Article

Long-term Effects of Preschool on School Performance, Earnings and Social Mobility

Studies in Microeconomics
6(1–2) 24–49

SAGE Publications
sagepub.in/home.nav
DOI: 10.1177/2321022218802023
http://journals.sagepub.com/home/mic

Lakshmi Raut[1]

Abstract

Children from disadvantaged families perform very poorly in school and labour market because they acquire low level of social, motivational and cognitive skills during their early childhood development. Using the NLSY data set, this paper formulates and then estimates the production processes for cognitive skills and non-cognitive skills such as social and motivational skills during early childhood development and the long-term effects of these skills on learning and lifetime earnings of an individual. Using these estimated relationships, the paper provides a calibrated intergenerational altruistic model of parental investment in children's preschool. This dynamic model is then used to estimate the effects of publicly provided preschool to the children of poor socioeconomic status (SES) as a social contract on lifetime earnings distribution, intergenerational college and social mobility, and to estimate the tax burden of such a social contract.

Keywords

Preschool investment, early childhood development, augmented earnings function, social mobility, college mobility

JEL Classifications: J24, J62, O15, I21

Introduction

Since the 1980s, the income gap between the rich and the poor and the wage gap between the college-educated and the non-college-educated workers have been widening in the US. In many other countries, the trends in wage gaps are similar. A large proportion of the US workers have not completed college, and a majority of them come from disadvantaged families. Many studies consistently show that the rate of return from college graduation is much higher than the market

[1] University of Chicago, Center for the Economics of Human Development Chicago, IL, USA.

Corresponding author:
Lakshmi Raut, Visiting Fellow, University of Chicago, Center for the Economics of Human Development, 1126 E. 59th St., Chicago, IL 60637, USA.
E-mail: lakshmiraut@gmail.com

interest rate. Could it be that the students from poor socioeconomic status (SES) are liquidity constrained for their college fund? This is the general perception. The students from poor SES are, however, eligible for many federal loan programmes for college education. The interest rates of these loan programmes are substantially lower than the rate of return from college graduation. Yet there is not enough demand for these loans. Contrary to the general perception, the liquidity constraint is not a major reason why children from disadvantaged families do not attend college. For instance, Carneiro and Heckman (2002) use the NLSY data to show that about 4 per cent of the US households only are liquidity constrained in the provision of post-secondary education to their children.[1] In the US, equalizing educational differences has remained a main policy instrument to reduce poverty and income disparities. The basic question is then: Can we conquer poverty and income disparity through school?

Many are highly sceptical about a positive answer to the aforementioned basic question. There are many reasons for this scepticism. In the US, education up to high school level is virtually free. Yet many children of poor SES do not complete high school and many of them perform poorly in schools. This naturally beckons to the possibility that the poor quality of the public schools that the children of poor SES attend is the reason for such failings. Improving school quality will improve school performance of these children only marginally. Many empirical studies find that better school quality in terms of lower class size, higher public expenditures per pupil, improved curriculum and higher desegregation have only marginal effects on school performance of the children of poor SES. See Hanushek (1986) for a survey of studies along this line. In theoretical overlapping generations growth models, choices from multiple school qualities can lead to equilibria in which some families choose low quality schooling for their children, generation after generation, that is, inhibiting intergenerational social and schooling mobilities (see Raut [1990] for a model with old-age security motive[2] and Raut [2007] for a model with altruistic motive for parental choice of school qualities for their children).

A growing consensus reached among educators, media writers (see for instance, Traub, 2000), researchers in sociology, psychology and education (for instance, see Barnett, 1995; Entwisle, 1995; McCormick, 1989; Reynolds, Ou, & Temple, 2018; Reynolds, Temple, Robertson, & Mann, 2001; Schweinhart et al., 1993) and researchers in economics, (see for instance, Currie, 2001, 2011; Currie & Almond, 2011; Duncan, Ziol-Guest, & Kalil, 2010; Heckman, 2000; Heckman, Moon, Pinto, Savelyev, & Yavitz, 2010; Heckman & Raut, 2013, 2016; Keane & Wolpin, 1997) is that the children of poor SES are not prepared for college because they were not prepared for school to begin with. The most effective intervention for the children of poor SES should be introduced at the preschool stage so that these children are prepared for schools and colleges. I briefly summarize this literature and the recently emerging microbiology literature that provides genetic and epigenetic mechanisms for various pathways of cognitive and non-cognitive developments of children.

Earlier research in the last century focussed on cognitive skills as the main determinant of socioeconomic behaviours, school performances and labour market outcomes. One line of influential but controversial research argues that poor parents have poor cognitive abilities and that is why they are poor; children of poor SES inherit poor cognitive abilities from their parents; thus very little can be done to improve the cognitive skills of the disadvantaged children, and hence their school performance and labour market outcomes (see Herrnstein & Murray [1994] and other references in Plomin & Deary [2015]). This view has been refuted using more appropriate data, statistical techniques and microbiological evidence.

Recent research in psychology, neurobiology, experimental game theory and economics emphasize that it is the interplay of personality, emotion and cognition that determines most socio-economic behaviours. A branch of the psychology literature argues and validates that the emotional intelligence drives most socio-economic decisions and behaviours, not the cognitive intelligence alone. Many definitions and measurements for emotional intelligence exist in the literature, however, the concept more relevant to our context is quoted from Mayer, Salovey, and Caruso (2004):

> [Emotional Intelligence is the] capacity to reason about emotions, and of emotions to enhance thinking. It includes the abilities to accurately perceive emotions, to access and generate emotions so as to assist thought, to understand emotions and emotional knowledge, and to reflectively regulate emotions so as to promote emotional and intellectual growth.

Bar-On (2000) and Goleman (2009) use somewhat broader definitions by including other personality traits in their definitions. It has been found that measures based on all these different definitions are highly correlated with each other and each explains strongly many socio-economic behaviours independent of cognitive skills (see Chakrabarti & Chatterjea [2017] for some of these results in psychology and for a synthesis of various definitions, and Raut [2003] and Heckman & Raut [2013, 2016] for significant positive effects of non-cognitive skills on labour market earnings, independent of the effects of cognitive skills).

Humans are social animals. They live in groups and work in groups for most economic and social activities. Group activities in economics are known as teamwork. Group outcomes are generally more efficient than what individuals could do by themselves. Group activities to attain some common goal, however, require each member of the group to perform constant mind reading of the other members and evaluate how others may react to one's action. The mechanism by which one reads other's mind in a conflicting or cooperative situation is known in the psychology literature as the theory of mind, a term introduced by Premack and Woodruff (1978), see Doherty (2008) for a description of various mechanisms for the theory of mind. One who has a better emotional intelligence and a better theory of mind can be more effective in a group and can become the leader of the group. A group can have a higher level of group emotional intelligence and cognitive intelligence than another group and can be more efficient and more productive as a result for many activities (see Woolley, Chabris, Pentland, Hashmi, & Malone [2010] for more on the group intelligence and related references). In experimental game theory such non-cognitive skills—emotional intelligence and theory of mind—play important role (see, for instance, Camerer, Loewenstein, & Prelec, 2005; Kahneman, 2013; Winter, 2014). The recent economics literature shows that non-cognitive skills such as socialization and motivation are also important for positive labour market outcomes, (see, for instance, Deming, 2017; Heckman & Raut, 2013, 2016; Raut, 2003). Deming provides a team theory explanation for why better socialization and motivational skills can lead to higher labour productivity.

