\phi} \left( \frac{c_1}{c_2} \right)^{1-\lambda}}{1 \text{ if unconstrained,}} \]

\[ <1 \text{ if constrained } (a \geq 2 \text{ binds}) \]

(9)

In the constrained case, \( \frac{I_1}{I_2} \) is less than it is in the unconstrained case, and \( I_1 \) is less than optimal. \(^{46}\) The ratio of early to late investments depends on parental preferences and endowments. If early parental income is low compared to later life income, or if \( \lambda \) is small, the level and timing of family resources will influence the parental investment. \(^{47}\) This constraint could be very harmful to a child if it binds in a critical period of development and the complementarity parameter \( \phi \) is low so that later life remediation is ineffective.

Credit constraints affect investment levels. They induce a suboptimal level of investment (and consumption) in each period in which the constraint is binding. If the constraint is binding during the early periods, because of the dynamic links induced by the technology of skill formation, late investments will be lower, even if the parent is not constrained in later periods. \(^{48}\)

### 4.2.1 The Presence of Constraints is not Synonymous with Low Levels of Investment

However, the presence of constraints is not necessarily synonymous with a low level of investment. For a given family, a binding constraint implies that the invest-

\(^{45}\) \( \lambda = 1 \) corresponds to perfect intertemporal substitutability.

\(^{46}\) In the extreme case of a Leontief technology, this ratio goes to 1. In the case of a linear technology, the solution is a corner solution: Invest only in the early years if \( \gamma > (1-\gamma)(1+r) \).

\(^{47}\) Estimates from Cunha et al. (2010) suggest that \( 1/(1-\phi) = 3 \), which, combined with an estimate of \( \lambda \in [-3, -1.5] \) (Attanasio and Browning, 1995), implies \( (1-\lambda)/(1-\phi) \in [0.83, 1.3] \). Notice that even if \( \lambda = 1 \), parents may hit constraints on the level of investment if future resources are of insufficient magnitude.

\(^{48}\) The case of low initial income and high growth rate corresponds to the earnings profiles of educated parents. The relevance of the model just discussed critically relies on the exogeneity of fertility. If more educated families postpone fertility (as in Almlund, 2013), the relevance of this constraint is lessened. The greater the altruism of the parent, and the lower \( \lambda \) in equation (9), the more likely it is that families will postpone fertility to match their life-cycle income growth profiles.
ments are lower than the unconstrained optimum. Whether a family is constrained, however, is uninformative on how that family compares with others in terms of the effective level of investments provided. Families might be constrained, for example, when they have an extremely high productivity of investments in children or give birth to a gifted child. This induces a high optimal level of desired investment that might not be affordable to the family at its current resource level. Thus, although constrained, the family might still be investing more than others.

More educated parents might face such situations. The steeper the expected income growth, the higher is the probability of being constrained. Relating this constraint likely impedes intergenerational mobility as measured by intergenerational elasticity (IGE).

Low-skill parents, on the other hand, have a low $\theta$, which makes investments less productive. In this case, it is the “accident of birth” that harms a gifted child rather than the intertemporal credit constraints of the parents. We assess the quantitative importance of credit constraints in Section 4.4.

If early investments matter a lot, and parents are credit-market constrained in the early years of their children, investments are suboptimal (see equation (9)). Caucutt and Lochner (2012) use a variant of the model of Cunha (2007, 2013) to investigate the role of income transfers and credit constraints in the early years. They find that a large proportion of young parents are credit constrained (up to 68% among college graduates) but that reducing borrowing constraints is effective in promoting skills only for the children in the generation in which they are relaxed.

As noted above, the families constrained by their criteria may be quite affluent. Indeed, Caucutt and Lochner report evidence showing that families that benefit from a reduction in the credit constraints are the ones with college-educated parents. These families are usually well off. Even if some of these families receive “bad shocks”, it is hard to think that 68% of college graduates can be considered “poor.”

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49 See Black and Devereux (2011) for a definition and discussion of the IGE.
50 After credit constraints are relaxed, future generations move back to a constrained position.
4.2.2 Introducing income uncertainty.

*Cunha* (2007, 2013) presents an overlapping-generations model with stochastic innovations to parental income. If $g$ is stochastic on the interval $[-1, \infty)$, so parents face uncertain income growth, constraints play a dual role. First, as before, if the constraints bind, they reduce investments in the constrained periods. Second, because future income is uncertain, so is the likelihood of binding future constraints. Absent full insurance markets, consumption and investments in children are less than optimal, even if the parent is not currently constrained but expects to be constrained in the future with a probability greater than zero. Under this scenario, young parents who just entered the labor force accumulate more assets than they would in the absence of possible future constraints to ensure against bad future shocks. This implies a reduction in household consumption and investments in child human capital.

4.3 Recent Extensions of the Basic Model

By and large, the recent literature has moved beyond the simple models just discussed. Table K.1 in the Web Appendix summarizes a recent literature in rapid flux. Most of the models in the recent literature are multiple-generation frameworks. Most assume parental altruism, but a few are explicitly paternalistic. They all feature investment in goods. Only recently has parental time been analyzed as an explicit input to child quality. Most models analyze how child investment depends on parental skills.

Surprisingly, some of the recent models omit parental skills as arguments in the technology of capability formation despite the evidence in a large literature that parental skills (apart from explicit parental investments) are important factors in producing child skills. Until recently, most studies considered the self-productivity of skills.

51See Subsection D.6 of the Web Appendix for a mathematical proof of this statement.
52Tables K.1, K.2, and K.3 in Subsection K.1 of the Web Appendix discuss each model in detail.
Some recent papers ignore this feature, despite the empirical evidence that supports it.

Most analyses assume that parents know the technology of skill formation, as well as the skills of their children, in making investment decisions. Cunha et al. (2013) provide an exception. The recent literature also ignores intergenerational transfers. Some papers consider extreme credit constraints that do not permit any borrowing (or lending), even within a lifetime of a generation, much less inter-generational transfers. Virtually the entire literature focuses on single-child models, exogenous fertility, and exogenous mating decisions. Most models are for single-parent families, for which the characteristics of the spouse are irrelevant.

These models do not capture the richness of the framework sketched in Section 3. First, with the exception of Cunha and Heckman (2008) and Cunha et al. (2010), human capital is treated as a scalar. This is inconsistent with the fact presented in Section 2. It is a practice inherited from the early literature of Becker and Tomes (1979, 1986), and Solon (2004). Instead, skills are multidimensional. Borghans et al. (2008), Almlund et al. (2011), and Heckman and Kautz (2012, 2014) present evidence showing that a single skill, such as cognitive ability or IQ, is insufficient to summarize the determinants of life achievements.

Second, in some recent models, investments are also treated as scalars. In truth, parents and schools have access to and use multiple methods of investment, and the nature of the investments changes over the life cycle of the child. The most relevant omissions in the first-stage models are time investments. Quality parenting is a time-intensive process. The recent literature shows that parental time is a prime factor influencing child skill formation (Bernal, 2008; Bernal and Keane, 2010, 2011; Del Boca et al., 2014; Gayle et al., 2013; Lee and Seshadri, 2014). Families differ in their productivity and availability of time and face different opportunity costs. Time investments may complement or substitute for goods investments. In addition, spending time with children allows parents to more accurately assess the capacities of their children.

54 See the analysis in Web Appendix E.
and to make more precisely targeted investment decisions. As discussed in Section 8, parent-child/child-mentor interactions operate in real time and parents/mentors actively engage the child to stimulate learning.

Third, families usually have more than one child. Parents make decisions on how to allocate investments across different siblings, compensating for or reinforcing initial differences among them (Behrman et al., 1982). Parental preferences might conflict with what is socially optimal. Del Boca et al. (2014) and Gayle et al. (2013) present models with multiple children. Firstborn children receive relatively more early investment and appear to do better as adults (Hotz and Pantano, 2013). This is consistent with dynamic complementarity.

Fourth, the models in the literature ignore the interaction of parents and children in the process of development. They treat the child as a passive being whose skills are known to the parent. They often assume that the parent fully internalizes the child’s utility as her own and the child’s utility function is that of the parents. We discuss models that account for parent-child interactions in Section 8.

Fifth, fertility is taken as exogenous. Forward-looking parents might attempt to time their fertility to balance the benefit from the presence of a child with the need and desire to provide a certain amount of monetary and time investments. The motive to avoid credit constraints, for example, may induce a greater delay in fertility for parents with a high preference for child quality. The greater the desired level of investment, the costlier it is to hit an early constraint. To avoid this risk, parents may delay fertility until a sufficient level of precautionary assets has been accumulated. This observation seems to be consistent with the fertility decisions of more educated parents (Almlund, 2013). This consideration suggests caution in taking too literally the models of credit constraints interacting with dynamic complementarity that take fertility as exogenously determined. The parents who hit the constraints may be less farsighted and may have less information. A variety of other attributes might be con-

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55 Gayle et al. (2013) provide the only paper of which we are aware that analyzes the impact of endogenous fertility choices on child outcomes.
founded with any effect of the levels of income or the constraint itself. In the empirical work on the importance of credit constraints, these factors are rarely accounted for.

