

The Economics of Human Development and Social Mobility

James J. Heckman and Stefano Mosso

Department of Economics, University of Chicago, Chicago, Illinois 60637;
email: jjh@uchicago.edu, smosso@uchicago.edu

Annu. Rev. Econ. 2014. 6:689–733

First published online as a Review in Advance on
April 25, 2014

The *Annual Review of Economics* is online at
economics.annualreviews.org

This article's doi:
10.1146/annurev-economics-080213-040753

Copyright © 2014 by Annual Reviews.
All rights reserved

JEL codes: J13, I20, I24, I28

Keywords

capacities, dynamic complementarity, parenting, scaffolding, attachment, credit constraints

Abstract

This article 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.

1. INTRODUCTION¹

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 (see, e.g., Cunha et al. 2005, Huggett et al. 2011, Keane & Wolpin 1997). Childhood is the province of the family. Any investigation of how conditions in childhood affect life outcomes is a study of family influence.

This article 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. (2006a) and Rubinstein & Weiss (2006) models schooling choices and postschool on-the-job investment. The outputs 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 & 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 article. 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 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 (a) 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, (b) multiple skills for both parents and children that extend traditional notions about the skills required for success in life, and (c) 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*² 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

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

²Scaffolding 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.

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 article 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-bones model of human development that captures 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 article. 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. The **Supplemental Appendix** presents more formal arguments and extensive empirical evidence on each topic covered in this article (follow the Supplemental Material link from the Annual Reviews home page at <http://www.annualreviews.org>).

 Supplemental Material

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.³ The recent empirical literature has established eight important facts about the process of human development and skill formation. Each fact is extensively documented in the **Supplemental Appendix**.

2.1. 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 (see section E in the **Supplemental Appendix**). Comprehensive surveys are presented in Borghans et al. (2008a) and Almlund et al. (2011).

2.2. Gaps in Skills

Gaps in skills between individuals and across socioeconomic groups open up at early ages for both cognitive and noncognitive skills. Carneiro & Heckman (2003), Cunha et al. (2006), and

³Capacities may also shape preferences, but in this case, the interpretation placed on the benefit of enlarged choice sets is quite different.

Cunha & 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.⁴

2.3. 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.⁵ 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 article.

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 (see the evidence in the **Supplemental Appendix**, section M). Epigenetics, the study of heritability not related to DNA sequencing, informs us that environmental influences are partly heritable (see Cole et al. 2012; Gluckman & Hanson 2005, 2006; Jablonka & Raz 2009; Kuzawa & Quinn 2009; Rutter 2006).

2.4. 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 & 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 & Currie (2011) for reviews of numerous studies on the importance of prenatal and early childhood environments on adolescent and adult health⁶ and socioeconomic outcomes.

2.5. Family Investments

Gaps in skills by age across different socioeconomic groups have counterparts in gaps in family investments and environments. Hart & Risley (1995), Fernald et al. (2013), and many other

Supplemental Material

⁴Cunha et al. (2006) and Cunha & 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 the **Supplemental Appendix** for an extensive analysis of gaps in cognitive and noncognitive skills).

⁵Readers are referred to section M of the **Supplemental 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 heritable [see, e.g., Krueger & Johnson (2008), who show that parenting style affects the heritability of personality].

⁶For example, Barker (1990) and Hales & 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 & Hanson 2005, 2006).

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 (see **Supplemental Table A.1**). 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.⁷ 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 the evidence in the **Supplemental Appendix**, section B) (see Hart & Risley 1995, Kalil 2013, Lareau 2011).

2.6. 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 (see **Supplemental Table I.1**).⁸ 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, Heckman & Kautz 2014, Heckman et al. 1999). 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 & Sacerdote 2013, Cook et al. 2014).

2.7. 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.

2.8. 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

⁷A large body of evidence on this question is summarized in section B of the **Supplemental Appendix**.

⁸Rutter 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.

young disadvantaged children.⁹ There is compelling evidence that high-quality interventions targeted to the early years are effective in promoting skills (see section I.1 of the **Supplemental Appendix**) (Heckman & Kautz 2014). The evidence is explained by dynamic complementarity, which is discussed in the next section.

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 θ_t over lifetime T . Decompose θ_t into three subvectors:

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

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 θ_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.¹⁰

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

$$Y_{j,t} = \psi_{j,t}(\theta_t, e_{j,t}, \mathbf{X}_{j,t}), \quad j \in \{1, \dots, J_t\}, \quad \text{and} \quad t \in \{1, \dots, T\}, \quad (2)$$

where $\mathbf{X}_{j,t}$ is a vector of purchased inputs that affect outcomes. Effort $e_{j,t}$ is characterized by the supply function

$$e_{j,t} = \delta_j(\theta_t, \mathbf{A}_t, \mathbf{X}_{j,t}, \mathbf{R}_{j,t}^a(\mathcal{I}_{t-1})|\mathbf{u}), \quad (3)$$

where \mathcal{I}_{t-1} is the information set, on the basis of which the agent evaluates outcomes; $\mathbf{R}_{j,t}^a(\mathcal{I}_{t-1})$ is the anticipated reward per unit effort in activity j in period t ; \mathbf{A}_t represents other determinants of effort; and \mathbf{u} represents a vector of parameters characterizing preferences.¹¹

⁹Recent 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. (2008a, 2011b), Almlund et al. (2011), and Heckman & Kautz (2012, 2014), 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 shows boosts in achievement test scores without raising IQ. Perry boosted noncognitive skills.

¹⁰They may also shape preferences.

¹¹In models of parent-child interactions, the utility functions of the parent and the child govern effort.

An active body of research investigates the role of skills in producing outcomes (see Almlund et al. 2011, Borghans et al. 2008a, Bowles et al. 2001, Dohmen et al. 2010). In general, each outcome is differentially affected by components of the (possibly age-dependent) capacity vector θ_t . Schooling, for example, depends more strongly on cognitive abilities, whereas earnings are equally affected by cognitive capacities and noncognitive capacities, such as conscientiousness.¹² Scores on achievement tests depend on both cognitive and noncognitive capacities (see Borghans et al. 2008a; Heckman & Kautz 2012, 2014). (This point is confused in a literature that equates cognition with scores on achievement tests.) Evidence that achievement tests predict outcomes better than measures of personality or IQ alone misses the point that achievement tests capture both (for a recent example of this confusion, see Duckworth et al. 2012). 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.¹³

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 (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 (θ_t), the situation (A_t), or the effort evoked by the interaction among θ_t , A_t , and the incentives to attain a given result ($R_{j,t}^a$)? Thaler et al. (2008) and many behavioral economists (e.g., Mullainathan & 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 & 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 (see Borghans et al. 2008a). 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 et al. 2008a,b). Incentivized boosts in achievement have not been shown to persist when the incentives are removed.¹⁴

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 in the recent literature using early behaviors as measures of child attributes (see Heckman et al. 2014, Jackson 2013, Piatek & Pinger

¹²Readers are referred to **Supplemental 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.”

¹³One version of this is the Roy model of occupational choice (see, e.g., Heckman & Sedlacek 1985).

¹⁴A literature in psychology (Deci & Ryan 1985, Ryan & Deci 2000) suggests that the performance is actually lower in the baseline after incentives are removed.

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 & Kautz 2012, 2014). The system of Equations 2 does not isolate θ_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 (see Anderson & Rubin 1956, Williams 2012). At best we can identify factors normalized relative to each other (see Almlund et al. 2011; Borghans et al. 2008a; Cunha et al. 2010; Heckman & 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 θ_t and hence outcomes (Y_t) and make comparisons across those literatures (see Cunha & 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 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.¹⁵

3.2. Technology

An important ingredient in the recent literature is the technology of skill formation (Cunha 2007, Cunha & Heckman 2007), where the vector θ_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):

$$\theta_{t+1} = \mathbf{f}^{(t)} \left(\underbrace{\theta_t}_{\substack{\text{self-productivity} \\ \text{and cross effects}}}, \underbrace{I_t}_{\text{investments}}, \underbrace{\theta_{P,t}}_{\substack{\text{parental} \\ \text{skills}}} \right). \quad (4)$$

$\mathbf{f}^{(t)}$ is assumed to be twice continuously differentiable, increasing in all arguments and concave in I_t . As noted above, the dimension of θ_t and $\mathbf{f}^{(t)}$ likely increases with the stage of the life cycle t , as does

¹⁵However, as noted by Doepke & 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 & Koo 2011).

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.¹⁶ This technology accommodates the family formation of child preferences, as in Becker & Mulligan (1997), Becker et al. (2012), Bisin & Verdier (2001), and Doepke & Zilibotti (2012).

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 & 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 childhood¹⁷:

$$\frac{\partial^2 \theta_{t+1}}{\partial \theta_t \partial I_t'} > 0, \quad t > t^*.$$

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 (see Cunha 2007, Cunha & Heckman 2008, Cunha et al. 2010):

$$\frac{\partial^2 \theta_{t+1}}{\partial \theta_t \partial I_t'} \uparrow t \uparrow.$$

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 θ_t tend to be more productive. This is a force for the social disqualification of investment. It is consistent with evidence reported by Cameron & 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 (see, e.g., **Supplemental Table G.1**). 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 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 & Kautz 2014, Knudsen et al. 2006, Sroufe et al. 2005).¹⁸ 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 & Heckman (2007, 2009). Because investment produces

¹⁶The 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, Rubinstein & Weiss 2006). It is more general than the Ben-Porath model and its extensions because it allows for multiple skill outputs (θ_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 (Equation 4) with the Ben-Porath model.