Where are these emotional intelligence or non-cognitive skills produced? For the effect of early childhood experiences, especially mother–child interactions, on the development of the theory of mind of the child, see Doherty (2008) and Ruffman, Slade, and Crowe (2002). Another branch of the psychology literature, for example, the work of Bowlby (1982), argues that affect (i.e., emotion) dysregulation which begins to form immediately after birth, especially during the first two years of age, from low-quality interaction of the primary caretaker (generally the mother) with the baby can have long-lasting effects on emotional development of the child in later ages. NETWORK (2004) carried out a longitudinal study and found evidence for such affect dysregulation mechanisms. The emotional dysregulation also conditions cognitive developments of children. More recent neurobiology research on this phenomenon confirms this (see, for instance, Schore [2005], and see Schore & Schore [2008] for a survey of this line of research). When parents are incapable of producing these skills, a good preschool programme can be a good substitute for it.

The rapidly growing microbiology literature that emerged around the turn of the twenty-first century is focussed on genetic and, more emphatically, epigenetic mechanisms of the personality, emotion and cognitive developments of individuals. The twenty first century emphasis that the full DNA mapping of human genome will be able to fully uncover the mechanism of human development pathways fell short of explaining why identical twins or an individual diverge so much in their gene expressions or phenotypes as they progress through their lives. All cells in a body starting with the single fertilized egg have the same genetic mapping (i.e., the same DNA sequence) throughout life. It is the epigenetic (literally means on top of genetic) codes, which are influenced by the internal and external environments of the body cells, indeed determine which genes are expressed, silenced or mutated during cell divisions, and hence determine the development of the mind and body and their health status. For instance, stress of various kinds can have effects on epigenetic reprogramming of the plasticity of various parts of the brain that perform cognitive processing, language processing, emotion or affect regulations, the size and efficiency of the working memory, and the long-term memory (see McEwen & Gianaros [2011] for the effects of stress in general, Champagne et al. [2008] and Hellstrom, Dhir, Diorio, & Meaney [2012] for the effects of parenting practices). Other environmental factors such as the quality of language exposure, the presence of books, computers, musical instruments at home, the speech pattern, cognitive skills of mother and other caregivers have also significant effects on the development of the neural network of the brain (i.e., the network of dendrites, axons and synapses) specialized for language processing, creative writing or musical talents (see, for instance, Mezzacappa, 2017; Murgatroyd & Spengler, 2011).

Using fMRI images of brain areas, a number of neurological studies found that poverty has significant negative effects on the development of a child's certain brain areas that are responsible for personality, emotion and executive functions. For instance, a large-scale neurological study by Noble et al. (2015) found that family income significantly affects children's brain size, particularly in the surface area of the cerebral cortex that does most of the cognitive processing. See also their earlier study Noble, Houston, Kan, and Sowell (2012) and the commentary in Balter (2015). Hair, Hanson, Wolfe, and Pollak (2015) conducted a large longitudinal neurological study on children starting at an early age and followed them up into their school years. They measured their scores on cognitive and academic achievements, and development of brain tissues, including grey matter of the total brain, frontal lobe, temporal lobe and hippocampus. They found significant negative effects of poverty on developments of these brain areas and on academic achievements.

Much of the literature discussed earlier in this article suggests that early age events have many lasting effects. We cannot study all these effects. In the scope of this paper, the question I address is: Does preschool investment have long-term positive effects on school performance, lifetime earnings, and intergenerational social and schooling mobility? Most of the studies along this line use data on Head Start preschool programme, which is funded by the Federal government. The programme is available only to children whose parents earn incomes below poverty line. The programme covers not all eligible children, however. The quality of the programme is very poor compared to the pilot programmes and most of the private preschool programmes. Some studies (see, for instance, Aughinbaugh, 2001) find that the Head Start preschool programme has no long-term effect on children's cognitive achievements and school performance, especially for the black children. Currie and Thomas (1995) carried out a careful econometric investigation and concluded that the benefits disappear for the black children because most of the Head Start black children attend low-quality public schools. After controlling for the school quality, however, they found significant positive effects of Head Start preschool programme. See Barnett (1995), Campbell, Ramey, Pungello, Sparling, and Miller-Johnson (2002), Consortium for Longitudinal Studies (1983), Schweinhart et al. (1993) and Yoshikawa (1995) for surveys and studies on the long-term effects of early childhood programmes in the US.

The aforementioned studies are not based on nationally representative samples of children, and most studies examine only the effects on school performance such as grade retention and high school and college graduation rates, and do not model parental choice of children's preschool investment. In this paper, I formulate a model of parental investment in preschool that is guided by economic incentives. I empirically show that preschool investment benefits children to acquire socialization and motivational skills, especially for the children of poor SES who live in poor HOME environments, that the motivational skills significantly improve school performance, and that the socialization and motivational skills improve the lifetime earnings of children. These significant positive effects are found after controlling for their education level, innate ability and family background. I formulate an intergenerational altruistic model of parental preschool investment. I use a mixed reduced form econometric estimation method and a calibration method to numerically specify the parameters of the model, and then use this model to examine the long-term intergenerational economic effects of publicly providing preschool to children of poor SES.

The rest of the paper is organized as follows: The next section provides the basic decision-making framework, the third section provides empirical estimates and the fourth section provides the economic benefits of a social programme of providing preschool to children of poor SES.

The Basic Framework

In this section, I formulate a model of preschool investment decision of an altruistic parent. The preschool investment decision of a parent depends on several other decisions made at later stages by the parent and the child. In this section, I describe each of these decision stages. In a later subsection, I discuss estimation issues. I report empirical estimates in the next section. For expositional ease, I assume that each family has one parent and one child, and address them using male gender.

I assume that an individual's life comprises of several discrete periods during which important life cycle events relevant to learning and earning occur. I aggregate the whole life cycle into four periods as follows: [0–5), [5–17), [17–26), [26–]. In each of these periods some educational and labour market decisions are made and outcomes are observed. During age [0–5), the parent invests in his child's preschool activities which develop the child's school readiness, and cognitive, social and motivational skills. Let h be the level of parental preschool investment. I assume that h is annualized over the working years of the parent[3]. At the end of this period, the child acquires a level of innate ability or cognitive skill τ, social skill σ and motivational skill μ. The level of each type of skills that the child acquires depends on other factors as well. For instance, it depends on child-rearing practices at home, the nature of neighbourhood in which the child grows up, and the level of schooling, cognitive, socialization and motivational skills of the parent. In the next section, I describe the role of parental preschool investment in the production of these skills and statistically estimate the effects of preschool in the production of these skills.

During period [5–17), the child goes to school. The school performance at this stage depends on the levels of τ, σ and μ that the child acquired during the previous stage, on the quality of the school that he attends, and also on the type of neighbourhood kids whom the child mingles with.[4] It also depends on the parental home inputs such as how many hours the parent spend time with the child to do his homework, how many hours the child watches TV and how stable and stimulating the relationships among the family members are. Many of these are choice variables for the parent. Since not much information about these is available in the data set, I assume that the levels of τ, σ and μ from the previous period remain constant at the end of the second stage.