Finally, a child’s development is influenced by the environment outside his family: day care, kindergarten, school, and neighborhood. In addition, the effectiveness of policies is determined in part by parental responses to them. Policies that complement rather than substitute for family investments will have greater impacts and lower costs. We discuss the evidence on parental responses to interventions in Section 8.

4.4 Empirical Estimates of Credit Constraints and the Effects of Family Income

Economists have a comparative advantage in analyzing the effects of constraints on behavior. There is an active literature analyzing the effects of various constraints on child outcomes. One strand summarized in Table 1 (continued) focuses on testing the effects of parental income on child outcomes, whereas another (summarized in Table 2) tests for the presence of credit constraints directly. The two are not synonymous, although they are often confused in the literature.

4.4.1 The Effects of Family Income

The literature is unanimous in establishing that families with higher levels of long-run (or permanent) income on average invest more in their children and have children with greater skills. The literature is much less clear in distinguishing the effect of income by source or in distinguishing pure income effects from substitution effects induced by changing wages and prices (including child-care subsidies or educational incentive payments). If some part of a family income change results from changes in labor supply, this will have implications for child development (see, e.g., Bernal 2008; Bernal and Keane 2010, 2011; Del Boca et al. 2012; Gayle et al. 2013). Higher levels of parental permanent income are associated with higher levels of parental education,
better schools, more capable parents, better peers, more engaged parenting, etc. All these factors likely affect child development.

Carneiro and Heckman (2003) and Cunha et al. (2006) present evidence that child cognitive and noncognitive skills diverge at early ages across families with different levels of permanent income during childhood.\footnote{This evidence is reviewed in Section A of the Web Appendix.} Levels of permanent income are highly correlated with family background factors such as parental education and maternal ability, which, when statistically controlled for, largely eliminate the gaps across income classes.\footnote{See Figure A.2 and A.3 in the Web Appendix.} The literature sometimes interprets this conditioning as reflecting parenting and parental investments, but it could arise from any or all of the panoply of correlates of permanent income associated with parental preferences and skills. This poses a major empirical challenge.
<table>
<thead>
<tr>
<th>Study</th>
<th>Data set</th>
<th>Outcome Studied</th>
<th>Timing of Income (Developmental Stage of the Child At Which Income Effects are Studied)</th>
<th>Separates the Effect of Income from Changes in Labor Supply or Family Environment?</th>
<th>Distinguishes the Effects of Contemporaneous vs Permanent Income?</th>
<th>Sources of Income Whose Effects are Studied</th>
<th>Instrument Used</th>
<th>Effect of Income on Human Capital Investments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akee et al. 2010</td>
<td>GSMS</td>
<td>Schooling outcomes and crime</td>
<td>Yearly family income in adolescence (ages 12-16)</td>
<td>No</td>
<td>Yes</td>
<td>Total family income</td>
<td>Experimental assignment</td>
<td>$4000 dollars per year to all adults tribal members of the Eastern Band of Cherokee Indians from Casino profits: 15% increase in high school graduation, one extra year of education by age 21 only for household in poverty prior to transfer. 22% reduction in probability of being arrested at age 16-17, no effect when older. The results confirms the increased parental income with the fact that children would become eligible to receive the $4,000 per year by age 18 only if they finished high school on time, otherwise they would have to wait until age 21. The results are consistent with children responding to the short-term monetary incentive for graduating high school on time rather than with a positive long-term effect induced by the increased parental income.</td>
</tr>
<tr>
<td>Belley and Lochner 2007</td>
<td>NLSY79, NLSY97</td>
<td>High school completion and college enrollment</td>
<td>Family income during adolescence (at age 16 or 17 for the NLSY79 cohort or 16 for the NLSY97 cohort) Discounted family income (using data from NLSY79)</td>
<td>No</td>
<td>No</td>
<td>Total family income</td>
<td>None</td>
<td>High school completion increased by 8.4% for highest-income quartile compared to lowest in 1979 and increased by 6.7 in 1997 (cannot reject equal effect of income). College enrollment increased by 9.3% for highest-income quartile compared to lowest in 1979 and increased by 16% in 1997 (cannot reject equal effect of income). Conditioning on ability and family background factors, the role of income in determining schooling decisions is minimal. The strongest evidence is in the low-ability group. The test for credit constraints is not robust to accounting for parental preferences and paternalism. Observed differences in attendance might result from a differential consumption value of the child’s schooling for parents rather than from credit constraints. Percentage of people constrained = weighted gap in educational outcome to highest-income group (calculations on NLSY79 data): 5.1% are constrained in college enrollment (2.2% among low income, low ability and 0.2% among low income, high ability), 9% in completion of two-year college (5.3% among low income, low ability and 0.3% low income, high ability). There is no evidence of a independent effect on college enrollment of early or late income once permanent income is accounted for (calculations on C-NLSY79 data). The claim that higher IV than OLS estimates of the Mincer coefficient implies that credit constraints are incorrect. Instruments used are invalid, the quality margin is ignored, and self-selection and comparative advantage can produce the result also in the absence of financial constraints.</td>
</tr>
<tr>
<td>Carneiro and Heckman 2002</td>
<td>NLSY79, C-NLSY79</td>
<td>College enrollment</td>
<td>Family income at age 16 or 17 (using data from NLSY79)</td>
<td>No</td>
<td>Yes</td>
<td>Total family income</td>
<td>None</td>
<td>Conditioning on ability and family background factors, the role of income in determining schooling decisions is minimal. The strongest evidence is in the low-ability group. The test for credit constraints is not robust to accounting for parental preferences and paternalism. Observed differences in attendance might result from a differential consumption value of the child’s schooling for parents rather than from credit constraints. Percentage of people constrained = weighted gap in educational outcome to highest-income group (calculations on NLSY79 data): 5.1% are constrained in college enrollment (2.2% among low income, low ability and 0.2% among low income, high ability), 9% in completion of two-year college (5.3% among low income, low ability and 0.3% low income, high ability). There is no evidence of a independent effect on college enrollment of early or late income once permanent income is accounted for (calculations on C-NLSY79 data). The claim that higher IV than OLS estimates of the Mincer coefficient implies that credit constraints are incorrect. Instruments used are invalid, the quality margin is ignored, and self-selection and comparative advantage can produce the result also in the absence of financial constraints.</td>
</tr>
<tr>
<td>Carneiro et al. 2013</td>
<td>Norwegian Registry</td>
<td>Multiple outcomes (schooling, health, IQ, teenage pregnancy) studied</td>
<td>Average discounted family income during childhood and adolescence (ages 0-18) broken up by stage of the child’s lifecycle (ages 0-5; 5-16; 16-18)</td>
<td>No</td>
<td>Yes</td>
<td>Total family income</td>
<td>None</td>
<td>For all outcomes, there is a monotone and concave relationship with permanent income. A $30,000 increase in permanent father’s earnings results in a gain of 0.3 years of schooling. For the timing of income, a balanced profile between early (ages 0–5) and late childhood (ages 6–11) is associated with the best outcomes, shifting income to adolescence is associated with better outcomes in dropping out of school, college attendance, earnings, IQ and teen pregnancy. Early and late childhood income are complements in determining schooling attainment, whereas early and adolescent income are substitutes.</td>
</tr>
<tr>
<td>Dahl and Lochner 2002</td>
<td>NLSY79, C-NLSY79</td>
<td>PIAT test scores</td>
<td>Yearly family income during preadolescence (ages 8-14)</td>
<td>No</td>
<td>No</td>
<td>Total family income</td>
<td>Policy variation in EITC eligibility</td>
<td>An additional $1,000 per year for two years results in a gain of 6% of a standard deviation in a math and reading combined PIAT score.</td>
</tr>
<tr>
<td>Duncan et al. 1998</td>
<td>PSID</td>
<td>Multiple schooling outcomes and hazard of non marital birth</td>
<td>Average family income during childhood and adolescence (ages 0-15)</td>
<td>No</td>
<td>Yes</td>
<td>Total family income</td>
<td>None</td>
<td>A $10,000 increase in average (ages 0–15) family income results in a gain of 1.3 years of schooling in low-income (&lt;$20,000) families and a gain of 0.13 years in high-income ones. The relevance of income is stronger in the early years (ages 0–5). A $10,000 increase in average (ages 0–5) family income leads to an additional 0.8 years of schooling in low-income families and an additional 0.1 years in high-income ones. There is no significant effect for income at ages 6–10 and 11–15. There are similar results in a sibling differences model.</td>
</tr>
</tbody>
</table>