¹⁷There are other notions of complementarity. For a discussion with reference to the technology of skill formation, readers are referred to Cunha et al. (2006).

¹⁸It 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.

greater stocks of skills, $I_t \uparrow \Rightarrow \theta_{t+1} \uparrow$, and because of self-productivity, $\theta_{t+1} \uparrow \Rightarrow \theta_{t+s} \uparrow$, $s \geq 1$, 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 θ_{t+s} and I_{t+s} are complements, irrespective of whether I_t and θ_t are complements or substitutes in some earlier period t .¹⁹ Early investment 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- θ_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.

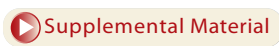
Parental skills also play a disequalizing role as they enhance the productivity of investments [$(\partial^2 \theta_{t+1}) / (\partial \theta_{P,t} \partial I'_t) > 0$]. There is evidence that more educated parents, by engaging their children more, increase the formative value of investments such as 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 out private investments relatively more among disadvantaged families, then public investments will also play a role toward disequalization.²⁰

¹⁹Dynamic 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 θ_t and I_t : $\theta_{t+1} = f^{(t)}(\theta_t, I_t)$. Denoting by f'_1 and f'_2 the derivatives with respect to the first and second argument, respectively, $\text{sign}\left\{\left(\partial^2 f^{(t+s)}(\theta_{t+s}, I_{t+s})\right) / \left(\partial I_{t+s} \partial I_t\right)\right\} = \text{sign}\left\{f'_{21} f^{(t+s)}\right\}$ independently of the sign of f'_{21} , for $s \geq 1$. To prove the claim, note that $\left(\partial^2 f^{(t+s)}(\theta_{t+s}, I_{t+s})\right) / \left(\partial I_{t+s} \partial I_t\right) = f'_{21} f^{(t+s)} \left(\underbrace{\prod_{j=1}^{s-1} f'_{1(t+j)}}_{>0}\right) f'_2 f^{(t)}$. (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 **Supplemental Appendix**). Empirical evidence (Cunha 2007, Cunha & Heckman 2008, Cunha et al. 2010) shows that in multiperiod models, $\dots > f'_{12} > f'_{12} > f'_{12}$. 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 complements in later stages as the elasticity of substitution becomes lower than 1 (for further discussion, see Cunha et al. 2006).

²⁰This is an argument against the universal provision of policies to promote the equality of outcomes. The evidence supporting the complementarity hypothesis is mixed (see the **Supplemental Appendix**, section J) (see Pop-Eleches & Urquiola 2013, Gelber & Isen 2013).



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 & Verdier 2001, Doepke & Zilibotti 2012).²¹ 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) genes; 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 article 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 & Heckman (2007). Section D of the **Supplemental 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 & Tomes 1986, Loury 1981). It has multiple periods of productive investments, 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 θ_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

²¹Altruistic parents care about the utility of their child and therefore evaluate their child's actions using the child's utility function. Paternalistic parents, conversely, 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.

by θ_1 the initial capability level of a child drawn from the distribution $J(\theta_1)$.²² 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, $\theta_{P,t}$. (For notational simplicity, we set $\theta_{P,t} = \theta_P$.) We follow conventions in the literature and equate scalar human capital with skill for both parents and children. Denoting by θ_3 the human capital of the child when he reaches adulthood, recursive substitution of the technology of skill formation using a CES specification gives the following representation:

$$\theta_3 = \delta_2 \left[\theta_1, \theta_P, \left(\gamma(I_1)^\phi + (1 - \gamma)(I_2)^\phi \right)^{\frac{\rho}{\phi}} \right]; \quad (5)$$

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

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

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

with $0 < \gamma_{1,t}$, $\gamma_{2,t}$, and $\gamma_{3,t}$; $\rho_t \leq 1$; $\phi_t \leq 1$; 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

$$\theta_3 = \delta_2 \left[\gamma_{1,2} \gamma_{1,1} \theta_1^\phi + \underbrace{\gamma_{1,2} \gamma_{2,1}}_{\text{multiplier}} I_1^\phi + \gamma_{2,2} I_2^\phi + (\gamma_{3,2} + \gamma_{1,2} \gamma_{3,1}) \theta_P^\phi \right]^{\frac{1}{\phi}}.$$

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, θ_3 . The parameter ϕ 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.²³ Given ρ , the smaller ϕ , the harder it is to remediate low levels of early investment I_1 by increasing later investments. At the same time, the stronger the

²²This may depend on parental skills $\theta_{P,t}$ and parental care in utero (see, e.g., Gluckman & Hanson 2004, 2005).

²³Direct 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.

complementarity (the lower ϕ), 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 nonnegative. 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, θ_P ; and the initial skill level of the child, θ_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

$$c_1 + I_1 + \frac{a}{(1+r)} = w\theta_P + b \quad (6)$$

and

$$c_2 + I_2 + \frac{b'}{(1+r)} = w(1+g)\theta_P + a. \quad (7)$$

We allow for the possibility of borrowing constraints $a \geq \underline{a}$ (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 $a \geq \underline{a}$. In the absence of these constraints, one simple lifetime budget constraint governs parental choices of investment in children.

Let $u(\cdot)$ denote the parental utility function, β the discount factor, and v the parental altruism given by the weight assigned to the utility of future generations. Letting θ'_1 be the uncertain initial endowment of the child's child, the goal of the parent is to optimize

$$V(\theta_P, b, \theta_1) = \max_{c_1, c_2, I_1, I_2} \left\{ u(c_1) + \beta u(c_2) + \beta^2 v \mathbb{E} \left[V(\theta_3, b', \theta'_1) \right] \right\}, \quad (8)$$

subject to Equations 5–7.²⁴ In models of paternalism, parental preferences are defined over specific outcomes and not necessarily the adult utility of children (see, e.g., Del Boca et al. 2012).

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 & Tomes 1986), as well as some recent work (Lee & 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.

²⁴One 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.

The assumed magnitudes of the substitution (ϕ), multiplier (γ), and scale (ρ) parameters play key roles in shaping policy.

If no intra- and intergenerational credit constraints are assumed, a key property of the Becker & 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 v (above zero) in determining the optimal level of investment because parents can borrow freely in the market to finance the wealth-maximizing level of investment.²⁵ However, even in this setup, returns to parental investments depend on parental skills, θ_p , as they affect the productivity of investments. The returns to investments are higher for children of parents with higher θ_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 θ_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.²⁶

Imperfect credit markets create another channel of intergenerational dependence. One possible constraint is the impossibility of borrowing against the child's future earnings (Becker & 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 & 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.²⁷

A second type of constraint arises when parents are prevented from borrowing fully against their own future labor income ($\underline{a} \geq q > -\infty$). In this case, investments are not perfect substitutes ($-\infty < \phi < 1$), $\rho = 1$, and parental utility is given by $u(c) = (c^\lambda - 1)/\lambda$,²⁸ the ratio of early to late investment is

$$I_1/I_2 = \underbrace{\left(\frac{\gamma}{(1-\gamma)(1+r)} \right)^{\frac{1}{1-\phi}}}_{\text{unconstrained ratio}} \cdot \underbrace{[\beta(1+r)]^{\frac{1}{1-\phi}} \left(\frac{c_1}{c_2} \right)^{\frac{1-\lambda}{1-\phi}}}_{\substack{=1 \text{ if unconstrained,} \\ <1 \text{ if constrained } (a \geq \underline{a} \text{ binds})}}. \quad (9)$$

$I_1/I_2 \uparrow$ as $\gamma \uparrow, \phi \uparrow,$ and $r \downarrow$

In the constrained case, I_1/I_2 is less than it is in the unconstrained case, and I_1 is less than optimal.²⁹ 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 λ is small, the level and timing of family resources will influence the parental investment.³⁰ This constraint could be very harmful to

²⁵Even 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.

²⁶Becker & Tomes (1986) discuss the importance of children's initial endowments. A third channel is parental paternalism. If parents value the child's θ_3 for itself, they may subsidize child education, even if the investment is economically inefficient.

²⁷The constraint binds uniformly across periods within generations.

²⁸ $\lambda = 1$ corresponds to perfect intertemporal substitutability.

²⁹In 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 $\gamma > (1-\gamma)(1+r)$.

³⁰Estimates from Cunha et al. (2010) suggest that $1/(1-\phi) = 0.\bar{3}$, which, combined with an estimate of $\lambda \in [-3, -1.5]$ (Attanasio & Browning 1995), implies $(1-\lambda)/(1-\phi) \in [0.8\bar{3}, 1.\bar{3}]$. Notice that even if $\lambda = 1$, parents may hit constraints on the level of investment if future resources are of insufficient magnitude.

a child if it binds in a critical period of development and the complementarity parameter ϕ 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.³¹

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 investments 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. Relaxing this constraint likely impedes intergenerational mobility as measured by intergenerational elasticity (IGE) (see Black & Devereux 2011 for a definition and discussion of the IGE). Low-skill parents, conversely, have a low θ_P , 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 & 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.³² As noted above, the families constrained by their criteria may be quite affluent. Indeed, Caucutt & 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.

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 (see section D.6 of the

³¹The 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 λ in Equation 9, the more likely it is that families will postpone fertility to match their life-cycle income growth profiles.