During [17–26), the child makes his schooling decisions. Two important ingredients to this decision are the costs and benefits of attaining a given level of schooling. There are many dimensions to the cost of schooling, but I make many simplifying assumptions. I assume that he does not work during this schooling period.[5] During [26–] he works, forms a family with a child and decides how much to invest in his preschool, elementary school and high school. At the beginning of the schooling period [17–26), the child decides how many years of college to have and what type of college to attend. An important determinant of this decision is the financial rewards or earnings in the labour market over the whole life time that an individual will command from various levels of schooling. Another non-financial benefit of higher schooling of an individual is that it provides better family background for his child from which his child benefits. The structure of schooling costs is generally very complicated. The type of college that he likes to attend depends on how much college fund he can raise from the market and how much college money he can get from his parent. I assume that each individual borrows the whole college fund from the market. The interest rate r for borrowing the college fund may depend on his parent's wealth position and if there is a government educational loans available at a low rate. Let $c(s, r)$ be the cost of s years of college annualized over the working years of the individual. There are many important life cycle events that also influence the schooling decision of an adult child. For instance, bad influence and financial responsibilities towards other family members because of bad health shocks, or loss of employment of the parent may cause a child choose less education. I represent these factors by an aggregate random variable ϵ_s.

I take the rewards or benefits from schooling to be the yearly permanent income, which depends on his number of years of schooling s, his innate ability τ, his level of socialization skills σ, his level of motivational skills μ and also on his life cycle experience of random shocks ϵ_p such as market luck, family connection and network. Let the yearly permanent income of the child over the working years[6] be denoted by $w\left(s; \tau, \sigma, \mu, \epsilon_p\right)$. His financial rewards net of schooling cost is then given by $\hat{w}\left(s; \tau, \sigma, \mu, \epsilon_p\right) = w\left(s; \tau, \sigma, \mu, \epsilon_p\right) - c(s, r)$.

I assume that ϵ_s is realized prior to making schooling decision during [17–26) and ϵ_p is realized during [26–] prior to making preschool investment decision. Given his level of τ, σ and μ, his life cycle shocks ϵ_s and the level of parental preschool investment level h, let $s^*(\tau, \sigma, \mu, h, \epsilon_s)$ be his optimal schooling plan.[7] Even though given the values of τ, σ, μ, ϵ_s, the pay-offs to the child during his decision period [17–26) does not depend directly on h, I however, assume that $s^*(\tau, \sigma, \mu, h, \epsilon_s)$ depends on h to allow for the possibility of strategic threats that the child may use in our Stackleberg situation with parent as the leader and his child as the follower.

Formally, denote the state variables of our system by the vector $z = \left(s, \tau, \sigma, \mu, \epsilon_s, \epsilon_p\right)$. Denote the vector of unobserved state variables representing the unobserved heterogeneity by $\epsilon = (\epsilon_s, \epsilon_p)$ and the vector of observed state variables by $\tilde{z} = (s, \tau, \sigma, \mu)$. I will sometimes use the notation $z = (\tilde{z}, \epsilon)$

to represent the information provided earlier. For any variable, x, I adopt the convention of using x if it refers to parent and x' if it refers to his child.

I assume that given the level of parental preschool investment h, and the realization of his parent's state variables $z = (\tilde{z}, \epsilon)$, a child has τ', σ', μ' and ϵ' which are produced stochastically and represented by the following conditional probability density functions:

$$\begin{aligned} & q_\tau\left(\tau'|\tau\right) \\ & q_\sigma\left(\sigma'|\tau', s, \tau, \sigma, \mu, h\right) \\ & q_\mu\left(\mu'|\tau', s, \tau, \sigma, \mu, h\right) \\ & q_{\epsilon_s}\left(\epsilon_s'|\tau', \sigma', \mu', s\right) \\ & q_{\epsilon_p}\left(\epsilon_p\right) \end{aligned} \tag{1}$$

In Equation (1), each of those conditional probabilities may depend on many other variables, but the variables that are shown as the conditioning variables represent our specifications of the processes generating the state variables. This particular specification that I use in Equation (1) is based on what is currently known about the production processes of these state variables. I will discuss each of these production processes in the next section.

Given the density functions in Equation (1), the preschool investment decision h, and a schooling decision rule $s' = s^*\left(\tau', \sigma', \mu', \epsilon_s', h\right)$, the transition probability measure $Q_h\left(z, z'\right)$ over the states of our system is determined. The preschool investment decision problem of a parent is then the following Bellamn equation of a dynamic programming problem:

$$V(z) = \max\nolimits_{0 \le h \le w\left(\tilde{z}, \epsilon_p\right)} u\left(\tilde{w}\left(\tilde{z}, \epsilon_p\right) - h\right) + \gamma \int V\left(z'\right) Q_h\left(z, dz'\right), \tag{2}$$

where V(.) is the value function, *u(.)* is the felicity index of yearly permanent consumption $\tilde{w}\left(\tilde{z}, \epsilon_p\right) - h$ of the parent and γ measures the degree of parental altruism towards his child. We assume that $0 \le \gamma \le 1$. Given a particular schooling reaction function $s' = s^*\left(\tau', \sigma', \mu', \epsilon_s^{'}, h\right)$, there exists a value function $V(z)$, and optimal decision rule $h^*(z)$ under quite general conditions on the primitives, $u(.)$, $Q_h\left(z, z'\right)$, γ and $\tilde{w}(z)$ (see Bhattacharya & Majumdar, 1989). How is the optimal schooling reaction function $s' = s^*\left(\tau', \sigma', \mu', \epsilon_s^{'}, h\right)$ determined? I use the notion of subgame perfect equilibrium to characterize it.

A subgame perfect equilibrium is a pair of decision rules $h = h^*\left(\tilde{z}, \epsilon_p\right)$ and $s' = s^*\left(\tau', \sigma', \mu', \epsilon_s^{'}, h\right)$ such that

1. $h = h^*\left(\tilde{z}, \epsilon_p\right)$ solves Equation (2) given the reaction function $s' = s^*\left(\tau', \sigma', \mu', \epsilon_s^{'}, h\right)$, and
2. $s' = s^*\left(\tau', \sigma', \mu', \epsilon_s^{'}, h\right) = \text{argmax}_{s'} \int V\left(s', \tau', \sigma', \mu', \epsilon_s^{'}, \epsilon_p^{'}\right) q_{\epsilon_p}\left(\epsilon_p^{'}\right) d\epsilon_p^{'}$.

It is clear from the second condition that the subgame perfect optimal schooling decision does not directly react to h. Furthermore, the optimal preschool investment decision depends on z only through $\tilde{w}$ and has the form, $h^* \left(\tilde{z}, \epsilon_p\right)$. In this paper, I do not explore properties of the subgame perfect equilibrium nor do I find conditions under which the equilibrium exists.

Structural Estimation, Reduced Form Estimation or Calibration?

It is not possible to carry out structural estimation of Equation (2) non-parametrically since there will exist many primitives that can rationalize any given subgame perfect solution $h^* \left(\tilde{z}, \epsilon_p\right)$ and $s^* \left(\tau', \sigma', \mu', \epsilon_s^{'}, h\right)$. Structural estimation[8] of our dynamic model involves two steps: (a) econometric estimation of the optimal policy function $h^* \left(\tilde{z}, \epsilon_p\right)$ and (b) identification of the structural parameters given the estimates of $h^* \left(\tilde{z}, \epsilon_p\right)$ and $s^* \left(\tau', \sigma', \mu', \epsilon_s^{'}, h\right)$.