*This study controls for labor supply, but endogeneity is not considered. *This study provides an analysis only of past versus contemporaneous income. "Labor supply is not modeled, but the effects of the instrument on it are studied and found insignificant. Unfortunately, this study is flawed by using an IV procedure for ordered choice models of schooling that counts outcomes for certain subsets of the population multiple times and is difficult to interpret economically (see Heckman et al. 2004 for a critical discussion of the method used). Additional notes: C-NLSY79, Children on the National Longitudinal Survey of Youth 1979; C(ITB), Canada Child Tax Benefit; EITC, Earned Income Tax Credit; GSMS, Great Smoky Mountains Study of Youth; IV, instrumental variables; NCBIS, National Child Benefit Supplement; NLSY79, National Longitudinal Survey of Youth 1979; NLSY97, National Longitudinal Survey of Youth 1997; OLS, ordinary least squares; PIAT, Peabody Individual Achievement Test; PSID, Panel Study of Income Dynamics.
### Table 1 (continued): Studies of the Role of Parental Income on Child Outcomes

<table>
<thead>
<tr>
<th>Study</th>
<th>Dataset</th>
<th>Outcome Studied</th>
<th>Timing of Income (Developmental Stage of the Child at Which Income Effects are Studied)</th>
<th>Separate the Effect of Income from Changes in Labor Supply or Family Environment?</th>
<th>Distinguishes the Effects of Contemporaneous vs Permanent Income?</th>
<th>Sources of Income Whose Effects are Studied</th>
<th>Instrument Used</th>
<th>Effect of Income on Human Capital Investments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duncan et al. (2011)</td>
<td>Randomized Interventions on Welfare Support</td>
<td>Achievement test scores</td>
<td>Yearly family income during childhood (ages 2-5)</td>
<td>No</td>
<td>No</td>
<td>Total family income</td>
<td>Random assignment to programs offering results in a gain of 6% of a standard deviation in a child’s achievement score.</td>
<td>An additional $1,000 per year in family income (ages 2-5) results in a gain of 6% of a standard deviation in a child’s achievement score.</td>
</tr>
<tr>
<td>Genovian and Miller (2002)</td>
<td>Multiple school sources on families involved in the Minnesota Family Investment Program (MFIP)</td>
<td>Multiple schooling and behavioral outcomes</td>
<td>Yearly family income during childhood (ages 8-9)</td>
<td>No</td>
<td>Yes</td>
<td>Total family income</td>
<td>Experimental assignment</td>
<td>Treated (MFIP “Incentives”) families (single-mothers at eligibility) received greater welfare benefits (benefits kept when working until income reached 140% of the federal poverty level), child-care expenses fully subsidized and directly paid to the provider. MFIP “plus” families also received employment and training activities. Children of MFIP families (both groups) showed greater engagement in school, a reduction in the likelihood of performing below average and reduced behavioral problems with the effect particularly pronounced for girls and during the school age. Children in MFIP “full” families however showed no benefits on the positive behavioral scale. In both MFIP group marriage rates increased and domestic abuse rates decreased. Earnings increased only in the MFIP “full” group, while the increased income in the MFIP “incentive group is due to greater welfare transfers. Mothers in the MFIP “full” group greatly increase the use of child-care arrangements. While employment rates increased in both groups (twice more in the “full” one), the mothers in the “incentive” group reduced their working hours. The authors do not isolate a pure income effect as they do not separate the effect from income transfers from the effect of increased time out of work (for the “incentive” group) or from the effect of the increased use of child-care subsidies (for the “full” group).</td>
</tr>
<tr>
<td>Loken (2010)</td>
<td>Norwegian Administrative Data</td>
<td>Multiple schooling outcomes</td>
<td>Average family income during childhood and preadolescence (ages 0-13)</td>
<td>Yes</td>
<td>No</td>
<td>Total family income</td>
<td>Oil discovery (inducing regional increase in wages)</td>
<td>With OLS, there is a positive relationship of average (ages 1-13) family income on children's education. With IV, there is no causal effect. Results are robust to different specifications and splitting the sample by parental education.</td>
</tr>
<tr>
<td>Loken et al. (2012)</td>
<td>Norwegian Administrative Data</td>
<td>Multiple schooling outcomes and adults’ IQ</td>
<td>Average family income during childhood (ages 0-11)</td>
<td>No</td>
<td>No</td>
<td>Total family income</td>
<td>Oil discovery (inducing regional increase in wages)</td>
<td>With nonlinear IV (quadratic model), an increase of $17,414 in family income results in a gain of 0.74 years of education for children in poor families and a gain of 0.05 years of education for children in rich families.</td>
</tr>
<tr>
<td>Mallar (1977)</td>
<td>New Jersey Income Maintenance Experiment</td>
<td>Multiple schooling outcomes</td>
<td>Yearly family income during adolescence (ages of high school enrollment)</td>
<td>No</td>
<td>Yes</td>
<td>Total family income</td>
<td>Experimental assignment</td>
<td>Positive effect of the negative income tax for the children of the families enrolled in one of the medium generosity plan: probability of high school graduation increased by 20% to 30% and number of completed school years increased by between 0.5 and 1. Negative results for the children of families enrolled in the most generous plan: probability of high school graduation decreased by 25% and number of completed school years decreased by 0.4.</td>
</tr>
</tbody>
</table>

*This study controls for labor supply, but endogeneity is not considered. bThis study provides an analysis only of past versus contemporaneous income. cLabor supply is not modeled, but the effects of the instrument on it are studied and found insignificant. dUnfortunately, this study is flawed by using an IV procedure for ordered choice models of schooling that counts outcomes for certain subsets of the population multiple times and is difficult to interpret economically (see Heckman et al. [2006] for a critical discussion of the method used). Abbreviations: C-NLSY79, Children on the National Longitudinal Survey of Youth 1979; CCTB, Canada Child Tax Benefit; EITC, Earned Income Tax Credit; GSMS, Great Smoky Mountains Study of Youth; IV, instrumental variables; NCBS, National Child Benefit Supplement; NLSY79, National Longitudinal Survey of Youth 1979; NLSY97, National Longitudinal Survey of Youth 1997; OLS, ordinary least squares; PIAT, Peabody Individual Achievement Test; PSID, Panel Study of Income Dynamics.
### Table 1 (continued): Studies of the Role of Parental Income on Child Outcomes

<table>
<thead>
<tr>
<th>Study</th>
<th>Data set</th>
<th>Outcome Studied</th>
<th>Timing of Income (Developmental Stage of the Child at Which Income Effects are Studied)</th>
<th>Separate the Effect of Income from Changes in Labor Supply or Family Environment?</th>
<th>Distinguishes the Effects of Contemporaneous vs Permanent Income?</th>
<th>Sources of Income Whose Effects are Studied</th>
<th>Instrument Used</th>
<th>Effect of Income on Human Capital Investments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maynard (1977)</td>
<td>Rural Income Maintenance Experiment (North Carolina and Iowa)</td>
<td>Multiple schooling outcomes</td>
<td>Yearly family income during childhood and preadolescence (ages 7-14, grades 2-8)</td>
<td>No</td>
<td>Yes</td>
<td>Total family income</td>
<td>Experimental assignment</td>
<td>North Carolina: positive effect from negative income tax on multiple schooling outcomes (30.5% absenteeism, 6.2% increase in GPA) for youngest group; no effects for older group. Iowa: null or negative effects on all outcomes.</td>
</tr>
<tr>
<td>Maynard and Murnane (1979)</td>
<td>Gary Income Maintenance Experiment</td>
<td>Multiple schooling outcomes</td>
<td>Yearly family income during childhood and preadolescence (ages 9-13, grades 4-6) and adolescence (ages 13-16, grades 7-10)</td>
<td>No</td>
<td>Yes</td>
<td>Total family income</td>
<td>Experimental assignment</td>
<td>Grades 4 to 6: positive effect from the negative income tax only on reading test scores (6 to 9 months difference on a grade equivalent measure). No effect on GPA and absenteeism. Grades 7 to 10: negative effects on GPA (all grades) and on absenteeism (6th grade).</td>
</tr>
<tr>
<td>Milligan and Stabile (2011)</td>
<td>Rural Income Maintenance Experiment (North Carolina and Iowa)</td>
<td>Multiple schooling outcomes</td>
<td>Yearly family income during childhood and preadolescence (ages 7-14, grades 2-8)</td>
<td>No</td>
<td>No</td>
<td>Child-related tax benefits and income transfers</td>
<td>Variation in benefits eligibility</td>
<td>For low-education mothers, there are positive effects of child benefits on cognitive outcomes for boys and on emotional outcomes for girls, weak on health. Results are nonrobust to the exclusion of Quebec.</td>
</tr>
<tr>
<td>Morris and Gennetian (2003)</td>
<td>Multiple sources on families involved in the Minnesota Family Investment Program (MFIP)</td>
<td>Multiple schooling and behavioral outcomes</td>
<td>Yearly family income during childhood (ages 2-9)</td>
<td>No</td>
<td>Yes</td>
<td>Total family income</td>
<td>Experimental assignment</td>
<td>Performing multiple IV regressions of children's school and behavioral outcomes on income and employment using treatment assignment to the MFIP program as instruments shows positive effects of income on school engagement and positive behavior (no effects on school achievement and behavior problems if variables are measured one year after random assignment. In the three years follow-up no significant effects are found. The modest significance of the one year results (p-values around 0.08), however, is unlikely to survive a careful control for multiple hypothesis testing (a required procedure in this set up unfortunately not used by the authors). These results also cast doubts on the validity of the conclusions from the mean differences analysis on the same data of Gennetian and Miller (2002).</td>
</tr>
</tbody>
</table>