³²After credit constraints are relaxed, future generations move back to a constrained position.

Supplemental Appendix for a mathematical proof of this statement). 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. **Supplemental Tables K.1–K.3** examine each model in detail, and **Supplemental Table K.1** 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 (see, e.g., Cunha & Heckman 2008, Cunha et al. 2010). Until recently, most studies considered the self-productivity of skills. 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 intergenerational 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 & Heckman (2008) and Cunha et al. (2010), human capital is treated as a scalar. This is inconsistent with the fact presented in Section 2.1. It is a practice inherited from the early literature of Becker & Tomes (1979, 1986), and Solon (2004). Instead, skills are multidimensional. Borghans et al. (2008a), Almlund et al. (2011), and Heckman & 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 (see the analysis in the **Supplemental Appendix**, section E).

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 & Keane 2010, 2011; Del Boca et al. 2014; Gayle et al. 2013; Lee & 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 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

Supplemental Material

receive relatively more early investment and appear to do better as adults (Hotz & 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 parent. 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).³³ 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 confounded 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 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 & 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 & 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

³³Gayle et al. (2013) provide the only paper of which we are aware that analyzes the impact of endogenous fertility choices on child outcomes.

Table 1 Studies of the role of parental income on child outcomes

Study	Data set	Outcome studied	Timing of income (developmental stage of the child at which income effects are studied)	Separates the effect of income from changes in labor supply or family environment?	Distinguishes the effects of contemporaneous versus permanent income?	Sources of income whose effects are studied	Instrument used	Effect of income on human capital investments
Akee et al. (2010)	GSMS	Schooling outcomes and crime	Yearly family income in adolescence (ages 12–16)	No	Yes	Total family income	Experimental assignment	\$4,000 per year was given to all adult tribal members of the Eastern Band of Cherokee Indians from casino profits; There was a 15% increase in high school graduation, one extra year of education by age 21 only for households in poverty prior to transfer, and 22% reduction in the probability of being arrested at ages 16–17 (no effect when older). The results confound the increased parental income with the fact that children would become themselves 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.
Belley & Lochner (2007)	NLSY79, NLSY97	High school completion and college enrollment	Family income during adolescence (at age 16 or 17 for the NLSY79 cohort; at age 13, 14, 15, or 16 for the NLSY97 cohort)	No	No	Total family income	None	High school completion increased by 8.4% for the highest-income quartile compared to the lowest in 1979 and increased by 6.7% in 1997 (cannot reject equal effect of income). College enrollment increased by 9.3% for the highest-income quartile compared to the lowest in 1979 and increased by 16% in 1997 (cannot reject equal effect of income).

(Continued)

Table 1 (Continued)

Study	Data set	Outcome studied	Timing of income (developmental stage of the child at which income effects are studied)	Separates the effect of income from changes in labor supply or family environment?	Distinguishes the effects of contemporaneous versus permanent income?	Sources of income whose effects are studied	Instrument used	Effect of income on human capital investments
Carniero & Heckman (2002)	NLSY79, C-NLSY79	College enrollment	Family income at age 16 or 17 (using data from NLSY79); discounted family income (using data from C-NLSY79) during childhood and adolescence (ages 0–18) broken up by stage of the child's life cycle (ages 0–5, 5–16, 16–18)	No	Yes	Total family income	None	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 (1.2% 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 an 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.

(Continued)

Table 1 (Continued)

Study	Data set	Outcome studied	Timing of income (developmental stage of the child at which income effects are studied)	Separates the effect of income from changes in labor supply or family environment?	Distinguishes the effects of contemporaneous versus permanent income?	Sources of income whose effects are studied	Instrument used	Effect of income on human capital investments
Carniero et al. (2013)	Norwegian Registry	Multiple outcomes (schooling, health, IQ, teen pregnancy)	Average discounted family income during childhood and adolescence (ages 0–17) broken up by stage of the child's life cycle (ages 0–6, 6–11, 12–17)	No	Yes	Total family income	None	For all outcomes, there is a monotone and concave relationship with permanent income. A €100,000 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.
Dahl & Lochner (2012)	NLSY79, C-NLSY79	PIAT test scores	Yearly family income during preadolescence (ages 8–14)	No ^a	No ^b	Total family income	Policy variation in EITC eligibility	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.
Duncan et al. (1998)	PSID	Multiple schooling outcomes and hazard of nonmarital birth	Average family income during childhood and adolescence (ages 0–15)	No	Yes	Total family income	None	A \$10,000 increase in average (ages 0–15) family income results in a gain of 1.3 years of schooling in low-income (<\$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.

(Continued)

Table 1 (Continued)

Study	Data set	Outcome studied	Timing of income (developmental stage of the child at which income effects are studied)	Separates the effect of income from changes in labor supply or family environment?	Distinguishes the effects of contemporaneous versus permanent income?	Sources of income whose effects are studied	Instrument used	Effect of income on human capital investments
Duncan et al. (2011)	Randomized interventions on welfare support	Achievement test scores	Yearly family income during childhood (ages 2–5)	No	No	Total family income	Random assignment to programs offering welfare transfers conditional on employment or education-related activities, or full-time work	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.
Gennetian & Miller (2002)	Multiple sources on families involved in the MFP	Multiple schooling and behavioral outcomes	Yearly family income during childhood (ages 8–9)	No	Yes	Total family income	Experimental assignment	Treated (MFP “incentive”) 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 were fully subsidized and directly paid to the provider. MFP “plus” families also received employment and training activities. Children of MFP families (both groups) showed greater engagement in school, a reduction in the likelihood of performing below averages, and reduced behavioral problems, with the effect particularly pronounced for girls and during school ages. Children in MFP “full” families, however, showed no benefits on the positive behavior scale. In both MFP groups, marriage rates increased and domestic abuse rates decreased. Earnings increased only in the MFP “full” group, whereas the increased income in the MFP “incentive” group resulted from greater welfare transfers. Mothers in the MFP “full” group greatly increased 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).

(Continued)

Table 1 (Continued)

Study	Data set	Outcome studied	Timing of income (developmental stage of the child at which income effects are studied)	Separates the effect of income from changes in labor supply or family environment?	Distinguishes the effects of contemporaneous versus permanent income?	Sources of income whose effects are studied	Instrument used	Effect of income on human capital investments
Loken (2010)	Norwegian administrative data	Multiple schooling outcomes	Average family income during childhood and preadolescence (ages 0–13)	Yes ^c	No	Total family income	Oil discovery (inducing regional increase in wages)	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.
Loken et al. (2012)	Norwegian administrative data	Multiple schooling outcomes and adults' IQ	Average family income during childhood (ages 0–11)	No	No	Total family income	Oil discovery (inducing regional increase in wages)	With nonlinear IV (quadratic model), an increase of \$17414 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. ^d
Mallar (1977)	New Jersey Income Maintenance Experiment	Multiple schooling outcomes	Yearly family income during adolescence (ages of high school enrollment)	No	Yes	Total family income	Experimental assignment	There is a positive effect of the negative income tax for the children of the families enrolled in one of the medium-generosity plans: The probability of high school graduation increased by 20–50%, and the number of completed years of schooling increased by 0.5–1. There are negative results for the children of families enrolled in the most generous plan: The probability of high school graduation decreased by 25%, and the number of completed years of schooling decreased by 0.4.
Maynard (1977)	Rural Income Maintenance Experiment (North Carolina and Iowa)	Multiple schooling outcomes	Yearly family income during childhood and preadolescence (ages 7–14, grades 2–8)	No	Yes	Total family income	Experimental assignment	In North Carolina, there is a positive effect from a negative income tax on multiple schooling outcomes (–30.5% absenteeism, 6.2% increase in GPA) for the youngest group; there are no effects for the older group. In Iowa, there are null or negative effects on all outcomes.
Maynard & Murnane (1979)	Gary Income Maintenance Experiment	Multiple schooling outcomes	Yearly family income during childhood and preadolescence (ages 9–13, grades 4–6) and adolescence (ages 13–16, grades 7–10)	No	Yes	Total family income	Experimental assignment	For grades 4–6, there is a positive effect from the negative income tax only on reading test scores (6–9 months difference on a grade equivalent measure). There is no effect on GPA and absenteeism. For grades 7–10, there are negative effects on GPA (all grades) and on absenteeism (grade 9).

(Continued)

Table 1 (Continued)

Study	Data set	Outcome studied	Timing of income (developmental stage of the child at which income effects are studied)	Separates the effect of income from changes in labor supply or family environment?	Distinguishes the effects of contemporaneous versus permanent income?	Sources of income whose effects are studied	Instrument used	Effect of income on human capital investments
Mulligan & Stable (2011)	Rural Income Maintenance Experiment (North Carolina and Iowa)	Multiple schooling outcomes	Yearly family income during childhood and preadolescence (ages 7–14, grades 2–8)	No	No	Child-related tax benefits and income transfers	Variation in benefits eligibility	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.
Morris & Genietian (2003)	Multiple sources on families involved in the MFIP	Multiple schooling and behavioral outcomes	Yearly family income during childhood (ages 2–9)	No	Yes	Total family income	Experimental assignment	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-year 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 setup unfortunately not used by the authors). These results also cast doubt on the validity of the conclusions from the mean differences analysis on the same data of Genietian & Miller (2002).