To estimate the optimal policy functions, one first needs to introduce a stochastic term in $h^* \left(\tilde{z}, \epsilon_p\right)$ and $s^* \left(\tau', \sigma', \mu', \epsilon_s^{'}, h\right)$ so that one can apply the method of moments or non-linear regression techniques to estimate these using the household-level data. There are many ways to incorporate this. In the earlier set-up, I assume that the decision-maker observes all the state variables, an econometrician does not observe ϵ_s and ϵ_p. These ϵ_s' can then constitute the error terms in the policy functions.

The identification problem reduces to the question: Given optimal solutions $h^* \left(\tilde{z}, \epsilon_p\right)$ and $s^* \left(\tau', \sigma', \mu', \epsilon_s^{'}, h\right)$, does there exist a unique combination of primitives $u(.)$, $Q_h \left(z, z'\right)$, γ and $\tilde{w}(z)$ which rationalizes the given optimal solutions? In general, there exist many combinations of primitives that can rationalize the optimal solution, and hence the answer to the identification problem is in general negative. One approach to the identification problem is to impose parametric restrictions on $u(.)$, $Q_h \left(z, z'\right)$ and $\tilde{w}(z)$. These conditions are generally very stringent and are worked out only for standard dynamic programming problem in which there is only one decision-maker. Not much is known for our more general subgame perfect set-up involving more than one decision-makers.

In the case of dynamic programming, if the decision variables are discrete, an alternative approach reduces the earlier dynamic programming problem to a random utility model by imposing suitable restrictions on the primitives (see Rust, 1994a, Theorem 2; 1994b, Theorem 3.2) . This approach has not been extended to the subgame perfect equilibrium set-up that incorporates more than one decision-makers. I will not pursue it either in this paper.

The NLSY data set does not have data on the amount spent on preschool. It has data only on a binary variable of whether the respondent had preschool or not. Given this data limitation, I treat parental preschool investment decision variable as a binary variable. Underlying this is the assumption that there are no variations in preschool qualities and the cost. Another serious limitation of the NLSY data set is that it does not have data on all the state variables relating to the parents of the respondents. For instance, it does not have data on τ, σ and μ. Furthermore, while the data set has information on τ, σ and μ for the respondents, it does not have information on the preschool investment of their own children, and thus I cannot follow the synthetic cohort approach of using respondents' data to estimate the counterfactual optimal preschool decision rule $h^* \left(\tilde{z}, \epsilon_p\right)$ of their parents. Therefore, given the data limitations, I cannot pursue structural estimation of the model even if I overcome the identification problem with appropriate restrictions on parametric specifications.

In this paper, I follow a mixed calibration and reduced form estimation procedure as follows: I drop ϵ_p from the model, that is, I assume that the permanent yearly income is independent of ϵ_p, and thus it does not enter the optimal preschool choice problem. I estimate $Q_h \left(z, z'\right)$, $w\left(\tilde{z}\right)$, $s^* \left(\tau', \sigma', \mu', \epsilon_s^{'}, h\right)$ directly using the NLSY data and specify numerically the felicity index $u(.)$ and parental altruism parameter γ. I then solve the fully specified dynamic programming problem numerically. I then use these estimates and the optimal solution to examine the economic effects of providing preschool resources to children of poor SES.

Empirical Findings

The NLSY79 Data set

A lot has been written about the NLSY79 data set, so I will not describe the data set in details. The NLSY79 data set contains life cycle information on a nationally representative sample of 12,686 young men and women who were 14–22 years old when they were first surveyed in 1979. From 1979 to 1994, these individuals were surveyed annually. Currently they are interviewed on a biennial basis. Since their first interview 1979, many of the respondents have made transitions from school to work, and formed their own family instead of living with their parents. This data set provides a large sample of American men and women that were born in the 1950s and 1960s and living in the US in 1979.

This data set contains richer information on school and labour market experiences of a nationally representative sample of individuals. This data set, however, contains limited information on early childhood inputs of the sampled individuals. Although there is a recent data set that collects panel data on the children of the NLSY respondents, we have to wait several years to obtain data on labour market outcomes of these children. From all these considerations, the NLSY data set stands out as the best choice for our analysis.

Production of Social and Motivational Skills

In this section, I consider the production process of the socialization and motivational skills. In the next two subsections, I empirically show that motivational and socialization skills are important determinants of earning and learning.

The literature in sociology, psychology and microbiology of human development suggest that early childhood investment is the most crucial input for development of cognitive, social and motivational skills. The studies in these literature link school success to home environment, child-rearing practices and neighbourhood type in which the kid is raised. For instance, the Coleman report (1968) and subsequent studies find that the family capital—which captures family tradition and values towards economic success and education—and the social capital—which captures the benefits of social bonds, social norms, social networks, the social bonds between adults and children and among children in a neighbourhood—are of immense value during a child's growing up. These factors affect parental choices of preschool investment and child-rearing methods which in turn determine a child's cognitive abilities and social abilities such as motivation and sociability that affect their learning and earning. Microbiology literature produces ample evidence that the human brain develops extremely rapidly during ages [2–4], and the type of stimulations regarding health and learning that the child experiences during this period is a critical determinant of a child's cognitive, social and motor developments. Child psychology literature also points out that a structured preschool stimulation boosts a child's self-confidence, school preparedness, parents' and teachers' assessment of the child's ability. These in turn create a conducive learning environment for the child over many more years of schooling, beginning with the elementary school. See Barnett (1995), Entwisle (1995), McEwen and Morrison (2013), McEwen and Gianaros (2011), Mezzacappa (2017) and Murgatroyd and Spengler (2011) for more on this. I construct the variables of this study as follows:

Early childhood inputs and home environment: I take father's and mother's education levels to measure family background. The NLSY data set has poor measures of respondent's early childhood inputs. It has only a binary variable containing information on whether the respondent had preschool (does not include Head Start) experience or not. I treated individuals with Head Start experience as no preschool. Notice that this will lead to underestimation of the effect of preschool investment. I use the revised AFQT score to measure innate ability.

Socialization skill (σ): Each respondent were asked how social he/she felt towards others at age 6. This was expressed in a scale of 1 to 4. The highest number represented most social. I create a binary sociability variable by assigning value 1 if a respondent reported an answer 3 or 4 to this question, and assigning 0 otherwise. About 39 per cent of the sample respondents are sociable. This measure of socialization may have recall error, as the respondents may not correctly recall how they were when they were 6 years old. Deming (2017) has used a principal component analysis with some other variables observed in later periods to construct a measure of socialization skills in his paper. I used the early childhood information only as other information taken from later ages might reflect the time effect and I did not do a robust analysis with his measure, as his construction was not known to me at the time of this research.