*This study controls for labor supply, but endogeneity is not considered. b) This study provides an analysis only of past versus contemporaneous income. c) Labor supply is not modeled, but the effects of the instrument on it are studied and found insignificant. d) Unfortunately, this study is flawed by using an IV procedure for ordered choice models of schooling that counts outcomes for certain subsamples of the population multiple times and is difficult to interpret economically (see Heckman et al. (2006) for a critical discussion of the method used). |

Abbreviations: C-NLSY79, Children on the National Longitudinal Survey of Youth 1979; CCTB, Canada Child Tax Benefit; EITC, Earned Income Tax Credit; GSMS, Great Smoky Mountains Study of Youth; IV, instrumental variables; NCBS, National Children’s Benefit Supplement; NLSY79, National Longitudinal Survey of Youth 1979; NLSY97, National Longitudinal Survey of Youth 1997; OLS, ordinary least squares; PIAT, Peabody Individual Achievement Test; PSID, Panel Study of Income Dynamics.
### Table 2: Studies of Credit Constraints

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Outcome Studied: Test Scores (T), Schooling (S)</th>
<th>Timing of Income (Developmental Stage of the Child at Which Constraints are Studied)</th>
<th>Explicit Dynamic Model?</th>
<th>Who is Affected by Constraints: Parent of the Agent (P), Agent / Child (C)</th>
<th>Method to Test for Credit Constraints</th>
<th>Finds Presence of Credit Constraints?</th>
<th>Effect of Income or Constraints on Human Capital Investments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keane and Wolpin 2001</td>
<td>NLSY79 Schooling and adult outcomes</td>
<td>Family income during adolescence (at age 16 or 17)</td>
<td>Yes</td>
<td>C</td>
<td>Structural estimation of the lower bound on asset level</td>
<td>Yes, but irrelevant for schooling decisions</td>
<td>An increase in the borrowing limit to $3,000 (three times the max estimated) results in no change in the mean highest grade completed; an increase of 0.2% in college enrollment; a decrease of 0.2 in mean hourly wage rate; an increase in consumption and reduction in market hours; and a moderate reduction in parental transfers, especially for the least-educated parents.</td>
</tr>
<tr>
<td>Cameron and Taber 2004</td>
<td>NLSY79 Schooling outcomes</td>
<td>Family income during adolescence (at age 16 or 17)</td>
<td>No</td>
<td>C</td>
<td>IV estimation of &quot;returns&quot; to schooling using costs of schooling or foregone earnings as instruments</td>
<td>No</td>
<td>For the theoretical prediction, if there are borrowing constraints, IV estimates using direct costs of schooling are higher than those using opportunity costs. For the data, IV estimates using the presence of a local college are smaller than those using foregone earnings. Regressions that interact college costs and characteristics potentially related to credit availability find no evidence of excess sensitivity to costs for a potentially constrained sample. For the structural model, almost 0% of the population is found to borrow at a rate higher than the market one.</td>
</tr>
<tr>
<td>Causcat and Lochner 2012</td>
<td>NLSY79, C-NLSY79 Test scores and schooling outcomes</td>
<td>Family income during childhood and adolescence (ages 0-23)</td>
<td>Yes</td>
<td>P</td>
<td>Structural estimation of the lower bound on asset level</td>
<td>Yes; stronger effect on high-skilled parents</td>
<td>50% of young parents are constrained: high school dropouts (50%), high school graduates (48%), college dropouts (60%), and college graduates (68%). 12% of old parents are constrained. Families with college-graduate parents benefit the most from a reduction in credit constraints.</td>
</tr>
</tbody>
</table>

*The consequences on child’s schooling outcomes are studied as well. Abbreviations: C-NLSY79, Children on the National Longitudinal Survey of Youth 1989; NLSY79, National Longitudinal Survey of Youth 1979; NLSY97, National Longitudinal Survey of Youth 1997.*
4.4.2 Effects of Borrowing Constraints

The literature also analyzes the effect of borrowing constraints on child outcomes. It considers whether there are Pareto-optimal interventions in borrowing markets that can improve the welfare of children and parents, given initial distributions of income (see, e.g., the survey in Lochner and Monge-Naranjo 2012). If markets are perfect, altruistic parents or selfish parents who can write binding contracts with their children will ensure that marginal returns to investments in skills will equal the market opportunity costs of funds. However, the presence of the parent environmental input $\theta_P$ in the technology of skill formation affects the level of investment in children and the initial condition $\theta_1$ (which may be genetically determined) and hence a child’s skills and the welfare of the child, even with perfect lending and borrowing markets. Allocations are Pareto-optimal given initial parental conditions. From other perspectives, however, these market-efficient outcomes may be suboptimal because they depend on the “accident of birth”. If, for example, parenting is deficient for whatever reason, choice outcomes might be improved by supplementing family resources (apart from income). A whole host of endowments of the child at the college-going age might be enhanced if the parental environment does not provide the information, the mentoring, and the encouragement (summarized in $\theta_P$ and $I$), and children cannot insure against these aspects of the environment.\footnote{Aiyagari et al. 2002 present an analysis of full insurances against the accident of birth.}

The recent literature that considers multiperiod childhoods builds on the analysis surrounding equation (9) and investigates the role of the timing of the receipt of income as it interacts with restrictions on credit markets and dynamic complementarity. We consider evidence from these strands of the literature.

4.4.3 Restrictions in Lending Markets for College Education

Using a variety of empirical approaches, Carneiro and Heckman (2002), Keane and Wolpin (2001), and Cameron and Taber (2004) find little evidence of an important
role for credit constraints in access to college education.\cite{Carneiro2002} Carneiro and Heckman (2002) show that although income is a determinant of enrollment in college, its effect disappears once ability in the adolescent years is controlled for.\cite{Cameron2004} Cameron and Taber (2004) develop and test the novel theoretical prediction that in the presence of borrowing constraints, instrumental variable (IV) estimates of the Mincer coefficient using direct costs of schooling should be higher than IV estimates using opportunity costs. They reject the hypothesis that there are binding credit constraints.

Belley and Lochner (2007), Bailey and Dynarski (2011), and Lochner and Monge-Naranjo (2012) claim that in later cohorts (in the NLSY97), there is stronger evidence of credit constraints as captured by the estimated effects of quantiles of family income (from whatever source) on college participation. The Belley and Lochner (2007) test of credit constraints is different from the one used in Keane and Wolpin (2001) or Cameron and Taber (2004). Belley and Lochner update the NLSY79 analysis of Carneiro and Heckman (2002) using NLSY97 data and claim that credit constraints seem to bind predominantly among less able poor children. However, their analysis shows that, across all ability groups, college enrollment increased in 1997 compared to 1979. The increases are more substantial for more affluent, low-ability children.\cite{Belley2007}

Belley and Lochner (2007) estimate the changing effects of affluence by comparing enrollments of children at the same quantiles of family income over time. Their analysis ignores the evolution of the shape of the income distribution over this period. Increases in inequality arise mostly from outward shifts of the right tail of the income distribution. Their documented increase in the college enrollment of more affluent children might simply be a consequence of paternalism. If the education of children is a normal or supernormal good for families, and higher-quantile families receive a

\footnote{Keane and Wolpin (2001) provide evidence for constraints affecting other dimensions of behavior, such as labor supply.}

\footnote{Carneiro and Heckman (2002) also show flaws in the argument proposed by Card (1999, 2001) that higher IV estimates than OLS estimates of the ‘returns’ to schooling provide evidence of credit constraints.}

\footnote{See Figures H.1 through H.3 of the Web Appendix.}
disproportionate share of the increase in family income, their results are readily explained.\footnote{Belley and Lochner (2007) address but do not resolve this issue in a satisfactory way. They show that the college attendance-family income relationship is stable over the period 1979–1997 but do not account for the greater level of family income at the top quartile, which could explain the greater college participation rate of less able children from richer families.}

Children with low-ability, but affluent parents are more likely to enroll in college. The estimates of Keane and Wolpin (2001) suggest that the source of the intergenerational correlation of school attainment results from more educated parents making larger \textit{tied} financial transfers to their children, conditional on their college attendance. The higher the educational level of the parents, the greater are the tied transfers to their children. Under this scenario, the education of their children is valued by parents as a consumption good (paternalism), even in the absence of a greater return from it.\footnote{Alternatively, parents may prefer in-kind transfers to cash transfers to avoid the “Samaritan’s dilemma” (Buchanan, 1975).} Low-income parents with low-ability children do not provide the same tied transfers to their children as more affluent parents. This is a constraint due to the “accident of birth”. According to the Keane-Wolpin estimates, if credit constraints are relieved, educational attainment does not increase, whereas consumption increases and work in school declines. Their evidence suggests that distortions may operate differently at different margins of choice. Interventions may be (conditionally) Pareto-optimal for financing life-cycle consumption but not for schooling. Empirical evidence by Carneiro et al. (2011) and Eisenhauer et al. (2014) using NLSY79 data suggests that for low-ability individuals, the returns to college enrollment are close to 0, if not negative.