^aThis 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. 2006b 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; GMS, Great Smoky Mountains Study of Youth; IV, instrumental variables; MFIP, Minnesota Family Investment Program; 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 2 Studies of credit constraints

Study	Data set	Outcome studied	Timing of income (developmental stage of the child at which income effects are studied)	Explicit dynamic model?	Who is affected by constraints	Method to test for credit constraints	Finds presence of credit constraints?	Effect of income or constraints on human capital investments
Keane & Wolpin (2001)	NLSY79	Schooling and adult outcomes	Family income during adolescence (at age 16 or 17)	Yes	Agent/child	Structural estimation of the lower bound on asset level	Yes, but irrelevant for schooling decisions	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 \$0.20 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.
Cameron & Taber (2004)	NLSY79	Schooling outcomes	Family income during adolescence (at age 16 or 17)	No	Agent/child	IV estimation of returns to schooling using costs of schooling or foregone earnings as instruments	No	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.

(Continued)

Table 2 (Continued)

Study	Data set	Outcome studied	Timing of income (developmental stage of the child at which income effects are studied)	Explicit dynamic model?	Who is affected by constraints	Method to test for credit constraints	Finds presence of credit constraints?	Effect of income or constraints on human capital investments
Caucutt & Lochner (2012)	NLSY79, C-NLSY79	Test scores and schooling outcomes	Family income during childhood and adolescence (ages 0–23)	Yes	Parent of the agent	Structural estimation of the lower bound on asset level	Yes; stronger effect on high-skilled parents	50% of young parents are constrained: high school dropouts (50%), high school graduates (38%), 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.

Abbreviations: C-NLSY79, Children on the National Longitudinal Survey of Youth 1979; IV, instrumental variables; NLSY79, National Longitudinal Survey of Youth 1979; NLSY97, National Longitudinal Survey of Youth 1997.

during childhood (this evidence is reviewed in section A of the **Supplemental 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 (see **Supplemental Figures A.2 and A.3**). 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.

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 & 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 θ_P in the technology of skill formation affects the level of investment in children and the initial condition θ_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 θ_P and I), and children cannot insure against these aspects of the environment.³⁴

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 & Heckman (2002), Keane & Wolpin (2001), and Cameron & Taber (2004) find little evidence of an important role for credit constraints in access to college education.³⁵ Carneiro & 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.³⁶ Cameron & 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 & Lochner (2007), Bailey & Dynarski (2011), and Lochner & Monge-Naranjo (2012) claim that in later cohorts [in the National Longitudinal Survey of Youth 1997 (NLSY97)], there is stronger evidence of credit constraints as captured by the estimated effects of quantiles of family

³⁴Aiyagari et al. (2002) present an analysis of full insurances against the *accident of birth*.

³⁵Keane & Wolpin (2001) provide evidence for constraints affecting other dimensions of behavior, such as labor supply.

³⁶Carneiro & 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.

income (from whatever source) on college participation. The Belley & Lochner (2007) test of credit constraints is different from the one used in Keane & Wolpin (2001) or Cameron & Taber (2004). Belley & Lochner update the NLSY79 analysis of Carneiro & 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 (see **Supplemental Figures H.1–H.3**).

Belley & 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 disproportionate share of the increase in family income, their results are readily explained.³⁷

Children with low-ability, but affluent parents are more likely to enroll in college. The estimates of Keane & Wolpin (2001) suggest that the source of the intergenerational correlation of school attainment results from more educated parents making larger 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.³⁸ Low-income parents with low-ability children do not provide the same tied transfers to their children that more affluent parents provide. 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 θ_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 & 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.³⁹ The magnitude of their reported estimated effect of

³⁷Belley & 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.

³⁸Alternatively, parents may prefer in-kind transfers to cash transfers to avoid the Samaritan’s dilemma (Buchanan 1975).

³⁹Some 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.

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 expects 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 & Keane (2010) suggests that maternal working time has substantial effects on child test scores. Dahl & 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 & 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 control 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 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.

Duncan et al. (2011) report estimates from 16 different program/site combinations. Fourteen programs/sites show no effect of income on child test scores. The two statistically significant estimates they report are 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 the SSP, although they do not reject it at a third site or in 13 other programs/sites they examine. Thus, in 14 of the 16 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 2 out of 16 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 14 statistically insignificant estimates to obtain an overall estimate. They compare this pooled estimate with the estimates from 13 programs/sites for which no effect is found and test and do not reject the equality of the two estimates. From this, they erroneously infer that the 13 programs/sites (all the ones located in the United States) for which no statistically significant effects of earnings on test scores are found support their inference from the SSP sites for which 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 is 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 & 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 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 & 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 & 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 controls 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 & Miller (2002) and Morris & 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 & 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 & 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 & 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 & 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 & 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 Caucutt & 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 & Lochner (2012) is an exception. They *calibrate* that a substantial fraction of the population is constrained owing 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. **Supplemental Table K.4** 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 & Lochner 2012, Cunha 2007, Cunha & 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 & Lochner 2012, Del Boca et al. 2014). Lee & 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 & 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 (see, however, Becker & Barro 1988, Del Boca et al. 2014, Gayle et al. 2013). The average family usually has more than one child, and society allocates public investments across multiple children.

The problem of intrachild allocations is sometimes formulated as a problem in fairness. A constant elasticity of substitution (CES) representation of parental utility V is often used:

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

V_k represents the adult outcome for child k that is valued by parents.⁴⁰ The ω_k are weights assigned to each child, and σ 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 $\sigma \rightarrow -\infty$, 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 & 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 ω_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. Thus, in a multiperiod model, where at stage t

$$\theta_{t+1} = f^{(t)}(\theta_t, I_t), \quad (11)$$


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 section D.7 in the **Supplemental Appendix**, 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 (for a proof, see section D.7 of the **Supplemental Appendix**). 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-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

⁴⁰Behrman et al. (1982) introduced this formulation into the literature.

 Supplemental Material

advantage of this opportunity. The weaker is the first-period complementarity $\left[f_{12}^{(1)}(\cdot) \right]$, the less offsetting is the disequalizing 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.

Section D.8 in the **Supplemental Appendix** illustrates these general features for CES technologies with different patterns of concavity and complementarity. We review the literature on multichild investment in section D.9 of the **Supplemental Appendix**.

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 (Equation 2) and technology equations (Equation 4) are nonparametrically 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.⁴¹ 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 1** plots the probability and the return⁴² of enrolling in college immediately after having graduated high school as a function of the deciles of scalar summaries of cognitive and noncognitive skills.⁴³

⁴¹Cunha 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 & Heckman 2008, Cunha et al. 2010).

⁴²The return is calculated over a 65-year-long working life. Life-cycle earning profiles are simulated using the estimated parameters (see Eisenhauer et al. 2014 for a precise description of the model, data, and computations).

⁴³Section E of the **Supplemental Appendix** presents a variety of other plots based on the same low-dimensional measures of capability.

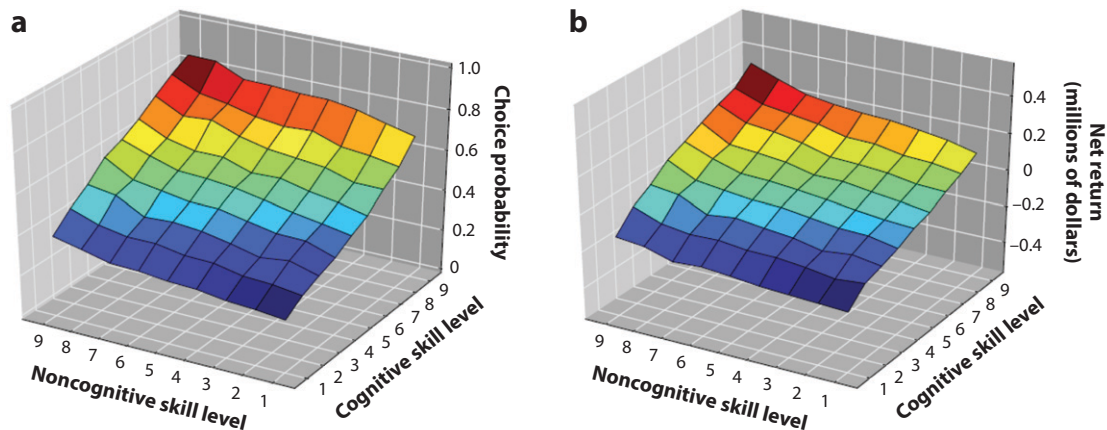


Figure 1

The (a) probability and (b) returns of college enrollment by endowment levels. College enrollment refers to the individuals who enroll in college immediately after having finished high school. Returns are expressed in units of millions of 2005 dollars. Higher deciles correspond to higher levels. Readers are referred to Eisenhauer et al. (2014) for greater details. Figure adapted with permission from Eisenhauer et al. (2014).

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 **Supplemental Table F.1**. Most of the literature estimates models only for cognitive skills.⁴⁴ Cunha & 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.⁴⁵

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 (ages 0–4 and ages 5–14) and two skills (cognitive and noncognitive skills) with skill measures anchored in outcomes.⁴⁶

Cunha et al.'s (2010) model explains 34% of the variance of educational attainment by measures of cognitive and noncognitive skills.⁴⁷ They find that self-productivity becomes stronger as children become older, for both cognitive and noncognitive skills (i.e., $\partial\theta_{t+1}/\partial\theta_t \uparrow t$).⁴⁸ 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

⁴⁴Section F of the **Supplemental Appendix** presents a detailed summary of the specifications and estimates of the technology of skill formation listed in **Supplemental Table F.1**. There we compare the estimates of self- and cross productivity and the productivity of investment (of each type).