Motivational skill (μ): I use three measures of motivation. (a) Job aspiration (μ_1) which I construct as a binary variable taking value 1 if during the first interview

Table 1. Determinants of Sociability and Motivations

Variables	Sociability (σ)	Job Aspiration (μ_1)	Education Goal (μ_2)	Self-control (Rotter) (μ_3)
Intercept	−0.6467	−0.6102	11.8089	1.9911
	(8.11)	(7.24)	(98.13)	(31.90)
Revised AFQT score	0.0013	0.0131	0.0311	0.0094
	(1.91)	(17.80)	(31.30)	(18.16)
Mother's grade	0.0115	−0.0064	0.0471	0.0100
	(1.63)	(0.86)	(4.45)	(1.82)
Father's grade	0.0199	0.0207	0.0421	0.0083
	(3.43)	(3.35)	(4.82)	(1.84)
Preschool	0.0884	0.1553	0.6100	0.0399
	(2.12)	(3.33)	(9.58)	(1.21)
Gender	−0.0462	0.2884	0.1484	−0.0322
	(1.41)	(8.17)	(2.99)	1.25
N	6072	6072	5961	6041
Log-likelihood/R^2	−4010.09	−3389.02	0.2541	0.0861

Source: The author.

Note: First two columns show parameter estimates from the Probit model and the last two columns show parameter estimates from the ordinary least squares models. The absolute t-value of a parameter estimate is shown in parentheses below the parameter estimate.

in 1979 the respondent aspired for professional jobs, otherwise taking value 0. About 71 per cent of the respondents in the sample are motivated. (b) The educational goal (μ_2) is the grade that the respondent in 1979 expected to achieve; the sample average is 15 years and standard deviation is 1.104. (c) The Rotter's scale of self-control and self-confidence (μ_3) which I reconstructed from the scores of original four questions in the data set. My measure takes values 0 to 4, a higher value representing more confidence and self-control. The sample average is 2.57 and standard deviation is 0.066.

The variable Gender = 1 if female, otherwise Gender = 0.

I estimated a Probit model for σ and μ_1 and OLS models for μ_2 and μ_3. The parameter estimates are reported in Table 1.

From Table 1, it is clear that after controlling parents' grades, preschool experience has a significantly positive effect on socialization skill and on all measures of motivational skills except the Rotter's scale of self-control. The estimates in the table also show that innate ability has strong positive effect on all measures of motivational skills, but has no significant effect on socialization skills. Socialization skills are created in the family using the preschool and neighbourhood inputs. The data set does not have information on parent's income, age and whether both parents are alive and reside in the same households. These variables are presumably important factors in the skill formations. The education levels of the parents have captured some of these effects. To the extent these variables are correlated with the preschool variable, the effect of preschool will be biased. There is no good information that could be used to estimate the parameters using the instrumental variable method. Thus, the underlying assumption in these estimates is that those variables are not correlated with the preschool decision.

It will be interesting to see if preschool has stronger positive effect on socialization and motivational skills of children of poorer SES. If so, then the preschool could be used to compensate for the better HOME environment that the well-to-do counterpart of these children have. That is, through intervention like preschool, we can achieve a higher equality of opportunities by equalizing the differences in the starting social, motivational and cognitive skills of the children.

An Augmented Earnings Function: Role of Socialization and Motivational Skills

In this section, I examine the effect of social and motivational skills together with the effect of innate ability and grades on earnings. The previous studies, however, included only innate ability, schooling level and school quality as the main determinants of earnings. While preschool investment is an important determinant of these skills, I also included preschool binary variable as one of the regressors in the earnings function to see if it has an independent effect. In my specification, I also included a dummy variable for college (taking value 1 if a respondent graduated from college). This dummy variable after controlling for the grade variable captures any earnings premiums that a worker earns by graduating from college. Since I included AFQT score which is a reasonably good measure of one's innate ability, the parameter estimates do not have the ability-bias problem.

Table 2 shows the parameter estimates of this augmented earnings function. The first column is for all three races together and the next three columns give the estimates for the Hispanics, Blacks and the Whites ethnic groups separately. It is clear from the estimates that after controlling for innate ability, family background and the schooling level, the measures of socialization and motivational skills have significant positive effect on earnings for all ethnic groups. Preschool has independent positive effect only for Blacks. It is also interesting to note that college graduates earn 8.35 per cent higher returns in the overall population, and for Blacks and Hispanics this premium is even higher (slightly above 10%). The sociability skills are significant only for White, but not for Black and Hispanic workers.

Estimation of Optimal Schooling Level

I consider two specifications of the optimal schooling function $s^*\left(\tau', \sigma', \mu', \epsilon_s', h\right)$ in this paper. In the first specification, I assume that the schooling level is a continuous variable and specify the optimal reaction function $s^*\left(\tau', \sigma', \mu', \epsilon_s', h\right)$ as a linear function. I assume that the random variable ϵ_s' constitutes the error term and satisfies all the assumptions of the OLS model.[9] The parameter estimates from this model are shown in Table 3. I included the socialization and motivational skills together with innate ability and family background measured by parents'

Table 2. Estimated Parameters of the Augmented Mincer Earnings Function

Variables	All Races	Hispanic	Black	White and Others
Intercept	0.4097	0.4716	−1.4676	0.6952
	(3.02)	(1.51)	(4.44)	(4.13)
Revised AFQT score	0.0062	0.0055	0.0068	0.0041
	(32.16)	(10.53)	(12.13)	(16.20)
Grade	0.0420	0.0291	0.0752	0.0426
	(14.68)	(5.11)	(9.93)	(11.51)
High school	0.0662	0.0851	−0.0030	0.0881
	(7.11)	(4.27)	(0.14)	(7.21)
College	0.0835	0.1003	0.1002	0.0839
	(5.91)	(2.39)	(2.69)	(5.18)
Age	0.5313	0.5196	0.5857	0.5244
	(52.68)	(22.11)	(24.17)	(42.21)
Age square	−0.0079	−0.0078	−0.0087	−0.0078
	(42.05)	(17.58)	(19.39)	(33.69)
Mother's grade	0.0025	0.0129	0.0230	−0.0022
	(1.41)	(4.13)	(5.17)	(0.82)
Father's grade	0.0077	0.0070	−0.0095	0.0130
	(5.30)	(2.45)	(2.94)	(6.47)
Preschool	0.0055	−0.0373	0.0752	0.0048
	(0.52)	(1.50)	(3.30)	(0.35)
Sociability (σ)	0.0226	−0.0314	0.0267	0.0265
	(2.72)	(1.60)	(1.31)	(2.62)
Motivation: Job	0.0419	0.0864	0.0427	0.0346
aspiration (μ_1)	(4.48)	(4.03)	(1.90)	(2.98)
Motivation: Education	0.0051	0.0278	0.0153	0.0058
goal (μ_2)	(2.07)	(5.09)	(2.59)	(1.80)
Motivation: Rotter	0.0305	0.0325	0.0367	0.0362
scale (μ_3)	(7.55)	(3.46)	(3.63)	(7.35)
Gender	−0.4997	−0.5090	−0.3710	−0.5549
	(61.37)	(26.47)	(18.64)	(55.43)
N	60,489	10,374	12,053	38,061
R^2	0.3186	0.3295	0.3152	0.3205

Source: The author.