If schooling investments are inefficient, there is no clear cost-benefit case for investing in the children of poorer families given parental endowments $\theta_P$.

Despite disagreements on the importance of credit constraints, this strand of the literature agrees that ability is a first-order determinant not only of schooling attainment, but also of the returns to schooling. Ability is the outcome of a process that starts early in life.
4.4.4 The Timing of Income, Dynamic Complementarity, and Credit Constraints

The interaction of dynamic complementarity and lifetime liquidity constraints motivates a recent literature. Dahl and Lochner (2012) investigate how credit constraints affect test scores of children in early adolescence. They exploit the policy variation in the Earned Income Tax Credit (EITC) as an exogenous instrument for the effect of income on child outcomes. The EITC does not have a uniform effect across income or education classes. The magnitude of their reported estimated effect of a $1,000 increase in pure transfer is 6% of a standard deviation in test scores. If families take their decisions under the assumption that the policy will persist forever, the cost of the improvements would be large (given by $1,000 times the expected number of years the average family expect to benefit from the EITC), diminishing further their estimated effect.

The “income effect” that they estimate is not a pure income effect. EITC induces greater employment but may reduce hours of work for workers, depending on where the family is located on the EITC budget set (see Heckman et al., 2003). The evidence from Gayle et al. (2013), Bernal (2008), and Bernal and Keane (2010) suggests that maternal working time has substantial effects on child test scores. Dahl and Lochner (2012) attempt to control for the time-allocation effects of the EITC (which may reduce parental time with children) but do not control for the endogeneity of the labor supply decisions of the families or for parental investments.

Duncan et al. (2011) analyze a group of randomized welfare-to-work interventions. They report an overall effect of income on child test scores at early ages that is surprisingly similar to the estimate reported by Dahl and Lochner (2012) for income received and child test scores at later ages. They do not distinguish effects on test scores by source of income (wage income or pure transfer income) although they con-

64 Some parents might have advance information on expected policy changes. This makes policy changes in the EITC an invalid instrument. Parents who have more information will adjust their investments in advance of receipt of payment. This likely biases their estimate downward.
trol for receipt of welfare income. They do not correct for endogeneity of receipt of welfare income. They control for labor supply but do not correct for its endogeneity either. Some of the programs they study subsidize child care and/or child education. However, they also report estimates from a subset of programs that do not have child care or education subsidies. Those estimates are in line with their main estimates.

They report estimates from sixteen different program/site combinations. Fourteen programs/sites show no effect of income on child test scores. The two statistically significant estimates they report are both from the Canadian Self-Sufficiency Project (SSP), which does not have a child care component. They reject the null hypothesis that income effects on test scores are zero at two of the three sites in SSP, although they do not reject it at a third site or in thirteen other programs/sites they examine. Thus in fourteen of the sixteen sites they study they do not reject the hypothesis that income has no effect on child test scores. A simple calculation shows that with a 5% significance level, there is a roughly 14% probability that two out of sixteen independent test statistics would be statistically significant even if the null hypothesis is true.

The authors make an elementary statistical error. They pool the statistically significant estimates of the SSP program with the fourteen statistically insignificant estimates to obtain an overall estimate. They compare this pooled estimate with the estimates from thirteen programs/sites where no effect is found and test and do not reject equality of the two estimates. From this they erroneously infer that the thirteen programs/sites (all the ones located in the US) where no statistically significant effects of earnings on test scores are found support their inference from the SSP sites where an effect is found.

A paper by Akee et al. (2010) is widely cited in the literature as showing strong evidence for an effect of income transfers on academic achievement. Children living on an Indian reservation that opened a casino and distributed revenue to tribe members were more likely to graduate high school. Their study conflates subsidy and income effects. Children were given a cash bonus for graduating high school so that the program offered a conditional cash transfer. Their paper also presents estimates of crime
outcomes consistent with their estimates for high school graduation. Only crime at ages 16 and 17 are significantly reduced. This is consistent with an incapacitation effect of schooling attendance on crime.

A recent comprehensive survey of the effects of family income on child academic achievement (Cooper and Stewart, 2013) suffers from some of the same problems as the studies just discussed. It does not distinguish price effects from income effects in the studies surveyed and does not distinguish the effects of family income by source or adjust for the labor supply and child investment time of parents.

There is mixed evidence on the effectiveness of experimentally determined negative income tax program transfers on the academic achievement of children in families receiving transfers. Most of the papers in the literature on negative income tax experiments conflate substitution (price) effects and pure income effects. (See Rees, 1977, for a discussion of the original New Jersey negative income tax experiment.) Maynard (1977) and Maynard and Murnane (1979) study effects of negative income tax (NIT) programs on academic achievement as measured by attendance, grades and test scores. Maynard (1977) finds significant experimental effects of an NIT program for all measures of academic achievement at one of two experimental sites. She finds no effects for children enrolled in later grades. Maynard and Murnane (1979) evaluate the Gary Income Maintenance Experiment and find positive effects of the NIT program on reading scores (but no effects on GPA and absenteeism) for a younger age group (grades 4–6), but no positive results (instead statistically significant negative results on GPA and positive results for school absenteeism among treatment group members) for an older group (grades 7–10). Mallar (1977) analyzes the academic attainment of adolescents in the New Jersey negative income tax experiment. He reports strong positive effects on years of schooling for most versions of the negative income tax plans offered, but a strong negative effect for adolescents whose parents were enrolled in the most generous plan. For other measures of academic attainment, he finds no effects. None of these papers control for labor supply responses or for
parental investment time effects even though the negative income tax reduces the net wage and effectively subsidizes leisure and parental investment in the child.

Gennetian and Miller (2002) and Morris and Gennetian (2003) analyze a negative income tax program in Minnesota (the Minnesota Family Investment Program). They report weak effects of increased income on children’s schooling performance and behavioral measures. Gennetian and Miller (2002) report evidence of decreased working hours for mothers in one of their treated samples and of increased child care use (fully subsidized and paid to the provider directly under the program) in the other treated sample. Both are relevant factors induced by the treatment which could, by themselves, explain the observed changes in child outcomes. Morris and Gennetian (2003) perform an instrumental variable analysis on the same data and find only weak short term effects of income (one year later) unlikely to survive proper testing for multiple hypotheses (no effect is found in the three year follow-up).

Milligan and Stabile (2011) report positive effects of child benefit programs in Canada, but their results are driven by strong positive effects in Quebec, a province where assistance programs consist of more than just income transfers, such as subsidized child care (Almond and Currie, 2011). Evidence of a role of income, from whatever source, on child outcomes in a reduced-form regression that does not separate effects from subsidy and relative price effects, is not convincing evidence that credit constraints matter.

Carneiro and Heckman (2002) respond to an analysis by Duncan et al. (1998) that early receipt of family income has more substantial effects on educational attainment than later receipt of income. Expressing income in terms of present value units, and conditioning on an early measure of child ability, they find no effect of the timing of income on child educational attainment. Their analysis has been faulted by Cutt and Lochner (2012), who argue that the early measure of child ability may be a consequence of receipt of family income in the early years of childhood, and hence understates the importance of early receipt of income.
4.4.5 Lessons from the Literature on Family Income and Credit Constraints

The literature on credit constraints and family income shows that higher levels of parental resources, broadly defined, promote child outcomes. However, a clear separation of parental resources into pure income flows, parental environmental variables, and parental investment has not yet been done. It is premature to advocate income transfer policies as effective policies for promoting child development.

The literature establishes the first-order importance of child ability for college-going, irrespective of family income levels. More advantaged families with less able children send their children to college at greater rates than less advantaged families, but the literature does not establish the existence of market imperfections or any basis for intervention in credit markets. The observed empirical regularity may result from the exercise of parental preferences. Recent work shows that the returns to college for less able children are low, if not negative.