⁴⁵Shakotko 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.


⁴⁶As 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 & Heckman 2008, Cunha et al. 2010).

⁴⁷Cunha et al. (2010) find substantial evidence of measurement error and show the importance of accounting for it.

⁴⁸This is consistent with earlier findings by Cunha (2007) and Cunha & Heckman (2008).

consistent with emerging dynamic complementarity.⁴⁹ 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 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 5. For a more extensive discussion of these results, readers are referred to Cunha & Heckman (2009) and the **Supplemental Appendix**, section F.

 **Supplemental Material**

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 & 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.

Supplemental Table I.1 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 adolescent 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

⁴⁹This is also found in Cunha (2007) and Cunha & Heckman (2008).

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 article facilitates understanding of the mechanisms producing treatment effects by distinguishing the effect of interventions on the vector of skills θ_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.⁵⁰ 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 through the enhancement of noncognitive skills.⁵¹ 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 and 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.

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

⁵⁰The 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 section I.1.2 of the **Supplemental Appendix**.) It has a rate of return of 7–10% per year for boys and girls, analyzed separately (Heckman et al. 2010a,b).

⁵¹The program and the decomposition are presented in section I.1.2 of the **Supplemental Appendix** (see **Supplemental Table I.2** and **Supplemental Figures I.1–I.5**).

successful parents do.⁵² 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 the **Supplemental Appendix**, section 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 **Supplemental Appendix** presents evidence for some major early childhood programs on 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; see the **Supplemental Appendix**, section I.1), changing parental preferences, and the responses of parents to the enhanced curiosity and engagement of the child induced by participation in the program.⁵³

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.⁵⁴

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

⁵²This is consistent with the wisdom of John Dewey summarized in the **Supplemental Appendix**, section N.

⁵³Cole 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).

⁵⁴Heckman & Kautz (2014) discuss the evidence on the effectiveness of the Nurse Family Partnership program and provide detailed references to numerous evaluation studies.

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 & Cox 2011).

8.3. Toward 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—the child's ability to shape his or her own environment, including the learning environment. As children mature, they generally make wiser choices.⁵⁵

Akabayashi (2006) provides one of few examples of a model of parent-child interactions and parental learning in the literature (we summarize this literature in **Supplemental Table K.5**). 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 or her performances and incentivizes effort by choosing the quality of interactions (praise or 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.

⁵⁵Even classical liberals such as Mill (1859) grant a role for informal paternalism on the part of the parents.

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 or her 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 & 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 or she learns about his or her ability, and this has long-term benefits. If the child is helped to avoid failure owing to deficiencies in his or her 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 correlation 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.⁵⁶

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 scaffolding that have long been associated with the successful process in human development (see Sroufe et al. 2005, Vygotskii 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 article 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

⁵⁶The model of multiple children presented in Section 5 can rationalize the evidence on limited impacts of common family influences. Child investment is individualized for reasons of both equity and efficiency.

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.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

ACKNOWLEDGMENTS

This research was supported in part by the American Bar Foundation, the Pritzker Children's Initiative, the Buffett Early Childhood Fund, NICHD R37HD065072, R01HD054702, the Human Capital and Economic Opportunity Global Working Group (an initiative of the Becker Friedman Institute for Research in Economics) funded by the Institute for New Economic Thinking (INET), and an anonymous funder. We also acknowledge the support of a European Research Council grant hosted by the University College Dublin (DEVHEALTH 269874). The views expressed in this article are those of the authors and not necessarily those of the funders or commentators mentioned here. We thank Hideo Akabayashi, Gary Becker, Alberto Bisin, Marco Cosconati, Flavio Cunha, Greg Duncan, Steve Durlauf, Chris Flinn, Lance Lochner, Magne Mogstad, Derek Neal, Robert Pollak, Ananth Seshadri, and Kitty Stewart for helpful comments. We thank Will Burgo, Jorge Luis García G. Menéndez, and Linor Kiknadze for exceptional research assistance.

LITERATURE CITED

- Aiyagari SR, Greenwood J, Seshadri A. 2002. Efficient investment in children. *J. Econ. Theory* 102:290–321
- Akabayashi H. 2006. An equilibrium model of child maltreatment. *J. Econ. Dyn. Control* 30:993–1025
- Akee RKQ, Copeland W, Keeler G, Angold A, Costello EJ. 2010. Parents' incomes and children's outcomes: a quasi-experiment using transfer payments from casino profits. *Am. Econ. J. Appl. Econ.* 2:86–115
- Almlund M. 2013. *Essays on credit constraints, education, and the family*. PhD Thesis, Dep. Econ., Univ. Chicago
- Almlund M, Duckworth A, Heckman JJ, Kautz T. 2011. Personality psychology and economics. In *Handbook of the Economics of Education*, Vol. 4, ed. EA Hanushek, S Machin, L Wößmann, pp. 1–181. Amsterdam: Elsevier

- Almond D, Currie J. 2011. Human capital development before age five. In *Handbook of Labor Economics*, Vol. 4B, ed. OC Ashenfelter, D Card, pp. 1315–486. Amsterdam: Elsevier
- Anderson TW, Rubin H. 1956. Statistical inference in factor analysis. In *Proceedings of the Third Berkeley Symposium on Mathematical Statistics and Probability*, Vol. 5: *Econometrics, Industrial Research, and Psychometry*, ed. J Neyman, pp. 111–50. Berkeley: Univ. Calif. Press
- Attanasio OP, Browning M. 1995. Consumption over the life cycle and over the business cycle. *Am. Econ. Rev.* 85:1118–37
- Bailey MJ, Dynarski SM. 2011. *Gains and gaps: changing inequality in U.S. college entry and completion*. NBER Work. Pap. 17633
- Barker DJP. 1990. The fetal and infant origins of adult disease. *BMJ* 301:1111
- Baumrind D. 1968. Authoritarian vs. authoritative parental control. *Adolescence* 3:255–72
- Becker GS, Barro RJ. 1988. A reformulation of the economic theory of fertility. *Q. J. Econ.* 103:1–25
- Becker GS, Mulligan CB. 1997. The endogenous determination of time preference. *Q. J. Econ.* 112:729–58
- Becker GS, Murphy KM, Spenkuch JL. 2012. *The manipulation of children's preferences, old age support, and investment in children's human capital*. Unpublished manuscript, Dep. Econ., Univ. Chicago
- Becker GS, Tomes N. 1979. An equilibrium theory of the distribution of income and intergenerational mobility. *J. Polit. Econ.* 87:1153–89
- Becker GS, Tomes N. 1986. Human capital and the rise and fall of families. *J. Labor Econ.* 4:S1–39
- Behrman JR, Pollak RA, Taubman PJ. 1982. Parental preferences and provision of progeny. *J. Polit. Econ.* 90:52–73
- Belley P, Lochner L. 2007. The changing role of family income and ability in determining educational achievement. *J. Hum. Cap.* 1:37–89
- Ben-Porath Y. 1967. The production of human capital and the life cycle of earnings. *J. Polit. Econ.* 75:352–65
- Bernal R. 2008. The effect of maternal employment and child care on children's cognitive development. *Int. Econ. Rev.* 49:1173–209
- Bernal R, Keane MP. 2010. Quasi-structural estimation of a model of childcare choices and child cognitive ability production. *J. Econom.* 156:164–89
- Bernal R, Keane MP. 2011. Child care choices and children's cognitive achievement: the case of single mothers. *J. Labor Econ.* 29:459–512
- Bettinger EP, Long BT, Oreopoulos P, Sanbonmatsu L. 2012. The role of application assistance and information in college decisions: results from the H&R Block FAFSA experiment. *Q. J. Econ.* 127:1205–42
- Bisin A, Verdier T. 2001. The economics of cultural transmission and the dynamics of preferences. *J. Econ. Theory* 97:298–319
- Black SE, Devereux PJ. 2011. Recent developments in intergenerational mobility. In *Handbook of Labor Economics*, Vol. 4B, ed. OC Ashenfelter, D Card, pp. 1487–541. Amsterdam: Elsevier
- Borghans L, Duckworth AL, Heckman JJ, ter Weel B. 2008a. The economics and psychology of personality traits. *J. Hum. Resour.* 43:972–1059
- Borghans L, Golsteyn BHH, Heckman JJ, Humphries JE. 2011a. Identification problems in personality psychology. *Pers. Individ. Differ.* 51:315–20
- Borghans L, Golsteyn BHH, Heckman JJ, Humphries JE. 2011b. *IQ, achievement, and personality*. Unpublished manuscript, Univ. Maastricht, Univ. Chicago
- Borghans L, Meijers H, ter Weel B. 2008b. The role of noncognitive skills in explaining cognitive test scores. *Econ. Inq.* 46:2–12
- Bowles S, Gintis H, Osborne M. 2001. The determinants of earnings: a behavioral approach. *J. Econ. Lit.* 39:1137–76
- Browning M, Hansen LP, Heckman JJ. 1999. Micro data and general equilibrium models. In *Handbook of Macroeconomics*, Vol. 1A, ed. JB Taylor, M Woodford, pp. 543–633. Amsterdam: Elsevier
- Buchanan JM. 1975. The Samaritan's dilemma. In *Altruism, Morality, and Economic Theory*, ed. E Phelps, pp. 71–85. New York: Russell Sage Found.
- Campbell F, Conti G, Moon S, Pungello E, Pinto R, Pan Y. 2014. Early childhood investments substantially boost adult health. *Science* 343:1478–85