Note: Absolute t-values are in parentheses.

education levels. It is clear from the estimates that the main determinant of grade is the innate ability measured by AFQT score. After controlling for family background, I also find that motivation measures have significant positive effect on schooling level. Out of the three measures of motivation, the measure μ_2 based on the expected grade that the respondent desired to attain while very young turns out to be the most important one. Note also that the motivation measure μ_1 based on job aspiration has significant positive effect only for the White but not for the Black or the Hispanic. The sociability skill has, however, no effect on the schooling level. After controlling for all other variables, preschool has still

Table 3. Determinants of Grade

Variables	All Races	Hispanic	Black	White and Others
Intercept	3.7172	4.6491	4.4417	3.0849
	(22.03)	(10.72)	(12.51)	(13.86)
Revised AFQT score	0.0288	0.0376	0.0337	0.0279
	(30.80)	(12.67)	(14.98)	(22.29)
Mother's grade	0.0622	0.0289	0.1184	0.0774
	(6.91)	(1.53)	(6.41)	(5.58)
Father's grade	0.0262	−0.0052	−0.0013	0.0659
	(3.54)	(0.30)	(0.09)	(6.41)
Preschool	0.2759	−0.0804	0.2880	0.2961
	(5.08)	(0.54)	(2.91)	(4.22)
Sociability (σ)	0.0653	−0.1205	0.1528	0.0813
	(1.51)	(1.00)	(1.74)	(1.53)
Motivation:	0.1788	0.1473	0.1501	0.2061
Job aspirations (μ_1)	(3.64)	(1.12)	(1.57)	(3.33)
Motivation:	0.4615	0.4354	0.3489	0.4674
Education goal (μ_2)	(41.18)	(14.52)	(14.94)	(31.40)
Motivation: Rotter scale	0.0724	0.0732	0.1236	0.0493
of self-control (μ_3)	(3.45)	(1.28)	(2.84)	(1.91)
Gender	0.1532	0.0761	0.4780	0.0798
	(3.63)	(0.65)	(5.72)	(1.53)
N	5,925	1,044	1,259	3,620
R^2	0.5577	0.4825	0.5326	0.5845

Source: The author.

Note: Absolute t-values are provided in parentheses below the parameter estimates.

an independent positive effect on the completed grade of Blacks. This may be because the preschool creates other skills that are important for school success but are not captured in the included determinants in our specification of optimal schooling function.

Notice that even after controlling for innate ability, the family backgrounds measured by mother's grade and father's grade have significant positive effects on the completed grade of the Black and White but not for the Hispanic.

In the second specification, I consider two levels of schooling: college or higher ($s = 1$) and no college ($s = 0$). This simplified specification is for the purpose of calibrating the dynamic programming problem in Equation (2). Again I assume that $s^*\left(\tau', \sigma', \mu', \epsilon_s^{'}, h\right)$ is linear and that $\epsilon_s^{'}$ constitutes the error term and it is normally distributed. This gives us the Probit model of college graduation. The parameter estimates are reported in Table 4. Here again the innate ability, motivation, preschool and the college status of parents (which takes 1, if at least one parent had some college and 0 otherwise) turn out to have significant positive effects on the probability of college graduation.

Optimal Parental Preschool Investment

To numerically solve the dynamic programming problem in Equation (1), one has a few choices. One could assume the state variables s, τ and ϵ are continuous and the rest of the variables are binary and then use the parametric path method of Judd (2002) or a suitable value iterations or policy iterations methods developed in the numerical dynamic programming literature (see Rust [1996] for a survey of these methods). Because we have many state variables, our problem is subject to the well-known ‘curse of dimensionality’ problem of numerical dynamic programming methods. I impose the following restrictions to keep the numerical computation manageable.

I assume that the state variables s, τ, σ and μ are binary, the random variable ϵ_s is continuous which is observed by the decision-maker but not by the econometrician, the random variable ϵ_p is absent and the preschool investment decision h is a binary variable, taking value 1 when parents decide to invest in preschool and 0 otherwise. For most children, we have two parents but in the model I have assumed one parent. I have used both parents’ information in computation as follows: I construct parent’s binary schooling variable s by assigning $s = 1$ if the average grades of two parents is more than 12, otherwise assigning $s = 0$. I assume that τ is biologically inherited and it is not influenced by preschool investment. I created the binary variable τ assigning it the value 1 (interpreted as the individual is highly talented) if the AFQT score of the individual is 70 or higher, and assigning it the value 0 otherwise. I do not have information on AFQT of parents. The literature on intelligence recommends that the correlation between parent’s IQ and the child’s IQ is anywhere between 0.3 and 0.7. I assume it to be US 0.3 in our numerical exercise. I use the binary job aspiration variable μ_1 as the measure of motivational skills. The specifications and the estimates of the Probit models of s^*, σ and μ are shown in Table 4. I use these estimates to calculate the transition matrix Q_h.

Schweinhart et al. (1993) took average yearly preschool cost to be US \$6,178 per year. Consistent with their study, I take the preschool cost per child to be \$18,000 for three years and annualize it over the working years of an individual. I further assume that the felicity index is linear and measured in US dollars. I numerically specify the parental altruism parameter to be $\gamma = 0.65$.

After calibrating the model as described above, I use the linear programming approach to solve the problem in Equation (2) numerically. The optimal preschool investment decision and the value function are shown respectively in columns 3 and 4 of Table 5. From Table 5, we notice that parents with income below a cut-off point do not invest in their children’s preschool. I will refer to these parents as parents of poor SES.

Economic Benefits from Public Provision of Preschool

I have shown that investment in preschool enhances certain skills that are important for learning and earning. The optimal solution reveals that the parents of poor SES

Table 4. Estimated Forms of Earnings Function and Probit Models of College Completion, Socialization and Motivation

Variables	$w(s, \tau, \sigma, \mu)$	Probability of College	Probability of Being Sociable	Probability of Being Motivated
Intercept	8,330.0784	−1.4313	0.4763	−0.3034
	(15.62)	(48.85)	(28.32)	(18.17)
Schooling (= 1	6,653.9343			
if college, 0 otherwise)	(7.50)			
Innate ability (τ)	6,109.6419	1.3779		
	(7.04)	(33.84)		
Sociability (σ)	1,293.8865			
	(1.94)			
Motivation:	2,731.5873	0.1344		
Job aspiration (μ_1)	(4.10)	(3.54)		
Preschool ($h = 1$)	2,126.5631	0.3431	0.1457	0.0728
$H = 0$ no preschool	(2.55)	(7.51)	(3.63)	(1.89)
Parent's schooling (= 1		0.9480	0.2005	0.2925
If college, 0 otherwise)		(13.34)	(2.99)	(4.78)
Average value of the dependent variable		0.2069	0.3848	0.2119

Source: The author.

Note: Absolute t-values are provided in parentheses below the parameter estimates.