The literature that presents more formal econometric analyses of the importance of credit market restrictions on educational attainment shows little evidence for them. The analysis of Caucutt and Lochner (2012) is an exception. They calibrate that a substantial fraction of the population is constrained due to the interaction of dynamic complementarity, the receipt of income, and the imperfection of lending markets. Much further research is required before definitive policy conclusions can be drawn on the empirical importance of the timing of receipt of income over the life cycle for child outcomes.

4.5 Structural Estimates of Behavioral Responses to Public Policies

Most studies of the role of income transfer programs discussed in Section 4.4 do not investigate the interactions of public policy interventions and family investments. To do so, some authors have estimated fully specified structural models and use them
to study the effect of various types of policy experiments. Table \text{K.4} in the Web Appendix reports the outcomes of these policy experiments.

Few clean conclusions emerge, and many that do are obvious. Authors estimate different models under different assumptions about their financing. Four main facts emerge from the literature. First, subsidies to parental investments are more cost-effective in improving adult outcomes of children such as schooling attainment or earnings, when provided in the early stages of life (Caucutt and Lochner, 2012; Cunha, 2007; Cunha and Heckman, 2007). Second, financial investment subsidies have stronger effects for families who are already engaging in complementary investments. Targeted public investments and targeted transfers restricted to child-related goods that guarantee minimum investment amounts to every child increase the level of investments received by the children of the least-active parents (Caucutt and Lochner, 2012; Del Boca et al., 2014). Lee and Seshadri (2014) provide evidence on the importance of targeted education subsidies for increasing the educational expenditures of poor families. Third, time-allocation decisions are affected by transfers. Del Boca et al. (2014) show that unrestricted transfers increase the time parents spend with their children through a wealth effect. The increase in child quality is minimal. Lee and Seshadri (2014) show how this effect is especially strong for parents without college education, whereas, in their model, public transfers negatively affect time spent with children for college-educated parents. Fourth, targeted conditional transfers (on a child’s ability improvements) are more cost-effective than pure income transfers to achieve any child outcome.
5 The Implications of Dynamic Complementarity for Investments across Children with Different Initial Endowments

Few models in the literature consider the allocation of investments across multiple children. The average family usually has more than one child, and society allocates public investments across multiple children.

The problem of intra-child allocations is sometimes formulated as a problem in fairness. A CES representation of parental utility $V$ is often used:

$$V = \left( \sum_{k=1}^{N} \omega_k V_k^\sigma \right)^{\frac{1}{\sigma}}. \quad (10)$$

$V_k$ represents the adult outcome for child $k$ that is valued by parents. The $\omega_k$ are weights assigned to each child and $\sigma$ is a measure of inequality aversion. A Benthamite model sets $\sigma = 1$ and assigns equal weights to children, so child utilities are perfect substitutes. A Rawlsian version of maximal inequality aversion is obtained when $\sigma \to -\infty$, so utilities are perfect complements, and parents are concerned only with the maximization of the minimum outcome across children.

In a two-child version of the one-period-of-childhood model analyzed by Becker and Tomes (1979, 1986), under complementarity between initial endowment and investment, the optimal policy when $\sigma = 1$ is to invest less in the initially disadvantaged child. Under substitutability, it is optimal to invest more in the disadvantaged child.

The story is richer when we consider a multiperiod model with dynamic complementarity. Investing relatively more in initially disadvantaged young children can be efficient even when the $\omega_k$ are equal and $\sigma = 1$. This is true even if there is complementarity in each period of the life cycle. Dynamic complementarity is a force promoting compensating early stage investments, even in the absence of family inequality aversion.

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65 See, however Becker and Barro (1988), Gayle et al. (2013), and Del Boca et al. (2014).
66 Behrman et al. (1982) introduced this formulation into the literature.
Thus, in a multiperiod model, where at stage $t$

$$\theta_{t+1} = f^{(t)}(\theta_t, I_t),$$

(11)

even if there is complementarity at all stages, so $f_{12}^{(t)}(\cdot) > 0$ (where $(\cdot)$ denotes the argument of the function), output-maximizing investments can be compensating.

In the two-period, two-child model developed in Web Appendix D.7, if $f_{12}^{(1)}(\cdot) < 0$, but $f_{12}^{(2)}(\cdot) > 0$, it is always efficient to invest relatively more in the initially disadvantaged child in the first period.$^{67}$ But it can also be productively efficient to invest in the disadvantaged child if $f_{12}^{(1)}(\cdot) > 0$, when initial endowments and investments are complements.

The intuition for this result comes from increasing complementarity over the life cycle. In this case, the stock of skills in the second period has a greater effect on the productivity of investments than it does in the first period ($f_{12}^{(2)}(\cdot) > f_{12}^{(1)}(\cdot)$). First-period investments bolster the stock of second-period skills and prepare disadvantaged children to make productive use of them in the second period. This effect is stronger when $f_{12}^{(2)}(\cdot)$ is larger. Another force promoting greater initial investment in the disadvantaged child is diminishing self-productivity of skills in the first period ($f_{11}^{(1)}(\cdot) < 0$): the greater the diminishing returns to investment for the better-endowed child, the lower the benefits of early advantage. Diminishing productivity of the stock of second-period skills ($f_{11}^{(2)}(\cdot) < 0$) operates in the same fashion to limit the effects of any initial advantage. The smaller the effect of the initial stock of skills on the productivity of investment in the first period ($f_{12}^{(1)}(\cdot)$), the weaker is the disequalizing force of complementarity toward promoting investment in the initially advantaged child.

Roughly speaking, the more concave are the technologies in terms of stocks of skills (the more they exhibit decreasing returns in the stocks of skills), the more favorable is the case for investing in more disadvantaged children. The stronger is second-

$^{67}$For a proof, see Section D.7 of the Web Appendix.
period complementarity \( f_{12}^{(2)}(\cdot) \), the stronger is the case for investing more in the initially advantaged child to build skill stocks to take advantage of this opportunity. The weaker is the first-period complementarity \( f_{12}^{(1)}(\cdot) \), the less offsetting is the dis-equalizing effect of complementarity coupled with initial advantage.

In general, even when investment is greater in the first period for the disadvantaged child, it is optimal for second-period investment to be greater for the initially advantaged child. It is generally not efficient to make the disadvantaged child whole in the first period. Greater second-period complementarity then kicks in to promote disequalizing second-period investments.

Web Appendix D.8 illustrates these general features for CES technologies with different patterns of concavity and complementarity. We review the literature on multi-child investment in Web Appendix D.9.

6 Operationalizing the Theory

A dynamic state-space model with constraints and family investment decisions is the natural econometric framework for operationalizing the model of equation (2) and the evolution of capacities, as presented in equation (4). Many studies in the literature focus attention on estimating the technology of skill formation without formulating or estimating models with explicit representation of parental preferences or budget constraints. They account for the endogeneity of input choice through a variety of strategies. This approach is more robust in that it focuses only on one ingredient of a model of family influence. It is, however, clearly limited in the information obtained about the process of human development.

6.1 Skills as Determinants of Outcomes

Cunha et al. (2010) present conditions under which the outcome equations (2) and technology equations (4) are non-parametrically identified. They develop methods for accounting for the measurement error of inputs, anchoring estimated skills on
adult outcomes (so that scales are defined in meaningful units), and accounting for the endogeneity of investments\textsuperscript{68} Heckman et al. (2013) develop and apply simple and easily implemented least-squares estimators of linear factor models to estimate equations for outcomes.

6.2 Multiple Skills Shape Human Achievement Across a Variety of Dimensions

The relationship between the skills estimated in the recent literature that links economics and personality psychology and traditional preference parameters (time preference, leisure, risk aversion, etc.) is weak (see Dohmen et al., 2011). This evidence suggests that richer descriptions of preferences and constraints than the ones traditionally used characterize choice behavior. The two literatures complement each other. Figure\textsuperscript{69} from Eisenhauer et al. (2014) plots the probability and the return\textsuperscript{69} of enrolling in college immediately after having graduated high school as a function of the deciles of scalar summaries of cognitive and noncognitive skills\textsuperscript{70}.

\textsuperscript{68} Cunha et al. (2010) show that accounting for measurement error substantially affects estimates of the technology of skill formation. Caution should be adopted in interpreting the burgeoning literature regressing wages or other outcomes on psychological measurements. The share of error variance for proxies of cognition, personality, and investments ranges from 30\% to 70\%. Not accounting for measurement error produces downward-biased estimates of self-productivity effects and perverse estimates of investment effects (Cunha and Heckman, 2008; Cunha et al., 2010).

\textsuperscript{69} The return is calculated over a 65-year-long working life. Lifecycle earning profiles are simulated using the estimated parameters. See Eisenhauer et al. (2014) for a precise description of the model, data, and computations.