- Cameron SV, Heckman JJ. 2001. The dynamics of educational attainment for black, Hispanic, and white males. *J. Polit. Econ.* 109:455–99
- Cameron SV, Taber C. 2004. Estimation of educational borrowing constraints using returns to schooling. *J. Polit. Econ.* 112:132–82
- Card D. 1999. The causal effect of education on earnings. In *Handbook of Labor Economics*, Vol. 3A, ed. OC Ashenfelter, D Card, pp. 1801–63. Amsterdam: Elsevier
- Card D. 2001. Estimating the return to schooling: progress on some persistent econometric problems. *Econometrica* 69:1127–60
- Carneiro P, Heckman JJ. 2002. The evidence on credit constraints in post-secondary schooling. *Econ. J.* 112:705–34
- Carneiro P, Heckman JJ. 2003. Human capital policy. In *Inequality in America: What Role for Human Capital Policies?*, ed. JJ Heckman, AB Krueger, BM Friedman, pp. 77–239. Cambridge, MA: MIT Press
- Carneiro P, Heckman JJ, Vytlačil EJ. 2011. Estimating marginal returns to education. *Am. Econ. Rev.* 101:2754–81
- Carneiro P, Lopez Garcia I, Salvanes KG, Tominey E. 2013. *Intergenerational mobility and the timing of parental income*. Presented at CESifo Area Conf. Econ. Educ., Munich
- Carrell SE, Sacerdote B. 2013. *Late interventions matter too: the case of college coaching in New Hampshire*. NBER Work. Pap. 19031
- Caucutt EM, Lochner L. 2012. *Early and late human capital investments, borrowing constraints, and the family*. NBER Work. Pap. 18493
- Chan TW, Koo A. 2011. Parenting style and youth outcomes in the UK. *Eur. Sociol. Rev.* 27:385–99
- Cole SW, Conti G, Arevalo JMG, Ruggiero AM, Heckman JJ, Suomi SJ. 2012. Transcriptional modulation of the developing immune system by early life social adversity. *Proc. Natl. Acad. Sci. USA* 109:20578–83
- Conti G, Hansman C, Heckman JJ, Novak MF, Ruggiero A, Suomi SJ. 2012. Primate evidence on the late health effects of early-life adversity. *Proc. Natl. Acad. Sci. USA* 109:8866–71
- Conti G, Heckman J, Moon S, Pinto R. 2014. The long-term health effects of early childhood interventions. *Econ. J.* Manuscript under revision
- Cook PJ, Dodge K, Farkas G, Fryer RGJ, Guryan J, et al. 2014. *The (surprising) efficacy of academic and behavioral intervention with disadvantaged youth: results from a randomized experiment in Chicago*. NBER Work. Pap. 19862
- Cooper K, Stewart K. 2013. *Does money affect children's outcomes? A systematic review*. Rep., Joseph Rowntree Found., York
- Cosconati M. 2013. *Optimal parenting styles: evidence from a dynamic model with multiple equilibria*. Tech. Rep., Bank Italy, Rome
- Cunha F. 2007. *An essay on skill formation*. PhD Thesis, Univ. Chicago
- Cunha F. 2013. Investments in children when markets are incomplete. *Rev. Econ. Stud.* Manuscript under revision
- Cunha F, Elo I, Culhane J. 2013. *Eliciting maternal expectations about the technology of cognitive skill formation*. NBER Work. Pap. 19144
- Cunha F, Heckman JJ. 2007. The technology of skill formation. *Am. Econ. Rev.* 97:31–47
- Cunha F, Heckman JJ. 2008. Formulating, identifying and estimating the technology of cognitive and noncognitive skill formation. *J. Hum. Resour.* 43:738–82
- Cunha F, Heckman JJ. 2009. The economics and psychology of inequality and human development. *J. Eur. Econ. Assoc.* 7:320–64
- Cunha F, Heckman JJ, Lochner L, Masterov DV. 2006. Interpreting the evidence on life cycle skill formation. In *Handbook of the Economics of Education*, Vol. 1, ed. EA Hanushek, F Welch, pp. 697–812. Amsterdam: Elsevier
- Cunha F, Heckman JJ, Navarro S. 2005. Separating uncertainty from heterogeneity in life cycle earnings. The 2004 Hicks Lecture. *Oxf. Econ. Pap.* 57:191–261
- Cunha F, Heckman JJ, Schennach SM. 2010. Estimating the technology of cognitive and noncognitive skill formation. *Econometrica* 78:883–931
- Dahl GB, Lochner L. 2012. The impact of family income on child achievement: evidence from the Earned Income Tax Credit. *Am. Econ. Rev.* 102:1927–56

- Deci EL, Ryan RM. 1985. *Intrinsic Motivation and Self-Determination in Human Behavior*. New York: Plenum
- Del Boca D, Flinn C, Wiswall M. 2012. *Transfers to Households with Children and Child Development*. Moncalieri Torino, Italy: Coll. Carlo Alberto
- Del Boca D, Flinn C, Wiswall M. 2014. Household choices and child development. *Rev. Econ. Stud.* 81:137–85
- Doepke M, Zilibotti F. 2012. *Parenting with style: altruism and paternalism in intergenerational preference transmission*. IZA Discuss. Pap. 7108, Inst. Study Labor, Bonn
- Dohmen T, Falk A, Huffman D, Sunde U. 2010. Are risk aversion and impatience related to cognitive ability? *Am. Econ. Rev.* 100:1238–60
- Dohmen T, Falk A, Huffman D, Sunde U, Schupp J, Wagner GG. 2011. Individual risk attitudes: measurement, determinants and behavioral consequences. *J. Eur. Econ. Assoc.* 9:522–50
- Duckworth K, Duncan GJ, Kokko K, Lyyra AL, Metzger M, Simonton S. 2012. *The relative importance of adolescent skills and behaviors for adult earnings: a cross-national study*. Work. Pap. 12-03, Dep. Quant. Soc. Sci., Univ. London
- Duncan GJ, Morris PA, Rodrigues C. 2011. Does money really matter? Estimating impacts of family income on young children’s achievement with data from random-assignment experiments. *Dev. Psychol.* 47:1263–79
- Duncan GJ, Yeung WJ, Brooks-Gunn J, Smith JR. 1998. How much does childhood poverty affect the life chances of children? *Am. Sociol. Rev.* 63:406–23
- Eisenhauer P, Heckman J, Mosso S. 2014. Estimation of dynamic discrete choice models by maximum likelihood and the simulated method of moments. *Int. Econ. Rev.* Manuscript under review
- Fernald A, Marchman VA, Weisler A. 2013. SES differences in language processing skill and vocabulary are evident at 18 months. *Dev. Sci.* 16:234–48
- Foster JE. 2011. Freedom, opportunity, and well-being. In *Handbook of Social Choice and Welfare*, Vol. 2, ed. KJ Arrow, AK Sen, K Suzumura, pp. 687–728. Amsterdam: Elsevier
- Fried HO, Lovell CAK, Schmidt SS. 2008. *The Measurements of Productive Efficiency and Productivity Growth*. New York: Oxford Univ. Press
- Gayle GL, Golan L, Soyta MA. 2013. *What accounts for the racial gap in time allocation and intergenerational transmission of human capital?* Unpublished manuscript, Dep. Econ., Wash. Univ., St. Louis
- Gelber AM, Isen A. 2013. Children’s schooling and parents’ behavior: evidence from the Head Start Impact Study. *J. Public Econ.* 101:25–38
- Gennetian L, Miller C. 2002. Children and welfare reform: a view from an experimental welfare program in Minnesota. *Child Dev.* 73:601–20
- Gluckman PD, Hanson MA. 2004. Developmental origins of disease paradigm: a mechanistic and evolutionary perspective. *Pediatr. Res.* 56:311–17
- Gluckman PD, Hanson M. 2005. *The Fetal Matrix: Evolution, Development, and Disease*. Cambridge, UK: Cambridge Univ. Press
- Gluckman PD, Hanson MA. 2006. *Developmental Origins of Health and Disease*. Cambridge, UK: Cambridge Univ. Press
- Gottlieb G. 1999. *Probabilistic Epigenesis and Evolution*. Worcester, MA: Clark Univ. Press
- Griffin M, Heckman JJ, Moon SH. 2013. *Preschool curricula*. Unpublished manuscript, Dep. Econ., Univ. Chicago
- Hales CN, Barker DJP. 1992. Type 2 (non-insulin-dependent) diabetes mellitus: the thrifty phenotype hypothesis. *Diabetologia* 35:595–601
- Harris JR. 2009. *The Nurture Assumption: Why Children Turn Out the Way They Do*. New York: Free
- Hart B, Risley TR. 1995. *Meaningful Differences in the Everyday Experience of Young American Children*. Baltimore, MD: P.H. Brookes
- Heckman JJ. 2008. Schools, skills and synapses. *Econ. Inq.* 46:289–324
- Heckman JJ, Humphries JE, Veramendi G, Urzúa S. 2014. Education, health, and wages. *J. Polit. Econ.* Manuscript under review
- Heckman JJ, Kautz T. 2012. Hard evidence on soft skills. *Labour Econ.* 19:451–64
- Heckman JJ, Kautz T. 2014. Fostering and measuring skills interventions that improve character and cognition. In *The GED Myth: Education, Achievement Tests, and the Role of Character in American Life*, ed. JJ Heckman, JE Humphries, T Kautz, pp. 341–430. Chicago: Univ. Chicago Press