Table 5. Solutions of the Subgame Perfect Equilibrium

State				Invariant Distribution		
(s, τ, β, μ)	$w(s, \tau, \beta, \mu)$	opt. h^*	V*(z) (without)	p^* (without)	p^* (with)	V*(z) (with)
(0, 0, 0, 0)	8,718.235854	0	32,951.71	0.0614	0.0409	33,471.62
(0, 0, 1, 0)	10,122.63317	0	34,356.11	0.1370	0.1147	34,876.02
(0, 0, 0, 1)	10,144.64353	0	34,378.12	0.1310	0.1094	34,898.03
(0, 0, 1, 1)	11,549.04085	0	35,782.52	0.3200	0.3289	36,302.43
(0, 1, 0, 0)	14,975.44989	1	41,575.34	0.0082	0.0049	41,575.34
(1, 0, 0, 0)	15,463.36815	1	41,740.68	0.0028	0.0036	41,740.68
(0, 1, 1, 0)	16,379.8472	1	42,979.74	0.0189	0.0139	42,979.74
(0, 1, 0, 1)	16,401.85757	1	43,001.75	0.0123	0.0086	43,001.75
(1, 0, 1, 0)	16,867.76546	1	43,145.07	0.0073	0.0108	43,145.07
(1, 0, 0, 1)	16,889.7583	1	43,167.08	0.0338	0.0438	43,167.08
(0, 1, 1, 1)	17,806.25488	1	44,406.14	0.0303	0.0256	44,406.14
(1, 0, 1, 1)	18,294.17314	1	44,571.48	0.1066	0.1480	44,571.48
(1, 1, 0, 0)	21,720.58218	1	50,395.88	0.0046	0.0043	50,395.88
(1, 1, 1, 0)	23,124.9795	1	51,800.28	0.0118	0.0128	51,800.28
(1, 1, 0, 1)	23,146.98986	1	51,822.29	0.0279	0.0298	51,822.29
(1, 1, 1, 1)	24,551.38718	1	53,226.69	0.0859	0.1001	53,226.69

Source: The author.

do not invest in their children's preschool. If preschool is publicly provided for the children of poor SES, it will have many economic benefits: It will increase social mobility, it will reduce income inequality, it will improve college graduation rate, it will improve the community or criminal behaviour and it will also bring higher tax revenues because more workers would earn higher wages. It is important to note that the magnitude of the effects of publicly provided preschool depends on whether the social protection is available to all future generations or it is just a one-time deal.

While examining the estimated economic benefits in the following, it is important to keep in mind that the reported effects are underestimated for many reasons: First, I have treated the Head Start children in the same footing as the children without preschool. Second, the preschool programmes that the respondents went into were the ones that existed during the 1960s. The quality of preschool programmes ever since has improved significantly and thus the effects of current preschool programmes will be much higher than the estimates that we have.

Note that since ϵ does not affect earnings, the optimal h^* depends only on the observable component of the parent's state variables. In the absence of a social contract, suppose the parents follow the optimum preschool investment plan h^* as shown in Table 5. The invariant distribution of the corresponding transition matrix Q_{h^*} is also shown in Table 5 under the heading p^*(without). The interpretation of this invariant distribution is as follows: if p^*(without) is the distribution of population over the observable states of generation t, and the parents of generation t follow the optimal preschool investment plan h^*, then the distribution of population of the next generation will also be p^*(without). V*(z)(without) is the optimal value function without the public policy. The corresponding variables after the introduction of the public policy are denoted with a postfix "(with)" in the table.

Social Mobility

Given any transition matrix Q_{h^*} over the observable states, there exists a number of mobility measures in the literature. Sommers and Conlisk (1979) argue that out of the existing measures, $1 - \lambda_{\max}$ is the most appropriate measure of social mobility, where $\lambda_{\max}$ is the second highest positive eigenvalue of the transition probability matrix Q_{h^*} (the highest positive eigenvalue of a transition matrix is always 1). I use this measure of social mobility to examine how the introduction of a social contract would improve social mobility. The estimate of this measure of social mobility without a social contract is 0.6163. After the introduction of a social contract, it improves to 0.6770. The estimate of 0.6163 for the measure is very close to the estimates found in other studies of social mobility in the US.

College Mobility

Denote the intergenerational college mobility matrix in which state 1 represents no college and state 2 represents college and higher by $Q^s = \left[q_{ij}\right], i, j = 1, 2$. The element q_{ij} represents the probability that a child of a parent of college education status j will move to college education status i. In the following, I report the estimates of college mobility matrices, the corresponding invariant distributions and the estimates of the mobility measure before and after the introduction of the social contract. These estimates indicate that the introduction of the social contract will increase college graduation rate from 0.24 to 0.28 for a child of non-college parent. And the percentage of college graduate population will increase in the long run from the current low rate of 21 per cent to a much higher rate of 41 per cent with the introduction of the social contract and to a rate of 38 per cent without the social contract. That is, there will be a 3 per cent increase in college graduation rate in the long run.

College mobility statistics before introduction of social contract:

$$Q^s = \begin{bmatrix} 0.758 & 0.400 \\ 0.242 & 0.600 \end{bmatrix} \quad p^s = \begin{bmatrix} 0.623 & 0.377 \end{bmatrix} \quad 1 - \lambda^s_{\max} = 0.642$$

College mobility statistics after introduction of social contract:

$$Q^s = \begin{bmatrix} 0.720 & 0.400 \\ 0.280 & 0.600 \end{bmatrix} \quad p^s = \begin{bmatrix} 0.588 & 0.412 \end{bmatrix} \quad 1 - \lambda^s_{\max} = 0.680$$

Income inequality

Preschool experience will increase the income of the children of poor SES and thus it will reduce the income gap between the rich and the poor. In the long run, the income distribution that one observes is the invariant distribution. Taking the Gini coefficient as a measure of income inequality, the estimated coefficients of income inequality are, respectively, 0.1809 without the social contract and 0.1484 with the social contract. The estimated Gini coefficient of 0.1809 turns out to be very close to the estimates found in other studies on the US. Thus, the social contract of publicly providing preschool to children of poor SES leads to a significant reduction in income inequality.

Tax Burden of the Social Contract

Suppose the government provides preschool to the children of poor SES perpetually. We know that the size of the population of poor SES will become smaller and smaller overtime. Thus, the resource needs of the programme will become smaller and the tax revenues will become higher overtime. One can look at the stream of these costs and benefits to the society and then compute the average per period costs and benefits to calculate the tax burdens of the social contract. Applying the ergodic theorem, however, this boils down to computing the costs and benefits for the invariant distribution that would result after the introduction of the social contract.

Assuming a flat average income tax rate of 15 per cent for all income groups, I computed that each dollar spent to provide free preschool to children of poor SES, the taxpayers get back $1.16. This estimate is, however, based on using the cost data of a very high cost programme whose benefits are much higher than the estimated benefits of this model and also this benefit calculation does not take into account other public savings such as savings from welfare assistance and savings to the criminal justice system and victims of crimes. If these effects are incorporated, the returns would be much higher. Using data from the High/Scope Perry Preschool Program, Schweinhart et al. (1993) estimated a total benefit from all these sources to be $7.16 for each dollar spent on the preschool programme.

Conclusion

In this paper, I briefly survey the literature in economics, psychology and genetics–epigenetics of the developments of non-cognitive and cognitive skills, which predominately suggest that these skills are produced at the preschool stage of human development with important inputs. The paper uses two types of cognitive skills—the IQ score and the schooling level, and four types of non-cognitive skills—a socialization skill, two motivational skills, measured in terms of job aspiration and educational aspiration, and the self-control skill, measured in Rotter's locus of control scale. I estimate production functions of these skills with some of these inputs that could be readily created from the NLSY79 and NLSY79 Children and Young Adults data sets. I estimated an augmented Mincer earnings function with these non-cognitive skills together with other traditional Mincer earnings function variables as regressors. I find statistically significant positive effects of non-cognitive skills—independent of the effects of cognitive skills—on schooling level and earnings. Using these estimated relationships, I provide a calibrated intergenerational altruistic model of parental investment in children's preschool. The calibrated dynamic model is then used to estimate the effects of publicly provided preschool to the children of poor SES on the distribution of lifetime earnings, intergenerational college and social mobility. The paper also calculates the tax burden of the preschool programme.