\textsuperscript{70} Section E of the Web Appendix presents a variety of other plots based on the same low-dimensional measures of capability.
6.3 Estimates of the Technology of Skill Formation in the Literature

The main features of the empirical models of the technology of skill formation are summarized in Table F.1. Most of the literature estimates models only for cognitive skills. Cunha and Heckman (2008) and Cunha et al. (2010) estimate models for both cognitive and noncognitive skills. They report evidence of cross-productivity (that noncognitive skills foster cognitive skills) and report that failure to account for noncognitive skills substantially distorts estimates of the cognitive technology. The literature has not yet estimated dynamic models of health.

We briefly summarize the findings of the most general specification estimated to date, that of Cunha et al. (2010). They estimate a model with two stages of childhood development.

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71 Section F of the Web Appendix presents a detailed summary of the specifications and estimates of the technology of skill formation listed in Table F.1. There we compare the estimates of self- and cross-productivity and the productivity of investment (of each type).

72 Shakotko et al. (1981) provide an early example of a dynamic model of health. There is no investment, per se, but they model the effect of parental environmental variables on child health.
(ages 0–4 and ages 5–14) and two skills (cognitive and noncognitive skills) with skill measures anchored in outcomes.\textsuperscript{73}

Cunha et al.’s (2010) model explains 34% of the variance of educational attainment by measures of cognitive and noncognitive skills.\textsuperscript{74} They find that self-productivity becomes stronger as children become older, for both cognitive and noncognitive skills (i.e., $\frac{\partial \theta_{t+1}}{\partial \theta_t} \uparrow t$).\textsuperscript{75} They report asymmetric cross effects. Noncognitive skills foster cognitive investment but not vice versa. There is static complementarity at each stage of the life cycle. Estimated complementarity between cognitive skills and investment becomes stronger at later stages of the life cycle. The elasticity of substitution for cognitive skill production is smaller in second-stage production. This evidence is consistent with emerging dynamic complementarity.\textsuperscript{76} However, estimated complementarity between noncognitive skills and investments is roughly constant over the life cycle of childhood. It is slightly easier at later stages of childhood to remediate early disadvantage using investments in noncognitive skills. This econometric evidence is consistent with a broad array of evidence from intervention studies across the life cycle, which we discuss in Section\textsuperscript{7}. It is also consistent with a large literature showing the emergence of self-control and other regulatory functions associated with the developing prefrontal cortex (see, e.g., Steinberg, 2007, 2008).

Simulations from their estimated model show that in spite of complementarity between investment and skills at each stage of the life cycle, and emerging dynamic complementarity, a socially efficient policy designed to maximize aggregate education or to minimize crime targets relatively more investment in the early years of children with poor initial endowments, in agreement with the analysis of Section\textsuperscript{5}.\textsuperscript{77}

\textsuperscript{73}As any monotonic function of a test score is still a valid test score, anchoring scores in outcomes is essential for producing interpretable estimates of the technology (see Cunha and Heckman, 2008; Cunha et al., 2010).

\textsuperscript{74}Cunha et al. (2010) find substantial evidence of measurement error and show the importance of accounting for it.

\textsuperscript{75}This is consistent with earlier findings by Cunha (2007) and Cunha and Heckman (2008).

\textsuperscript{76}This is also found in Cunha (2007) and Cunha and Heckman (2008).

\textsuperscript{77}For a more extensive discussion of these results, see Cunha and Heckman (2009) and Web Appendix F.
7 Interpreting the Intervention Literature

The models developed in the recent literature in the economics of the family can be used to interpret the intervention literature. Heckman and Kautz (2014) summarize the empirical evidence from a variety of interventions targeting disadvantaged children that range in their target populations from infants to adults. They analyze programs that have been well studied (usually by randomized trials), have long-term follow-ups, and have been widely advocated. Comparisons among programs are problematic as the various programs often differ in the baseline characteristics for the targeted population, in the measurements available to evaluate their effects, and in the packages of interventions offered.

Table I.1 in the Web Appendix summarizes the estimated effects for the most important interventions. Three striking patterns emerge. First, many early childhood interventions have longer follow-ups (10 or 20 years) than do adolescent interventions. Second, evaluations of early childhood programs tend to measure cognitive and noncognitive skills in addition to a variety of later-life outcomes. Many evaluations of programs for adolescents focus solely on labor market outcomes. Examination of the curriculum of these programs is necessary to understand their primary program focus (e.g. cognitive or noncognitive stimulation). Third, the selection of children into early interventions is often dependent on parental choices, whereas adolescents participants decide themselves whether to opt in.

7.1 The Main Findings of the Literature

Three main findings emerge. First, only very early interventions (before age 3) improve IQ in lasting ways consistent with the evidence that early childhood is a critical period for cognitive development. Second, programs targeting disadvantaged adolescents are less effective than are early intervention programs. This evidence is broadly consistent with dynamic complementarity. The few successful programs are a consequence of the direct effect of incentives put in place in these programs (versions
of incapacitation effects), but they fail to have lasting effects. Third, the most promising adolescent interventions feature mentoring and scaffolding. They often integrate work with traditional education and attenuate the rigid separation between school and work that characterizes the American high school. Mentoring involves teaching valuable character (noncognitive) skills (showing up for work, cooperating with others, and persevering on tasks). The effectiveness of mentoring programs is consistent with the evidence on the importance of attachment, parenting, and interaction discussed below. Some form of mentoring and parenting is present in all successful intervention programs at all stages of childhood.

### 7.2 The Mechanisms Producing the Treatment Effects

The literature on program evaluation usually focuses on estimating treatment effects and not on the mechanisms producing the treatment effects. The model of skill formation presented in this paper facilitates understanding of the mechanisms producing treatment effects by distinguishing the effect of interventions on the vector of skills \( \theta_t \) (equation (4)) from the effects the skills themselves have on outcomes (equation (2)). It facilitates unification of the family influence literature with the literature on treatment effects.

[Heckman et al. (2013)] use the dynamic factor approach discussed in Section 6 to study a major intervention with a long-term (age 40) follow-up of the Perry Preschool Program.\(^{78,79}\) They decompose the experimentally determined treatment effects for adult outcomes into components due to treatment-induced changes in cognitive and noncognitive capacities. They show how the effects of the program primarily operate...

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\(^{78}\) The program provided disadvantaged three- and four-year-old children the social and emotional stimulation available to most children from more advantaged families (see [Griffin et al. 2013]). The program is discussed in detail in Subsection 1.1.2 of the Web Appendix.

\(^{79}\) It has a rate of return of 7–10% per annum for boys and girls, analyzed separately ([Heckman et al. 2010a](#)).
through the enhancement of noncognitive skills.\textsuperscript{80} The program boosted adult health, education, and wages and reduced crime and social isolation for males and females.

The core ingredients of the Perry program are similar to those of the ABC program (see Griffin et al., 2013). Both promote cognitive and noncognitive skills through scaffolding the child. A long-term evaluation of the ABC program shows striking effects on adult health and other child outcomes (see Campbell et al., 2014; Conti et al., 2014). The program boosted the cognitive and noncognitive skills of participants, which led to healthier lifestyle choices. This emerging body of research demonstrates the value of the skill formation approach for interpreting and guiding the analysis of interventions.

\textsuperscript{80}The program and the decomposition are presented in Section I.1.2 of the Web Appendix. See Table I.2 and Figures I.1–I.5.
8 Attachment, Engagement, and Interaction: Toward a Deeper Understanding of Parenting, Mentoring, and Learning

A major lesson from the intervention literature is that successful early childhood interventions scaffold children and supplement parenting. They generate positive and sustained parent-child interactions that last after the interventions end. When programs strengthen home environments in lasting ways, the effects of any intervention are more durable. The early investment administered by an effective program stimulates parental investment contemporaneously, which, through complementarity between parental skills and investment, enhances the impact of any intervention.

This section reports evidence of the impacts of interventions on parent-child interactions. Successful interventions are more than just subsidies to disadvantaged families. They scaffold children by interacting closely with them, encouraging and mentoring them, mimicking what successful parents do. Recent evidence shows that they are also effective in increasing the parental capacities to provide mentoring and scaffolding after the interventions are over. Readers are referred to the evidence in Web Appendix J.

8.1 Parental Responses to Intervention

Altering the course of parental investment and engagement with the child during and after the early years of childhood extends the reach of any intervention as parents nurture their children through childhood. In the presence of dynamic complementarities in the production function for capacities, the most effective remediation strategy for disadvantaged children is to couple increased early investments with increased later ones. Improving parenting is a complementary investment. Section J of the Web Appendix presents evidence for some major early childhood programs on

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81 This is consistent with the wisdom of John Dewey summarized in Appendix N.
parental responses to interventions in terms of interactions with the child and in terms of boosting the quality of home environments. On a variety of dimensions, these programs increase the parental investments of treated group members during the course of their intervention. Parents held more positive views about parenting and their role in shaping the character and abilities of their children. Parental attitudes and the home environment also improved. Follow-up measurements provide evidence of the capacity to permanently alter the parents’ investment strategy. If after a few years of formal intervention it is possible to boost parental investment for all child-rearing years, the potential for improvement grows substantially. The mechanisms through which these programs are effective are enhanced information (as in the Nurse Family Partnership program)\(^\text{82}\) changing parental preferences, and the responses of parents to the enhanced curiosity and engagement of the child induced by participation in the program\(^\text{83}\).