- Heckman JJ, LaLonde RJ, Smith JA. 1999. The economics and econometrics of active labor market programs. In *Handbook of Labor Economics*, Vol. 3A, ed. OC Ashenfelter, D Card, pp. 1865–2097. Amsterdam: Elsevier
- Heckman JJ, Lochner LJ, Cossa R. 2003. Learning-by-doing versus on-the-job training: using variation induced by the EITC to distinguish between models of skill formation. In *Designing Social Inclusion: Tools to Raise Low-End Pay and Employment in Private Enterprise*, ed. ES Phelps, pp. 74–130. Cambridge, UK: Cambridge Univ. Press
- Heckman JJ, Lochner LJ, Todd PE. 2006a. Earnings equations, rates of return and treatment effects: the Mincer equation and beyond. In *Handbook of the Economics of Education*, Vol. 1, ed. EA Hanushek, F Welch, pp. 307–458. Amsterdam: Elsevier
- Heckman JJ, Moon SH, Pinto R, Savelyev PA, Yavitz A. 2010a. The rate of return to the HighScope Perry Preschool Program. *J. Public Econ.* 94:114–28
- Heckman JJ, Moon SH, Pinto R, Savelyev PA, Yavitz AQ. 2010b. Analyzing social experiments as implemented: a reexamination of the evidence from the HighScope Perry Preschool Program. *Quant. Econ.* 1:1–46
- Heckman JJ, Pinto R, Savelyev PA. 2013. Understanding the mechanisms through which an influential early childhood program boosted adult outcomes. *Am. Econ. Rev.* 103:2052–86
- Heckman JJ, Sedlacek G. 1985. Heterogeneity, aggregation and market wage functions: an empirical model of self-selection in the labor market. *J. Polit. Econ.* 93:1077–125
- Heckman JJ, Urzúa S, Vytlacil EJ. 2006b. Understanding instrumental variables in models with essential heterogeneity. *Rev. Econ. Stat.* 88:389–432
- Hotz VJ, Pantano J. 2013. *Strategic parenting, birth order and school performance*. NBER Work. Pap. 19542
- Huggett M, Ventura G, Yaron A. 2011. Sources of lifetime inequality. *Am. Econ. Rev.* 101:2923–54
- Jablonka E, Raz G. 2009. Transgenerational epigenetic inheritance: prevalence, mechanisms, and implications for the study of heredity and evolution. *Q. Rev. Biol.* 84:131–76
- Jackson CK. 2013. *Non-cognitive ability, test scores, and teacher quality: evidence from 9th grade teachers in North Carolina*. NBER Work. Pap. 18624
- Kalil A. 2013. *Inequality begins at home: the role of parenting in the diverging destinies of rich and poor children*. Unpublished manuscript, Harris Sch. Public Policy, Univ. Chicago
- Keane MP, Wolpin KI. 1997. The career decisions of young men. *J. Polit. Econ.* 105:473–522
- Keane MP, Wolpin KI. 2001. The effect of parental transfers and borrowing constraints on educational attainment. *Int. Econ. Rev.* 42:1051–103
- Knudsen EI, Heckman JJ, Cameron JL, Shonkoff JP. 2006. Economic, neurobiological, and behavioral perspectives on building America’s future workforce. *Proc. Natl. Acad. Sci. USA* 103:10155–62
- Kohler HP, Behrman JR, Schnittker J. 2011. Social science methods for twins data: integrating causality, endowments, and heritability. *Biodemogr. Soc. Biol.* 57:88–141
- Kreps DM. 1979. A representation theorem for “preference for flexibility.” *Econometrica* 47:565–77
- Krueger RF, Johnson W. 2008. Behavioral genetics and personality: a new look at the integration of nature and nurture. In *Handbook of Personality: Theory and Research*, ed. OP John, RW Robins, LA Pervin, pp. 287–310. New York: Guilford. 3rd ed.
- Kuzawa CW, Quinn EA. 2009. Developmental origins of adult function and health: evolutionary hypotheses. *Annu. Rev. Anthropol.* 38:131–47
- Lareau A. 2011. *Unequal Childhoods: Class, Race, and Family Life*. Berkeley: Univ. Calif. Press. 2nd ed.
- Lareau A, Cox A. 2011. Social class and the transition to adulthood: differences in parents’ interactions with institutions. In *Social Class and Changing Families in an Unequal America*, ed. MJ Carlson, P England, pp. 134–64. Stanford, CA: Stanford Univ. Press
- Lee SY, Seshadri A. 2014. *On the intergenerational transmission of economic status*. Unpublished manuscript, Dep. Econ., Univ. Wisconsin–Madison
- Lizzeri A, Siniscalchi M. 2008. Parental guidance and supervised learning. *Q. J. Econ.* 123:1161–95
- Lochner L, Monge-Naranjo A. 2012. Credit constraints in education. *Annu. Rev. Econ.* 4:225–56
- Loken KV. 2010. Family income and children’s education: using the Norwegian oil boom as a natural experiment. *Labour Econ.* 17:118–29

- Loken KV, Mogstad M, Wiswall M. 2012. What linear estimators miss: the effects of family income on child outcomes. *Am. Econ. J. Appl. Econ.* 4:1–35
- Loury GC. 1981. Intergenerational transfers and the distribution of earnings. *Econometrica* 49:843–67
- Mallar C. 1977. The educational and labor supply responses of young adults on the urban graduated work incentive experiment. In *The New Jersey Income Maintenance Experiment*, ed H Watts, A Rees, pp. 163–84. New York: Academic
- Maynard RA. 1977. The effects of the Rural Income Maintenance Experiment on the school performance of children. *Am. Econ. Rev.* 67:370–75
- Maynard RA, Murnane RJ. 1979. Effects of a negative income tax on school performance: results of an experiment. *J. Hum. Resour.* 14:463–76
- Mill JS. 1859. *On Liberty*. London: J.W. Parker & Son
- Milligan K, Stabile M. 2011. Do child tax benefits affect the well-being of children? Evidence from Canadian child benefit expansions. *Am. Econ. J. Econ. Policy* 3:175–205
- Moon SH. 2014. *Multi-dimensional human skill formation with multi-dimensional parental investment*. Unpublished manuscript, Dep. Econ., Univ. Chicago
- Morris P, Gennetian L. 2003. Identifying the effects of income on children’s development: using experimental data. *J. Marriage Fam.* 65:716–29
- Mullainathan S, Shafir E. 2013. *Scarcity: Why Having Too Little Means So Much*. New York: Times Books
- Nisbett RE, Aronson J, Blair C, Dickens W, Flynn J, et al. 2012. Intelligence: new findings and theoretical developments. *Am. Psychol.* 67:130–59
- Nussbaum MC. 2011. *Creating Capabilities: The Human Development Approach*. Cambridge, MA: Harvard Univ. Press
- Piatek R, Pinger P. 2010. *Maintaining (locus of) control? Assessing the impact of locus of control on education decisions and wages*. IZA Discuss. Pap. 5289, Inst. Study Labor, Bonn
- Pop-Eleches C, Urquiola M. 2013. Going to a better school: effects and behavioral responses. *Am. Econ. Rev.* 103:1289–324
- Rees AA. 1977. The labor supply results of the experiment: a summary. In *The New Jersey Income Maintenance Experiment*, ed H Watts, A Rees, pp. 5–32. New York: Academic
- Rubinstein Y, Weiss Y. 2006. Post schooling wage growth: investment, search and learning. In *Handbook of the Economics of Education*, Vol. 1, ed E Hanushek, F Welch, pp. 1–67. Amsterdam: Elsevier
- Rutter M. 2006. *Genes and Behavior: Nature–Nurture Interplay Explained*. Malden, MA: Blackwell
- Rutter M, Sonuga-Barke EJ, Beckett C, Castle J, Kreppner J, et al. 2010. *Deprivation-Specific Psychological Patterns: Effects of Institutional Deprivation*. Malden, MA: Blackwell
- Ryan RM, Deci EL. 2000. Intrinsic and extrinsic motivations: classic definitions and new directions. *Contemp. Educ. Psychol.* 25:54–67
- Sen A. 1985. *Commodities and Capabilities*. Amsterdam: North-Holland
- Shakotko RA, Edwards LN, Grossman M. 1981. An exploration of the dynamic relationship between health and cognitive development in adolescence. In *Health, Economics, and Health Economics: Proceedings of the World Congress on Health Economics, Leiden, The Netherlands, September 1980*, ed J van der Gaag, M Perlman, pp. 305–28. Amsterdam: North-Holland
- Solon G. 2004. A model of intergenerational mobility variation over time and place. In *Generational Income Mobility in North America and Europe*, ed M Corak, pp. 38–47. Cambridge, UK: Cambridge Univ. Press
- Sroufe LA, Egeland B, Carlson EA, Collins WA. 2005. *The Development of the Person: The Minnesota Study of Risk and Adaptation from Birth to Adulthood*. New York: Guilford
- Steinberg L. 2007. Risk taking in adolescence: new perspectives from brain and behavioral science. *Curr. Dir. Psychol. Sci.* 16:55–59
- Steinberg L. 2008. A social neuroscience perspective on adolescent risk-taking. *Dev. Rev.* 28:78–106
- Suomi SJ. 1999. Attachment in rhesus monkeys. In *Handbook of Attachment: Theory, Research, and Clinical Applications*, ed J Cassidy, PR Shaver, pp. 181–97. New York: Guilford
- Thaler RH, Mullainathan S, Kahneman D. 2008. *A short course in behavioral economics*. Edge Master Class. http://www.edge.org/3rd_culture/thaler_sendhil08/thaler_sendhil_index.html