### 8.2 What Parents Know and How They Parent

There are two main explanations for the changes in parental behavior induced by successful interventions. First, intervention increases the child’s skills, and this in turn induces a change in parental behavior. This is consistent with the complementarity central to the models presented in Section 4. Second, the interventions may convey information to the parents about their child’s skills, on successful investment strategies and on their returns, and thereby increase parental knowledge. The evidence on the effectiveness of the Nurse Family Partnership program shows that giving beneficial information to parents improves child outcomes and changes parenting behavior\(^\text{84}\).

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\(^{82}\) See Web Appendix I.1.

\(^{83}\) Cole et al. (2012) and Conti et al. (2012) experimentally examine the role of parenting and attachment on the health and genetic expression of rhesus monkeys. They establish that when infant monkeys are deprived of early stimulation and interaction with their mothers, their gene expression is altered in ways that make them more susceptible to disease in adulthood. See Suomi (1999) for discussion of a systematic body of evidence on the withdrawal of attachment and stimulation on monkey development.

\(^{84}\) Heckman and Kautz (2014) discuss the evidence on the effectiveness of the NFP program and provide detailed references to numerous evaluation studies.
The research of Cunha et al. (2013) directly investigates beliefs and information mothers have about parenting. They find considerable heterogeneity among less educated mothers. Compared with a benchmark estimated technology, socioeconomically disadvantaged mothers underestimate the responsiveness of child development with respect to investments.

National samples also provide evidence that maternal knowledge is a main factor in explaining differences in the amount of activities children are involved in. Through in-depth interviews of dozens of middle-class, working-class, and poor families, Lareau (2011) shows that professional parents often engage children after an activity to determine what they have learned, whereas in working-class homes, there is little parental follow-up. Middle-class families have a better understanding of the educational institutions their children are involved with and hope to attend. They also intervene far more frequently on their child’s behalf, whereas working-class and poor families generally allow the school to guide their child’s educational decisions. Additionally, for middle-class families, social ties tend to be woven through children’s lives, especially through the organized activities they participate in, as well as through informal contacts with educators and other professionals. In contrast, the social networks of working-class and poor families tend to be rooted in and around kinship groups. Ties to other parents and to professionals are considerably less common (Lareau and Cox, 2011).

8.3 Towards a More General Model of Parent-Child Interactions

The productivity of any investment or parental stimulus is influenced by the child’s response to it. Parents and children can have different goals. For example, the child can be more shortsighted than the parent (Akabayashi, 2006) or have different values for leisure and future human capital (Cosconati, 2013). The parent may act as a principal whose goal is to maximize the effort from an agent—their child. The child’s ability
and effort are not observed by the parent, and this creates a moral hazard problem. As the interaction is repeated over time, parents can learn about the child’s ability by using responses to stimuli as signals of it. The greater the knowledge about the child’s ability, the easier it is for the parent to induce the desired effort via better-targeted stimuli.

The models discussed thus far do not consider the role of a child’s own actions on his human capital accumulation, nor do they consider parental learning about child ability and about the most-effective parenting strategies. In most of the literature, parental investments are assumed to be made under perfect knowledge of the child’s current skills, as well as the technology that determines their law of motion. In truth, parent-child interactions are an emergent system shaped by mutual interactions and learning (Gottlieb, 1999; Sroufe et al., 2005). Parents learn about a child’s characteristics and about the effectiveness of their investments by observing their child’s behavior and directly interacting with the child. A child’s accumulation of skills is a process of learning guided by the mentoring role of parents and educators. Parental guidance often involves conflicts with the child’s own desires. Paternalistic parents evaluate the child’s future outcomes differently than the child does, and the capacities, knowledge, and autonomy of the child evolve with experience. A richer model of child learning investigates the formation of the agency of the child—his ability to shape his own environment, including his learning environment. As children mature, they generally make wiser choices.

Akabayashi (2006) provides one of few examples of a model of parent-child interactions and parental learning in the literature. He considers a framework in which a myopic child does not take into account the value of future human capital. As the child’s effort is productive, but unobservable to the parent, an altruistic parent forms beliefs on the child’s human capital and effort from observations of his performances and incentivizes effort by choosing the quality of interactions (praise or

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85 Even classical liberals such as Mill (1859) grant a role for informal paternalism on the part of the parents.

86 We summarize this literature in Table K.5 in the Web Appendix.
punishment) to engage the child. This process of interaction determines the evolution of a child’s skills and parental beliefs. Substantial uncertainty about a child’s human capital might produce divergence between parental expectations about it and its actual level, leading to pathological interactions such as maltreatment.

Cosconati (2013) relaxes Akabayashi’s myopic child assumptions and develops a related model of parent-child interactions in which parents are also more patient than their child and cannot directly observe his effort. To incentivize effort and human capital accumulation, parents limit the child’s leisure. The stricter the limits set by the parents, the higher is their monitoring cost. Cosconati shows how an authoritative parenting style (Baumrind, 1968) emerges in equilibrium as the optimal strategy for parents. He presents preliminary estimates of his model.

The preceding models are built around “arms-length” parent-child interactions in which parents respond to child behavior and children reciprocate. The model of Lizzeri and Lizzeri and Siniscalchi (2008) involves a deeper type of interaction in which parents can help the child in performing a task (e.g., getting good grades in school). Failure to properly perform the task has negative consequences for the child’s utility. For this reason, the parents may help the child to make them happier. If the child fails, however, he learns about his ability, and this has long-term benefits. If the child is helped to avoid failure due to deficiencies in his own ability, learning is diminished. This creates a trade-off in parental preferences. The authors prove that partial sheltering from failure (limited parental intervention) is optimal. The model generates correlations patterns between parents’ and children’s performance that are consistent with what is found in the literature on behavioral genetics. Contrary to the interpretation in a literature that claims a limited role for parental influence (Harris, 2009), the observed correlations are the result of successful active parenting.87

These studies go beyond the technology of skill formation to understand the interactions that transform time and goods investments to shape children’s capacities. They are the first step toward formalizing notions such as attachment, mentoring, and

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87The model of multiple children presented in Section 5 can rationalize the evidence on limited impacts of common family influences. Child investment is individuated for reasons of both equity and efficiency.
scaffolding that have long been associated with the successful process in human development (see Sroufe et al., 2005; Vygotski, 1978). They help explain the observed heterogeneity in parental behavior and help interpret why interventions promoting parental engagement with the child show stronger beneficial long-term results. A greater knowledge of the mechanisms behind learning is crucial for the design of more effective policies and interventions. Successful interventions alter parental behavior. Understanding why this happens, how parenting can be incentivized, and through which channels parenting influences child development are crucial tasks for the next generation of studies of child development.
9 Summary

This paper reviews a vibrant recent literature that investigates the determinants and consequences of parental actions and environments on child outcomes. It documents differences in investments received by children of different socioeconomic status.

The recent literature is based on multiple-generation models with multiple periods of childhood and adulthood. It emphasizes the dynamics of skill formation. Central to the literature are the concepts of complementarity, dynamic complementarity, the multiplicity of skills, and critical and sensitive periods for different skills. These concepts account for a variety of empirical regularities that describe the process of human development.

Family environments during the early years and parenting are critical determinants of human development because they shape the lifetime skill base. Through dynamic complementarity, they enhance the productivity of downstream investments. We establish conditions under which it is socially productive to invest in the early years of disadvantaged children. These conditions are supported by evidence from the literature. Later-stage remedial interventions are generally less effective, especially if they target IQ. Interventions aimed at disadvantaged adolescents can be effective if they target the enhancement of noncognitive capabilities, and provide valuable information that helps them make wise choices.

The evidence summarized here demonstrates the value of a perspective with multiple skills. An approach based on the dynamic evolution of skills unifies the literature on family economics with the intervention literature.

The role of the timing of receipt of income and the role of credit constraints in shaping child development are closely examined. We find that the importance of these factors in shaping child outcomes has been exaggerated in the recent literature compared to the importance of parenting and mentoring. Untargeted cash transfers are unlikely to be effective in promoting child skills.
Mentoring, parenting, and human interaction are the unifying themes of successful skill-development strategies across the entire life cycle. The study of parent-child interactions as an emergent system is a promising approach to human development. Effective early life interventions promote beneficial changes in parenting. The analysis of parent-child interactions and parental learning; the formalization of the notions of attachment, mentoring, and scaffolding; and their integration into life-cycle overlapping-generations models with dynamic skill accumulation constitute the research frontier in the field.
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