- Thompson RA, Nelson CA. 2001. Developmental science and the media: early brain development. *Am. Psychol.* 56:5–15
- Tucker-Drob EM, Harden KP, Turkheimer E. 2009. Combining nonlinear biometric and psychometric models of cognitive abilities. *Behav. Genet.* 39:461–71
- Turkheimer E, Haley A, Waldron M, D’Onofrio B, Gottesman II. 2003. Socioeconomic status modifies heritability of IQ in young children. *Psychol. Sci.* 14:623–28
- Vygotskii LS. 1978. *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard Univ. Press
- Williams B. 2012. *Latent variable models*. PhD Thesis, Dep. Econ., Univ. Chicago



Contents

Probabilistic Expectations in Developing Countries <i>Adeline Delavande</i>	1
Ill-Posed Inverse Problems in Economics <i>Joel L. Horowitz</i>	21
Financing Old Age Dependency <i>Shinichi Nishiyama and Kent Smetters</i>	53
Recent Developments in Empirical Likelihood and Related Methods <i>Paulo M.D.C. Parente and Richard J. Smith</i>	77
Belief Elicitation in the Laboratory <i>Andrew Schotter and Isabel Trevino</i>	103
Models of Caring, or Acting as if One Cared, About the Welfare of Others <i>Julio J. Rotemberg</i>	129
Exchange Rate Stabilization and Welfare <i>Charles Engel</i>	155
Copulas in Econometrics <i>Yanqin Fan and Andrew J. Patton</i>	179
Firm Performance in a Global Market <i>Jan De Loecker and Pinelopi Koujianou Goldberg</i>	201
Applications of Random Set Theory in Econometrics <i>Ilya Molchanov and Francesca Molinari</i>	229
Experimental and Quasi-Experimental Analysis of Peer Effects: Two Steps Forward? <i>Bruce Sacerdote</i>	253
Coordination of Expectations: The Eductive Stability Viewpoint <i>Gabriel Desgranges</i>	273

From Sudden Stops to Fisherian Deflation: Quantitative Theory and Policy <i>Anton Korinek and Enrique G. Mendoza</i>	299
China's Great Convergence and Beyond <i>Kjetil Storesletten and Fabrizio Zilibotti</i>	333
Precocious Albion: A New Interpretation of the British Industrial Revolution <i>Morgan Kelly, Joel Mokyr, and Cormac Ó Gráda</i>	363
Disclosure: Psychology Changes Everything <i>George Loewenstein, Cass R. Sunstein, and Russell Golman</i>	391
Expectations in Experiments <i>Florian Wagener</i>	421
Optimal Design of Funded Pension Schemes <i>Lans Bovenberg and Roel Mehlkopf</i>	445
The Measurement of Household Consumption Expenditures <i>Martin Browning, Thomas F. Crossley, and Joachim Winter</i>	475
Empirical Revealed Preference <i>Ian Crawford and Bram De Rock</i>	503
Quality of Primary Care in Low-Income Countries: Facts and Economics <i>Jishnu Das and Jeffrey Hammer</i>	525
The Endowment Effect <i>Keith M. Marzilli Ericson and Andreas Fuster</i>	555
Decentralization in Developing Economies <i>Lucie Gadenne and Monica Singhal</i>	581
Local Labor Markets and the Evolution of Inequality <i>Dan A. Black, Natalia Kolesnikova, and Lowell J. Taylor</i>	605
People, Places, and Public Policy: Some Simple Welfare Economics of Local Economic Development Programs <i>Patrick Kline and Enrico Moretti</i>	629
Applying Insights from Behavioral Economics to Policy Design <i>Brigitte C. Madrian</i>	663
The Economics of Human Development and Social Mobility <i>James J. Heckman and Stefano Mosso</i>	689
Firms, Misallocation, and Aggregate Productivity: A Review <i>Hugo A. Hopenhayn</i>	735
Endogenous Collateral Constraints and the Leverage Cycle <i>Ana Fostel and John Geanakoplos</i>	771

Teacher Effects and Teacher-Related Policies <i>C. Kirabo Jackson, Jonah E. Rockoff, and Douglas O. Staiger</i>	801
Social Learning in Economics <i>Markus Mobius and Tanya Rosenblat</i>	827
Rethinking Reciprocity <i>Ulrike Malmendier, Vera L. te Velde, and Roberto A. Weber</i>	849
Symposium: The Institutional Underpinnings of Long-Run Income Differences	
Institutions, Human Capital, and Development <i>Daron Acemoglu, Francisco A. Gallego, and James A. Robinson</i>	875
Growth and the Smart State <i>Philippe Aghion and Alexandra Roulet</i>	913
The Causes and Consequences of Development Clusters: State Capacity, Peace, and Income <i>Timothy Besley and Torsten Persson</i>	927
Under the Thumb of History? Political Institutions and the Scope for Action <i>Abhijit V. Banerjee and Esther Duflo</i>	951

Indexes

Cumulative Index of Contributing Authors, Volumes 2–6	973
Cumulative Index of Article Titles, Volumes 2–6	976

Errata

An online log of corrections to *Annual Review of Economics* articles may be found at <http://www.annualreviews.org/errata/economics>



ANNUAL REVIEWS

It's about time. Your time. It's time well spent.

New From Annual Reviews:

Annual Review of Statistics and Its Application

Volume 1 • Online January 2014 • <http://statistics.annualreviews.org>

Editor: **Stephen E. Fienberg**, *Carnegie Mellon University*

Associate Editors: **Nancy Reid**, *University of Toronto*

Stephen M. Stigler, *University of Chicago*

The *Annual Review of Statistics and Its Application* aims to inform statisticians and quantitative methodologists, as well as all scientists and users of statistics about major methodological advances and the computational tools that allow for their implementation. It will include developments in the field of statistics, including theoretical statistical underpinnings of new methodology, as well as developments in specific application domains such as biostatistics and bioinformatics, economics, machine learning, psychology, sociology, and aspects of the physical sciences.

Complimentary online access to the first volume will be available until January 2015.

TABLE OF CONTENTS:

- *What Is Statistics?* Stephen E. Fienberg
- *A Systematic Statistical Approach to Evaluating Evidence from Observational Studies*, David Madigan, Paul E. Stang, Jesse A. Berlin, Martijn Schuemie, J. Marc Overhage, Marc A. Suchard, Bill Dumouchel, Abraham G. Hartzema, Patrick B. Ryan
- *The Role of Statistics in the Discovery of a Higgs Boson*, David A. van Dyk
- *Brain Imaging Analysis*, F. DuBois Bowman
- *Statistics and Climate*, Peter Guttorp
- *Climate Simulators and Climate Projections*, Jonathan Rougier, Michael Goldstein
- *Probabilistic Forecasting*, Tilmann Gneiting, Matthias Katzfuss
- *Bayesian Computational Tools*, Christian P. Robert
- *Bayesian Computation Via Markov Chain Monte Carlo*, Radu V. Craiu, Jeffrey S. Rosenthal
- *Build, Compute, Critique, Repeat: Data Analysis with Latent Variable Models*, David M. Blei
- *Structured Regularizers for High-Dimensional Problems: Statistical and Computational Issues*, Martin J. Wainwright
- *High-Dimensional Statistics with a View Toward Applications in Biology*, Peter Bühlmann, Markus Kalisch, Lukas Meier
- *Next-Generation Statistical Genetics: Modeling, Penalization, and Optimization in High-Dimensional Data*, Kenneth Lange, Jeanette C. Papp, Janet S. Sinsheimer, Eric M. Sobel
- *Breaking Bad: Two Decades of Life-Course Data Analysis in Criminology, Developmental Psychology, and Beyond*, Elena A. Erosheva, Ross L. Matsueda, Donatello Telesca
- *Event History Analysis*, Niels Keiding
- *Statistical Evaluation of Forensic DNA Profile Evidence*, Christopher D. Steele, David J. Balding
- *Using League Table Rankings in Public Policy Formation: Statistical Issues*, Harvey Goldstein
- *Statistical Ecology*, Ruth King
- *Estimating the Number of Species in Microbial Diversity Studies*, John Bunge, Amy Willis, Fiona Walsh
- *Dynamic Treatment Regimes*, Bibhas Chakraborty, Susan A. Murphy
- *Statistics and Related Topics in Single-Molecule Biophysics*, Hong Qian, S.C. Kou
- *Statistics and Quantitative Risk Management for Banking and Insurance*, Paul Embrechts, Marius Hofert

Access this and all other Annual Reviews journals via your institution at www.annualreviews.org.

ANNUAL REVIEWS | Connect With Our Experts

Tel: 800.523.8635 (US/CAN) | Tel: 650.493.4400 | Fax: 650.424.0910 | Email: service@annualreviews.org