The public policy effects in the long run found in the paper are as follows: Measured on a scale of 0 to 1, the policy improves the intergenerational earnings mobility from 0.616 to 0.677, and the college mobility from 0.642 to 0.680; reduces the within-generation lifetime earnings inequality measured by the Gini coefficient from 0.1809 to 0.1484; increases the college completion rate of the children of non-college-educated parents from 24 per cent to 28 per cent, a 4 percentage point increase; and the college-educated population increases from 37 per cent to 41 per cent, also a 4 percentage point increase. The policy results in a net gain (net of taxes) of the long-run per capita earnings. The society gets back 1.16 dollars for each dollar invested in the public programme.

The estimated affects in the paper may be underestimated for many reasons. First, the preschool programmes of the 1960s that the respondents attended were of lower quality than the quality of the current preschool programmes. Second, the pool of skill labour can create a positive externality in the aggregate production function of the economy, as is assumed in the endogenous growth models (for two such mechanisms, see Lucas [1988] and Raut [1995]). Third, the paper does not incorporate other savings to the society such as savings to the welfare programmes, criminal justice system and victims of crimes that would accrue because of the public preschool policy. When those effects are incorporated, the gains from the public preschool policy could be higher.

Acknowledgment

In memory of my mentor, collaborator and very good friend, Professor T.N. Srinivasan who passed away on November 10, 2018. Earlier drafts of this paper were presented at the 2003 Western Economic Association Meeting, and at the University of Southern California; Indian Statistical Institute, Kolkata; University of Nevada, Las Vegas; and California State University, Fullerton. I am grateful to the participants for making many useful comments. When I was a Visiting Fellow at the University of Chicago during 1998–1999, I had discussions with Professor James Heckman at an early stage of this preschool research project. In September 2015, my son, Han Altae-Tran, an Engineering undergrad student at Stanford at the time, suggested to me that emotions are important in socioeconomic behaviours, which triggered me to look into the neurobiology literature for my preschool research. During that summer, Professor T.N. Srinivasan at a dinner that we organized in his honor talked about neuroeconomics to us and to encourage Han with his interests in this area, sent us work of Camerer et al. (2005) and other references. I am grateful to them. I am also grateful to two anonymous referees of this journal for many valuable comments. This paper is a slightly updated version of my original (i.e., Raut, 2003).

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Notes

1. This might be true for post-secondary education in community colleges. Even for community colleges, the rate of returns from college education is higher than the interest rate for the federal college loan programme. Significantly higher percentages of students, however, are liquidity constrained for higher quality colleges, for which the rates of returns are even higher.

2. Interpreting no schooling in this model as low-quality schooling.
3. I am assuming that parents are not liquidity constrained for investing in their children's preschool. This is a strong assumption given that parents are at their early years of working age when they have children and might not have built up enough assets to be able to borrow from the market at the market interest rate.
4. See also the studies by Mohanty and Raut (2009) Cunha, Heckman, and Schennach (2010) and Del Boca, Flinn, and Wiswall (2014).
5. A recent US census reveals that more than 70 per cent of college students have worked while attending schools. I am assuming that their earnings are negligible relative to the cost of college or spent on consumption, not education, during the period.
6. Since the traditional Mincer earnings function does not incorporate skills such as σ and μ which can be produced by spending resources, I refer to our yearly permanent income incorporating σ and μ as an augmented Mincer earnings function.
7. Raut and Tran (2005) derive and estimate a model of schooling investment s^* as a Nash equilibrium outcome of a child-parent bargaining game in a model with only two overlapping generations.
8. Estimation of $h^*\left(\tilde{z}, \epsilon_p\right)$ and $s^*\left(\tau', \sigma', \mu', \epsilon_s', h\right)$ directly using actual data on preschool investment and completed schooling level is also known as reduced form estimation.
9. More generally, I could assume that $E\left(\epsilon_s'|\tau', \sigma', \mu', h\right) = 0$ and use the GLS method to correct for heteroskedasticity.

References

Aughinbaugh, A. (2001). Does head start yield long-term benefits? *The Journal of Human Resources*, *36*(4), 641. doi:10.2307/3069637

Balter, M. (2015). Poverty may affect the growth of children's brains. *Science*. doi:10.1126/science.aab0395

Bar-On, R. (2000). Emotional and social intelligence: Insights from the Emotional Quotient Inventory (EQ-I). In R. Bar-On & J. D. A. Parker (Eds.), *The handbook of emotional intelligence.* San Francisco, CA: Jossey-Bass.

Barnett, W. S. (1995). Long-term effects of early childhood programs on cognitive and school outcomes. *The Future of Children*, *5*(3), 25–50. doi:10.2307/1602366

Bhattacharya, R. N., & Majumdar, M. (1989). Controlled semi-markov models: The discounted case. *Journal of Statistical Planning and Inference*, *21*(3), 365–381. doi:https://doi.org/10.1016/0378-3758(89)90053-0

Bowlby, J. (1982). Attachment and loss: Retrospect and prospect. *American Journal of Orthopsychiatry*, *52*(4), 664–678. doi:10.1111/j.1939-0025.1982. tb01456.x

Camerer, C., Loewenstein, G., & Prelec, D. (2005). Neuroeconomics: How neuroscience can inform economics. *Journal of Economic Literature*, *43*(1), 9–64. doi:10.1257/0022051053737843

Campbell, F. A., Ramey, C. T., Pungello, E., Sparling, J., & Miller-Johnson, S. (2002). Early childhood education: Young adult outcomes from the abecedarian project. *Applied Developmental Science*, *6*(1), 42–57. doi:10.1207/s1532480xads0601_05

Carneiro, P., & Heckman, J. J. (2002). The evidence on credit constraints in post-secondary schooling. *The Economic Journal*, *112*(482), 705–734. doi:10.1111/1468-0297.00075

Chakrabarti, G., & Chatterjea, T. (2017). Intelligence?… emotions?… or, the emotional intelligence: Theories and evidence in global context. *Employees' Emotional Intelligence, Motivation & Productivity, and Organizational Excellence*, 11–49.

Champagne, D. L., Bagot, R. C., Hasselt, F. van, Ramakers, G., Meaney, M. J., Kloet, E. R. de, Joëls, M., & Krugers, H. (2008). Maternal care and hippocampal plasticity: Evidence for experience-dependent structural plasticity, altered synaptic functioning, and differential responsiveness to glucocorticoids and stress. *Journal of Neurosciencem*, *28*(23), 6037–6045. doi:10.1523/JNEUROSCI.0526-08.2008

Coleman, J. S. (1968). Equality of educational opportunity. *Equity & Excellence in Education*, *6*(5) 19–28. doi:10.1080/0020486680060504

Consortium for Longitudinal Studies. (1983). *As the twig is bent: Lasting effects of preschool programs*. Hillsdale, NJ: Lawrence Erlbaum.

Cunha, F., Heckman, J. J., & Schennach, S. M. (2010). Estimating the technology of cognitive and noncognitive skill formation. *Econometrica*, *78*(3), 883–931. doi:10.3982/ECTA6551

Currie, J. (2001). Early childhood education programs. *Journal of Economic Perspectives*, *15*(2), 213–238.

———. (2011). Inequality at birth: Some causes and consequences. *The American Economic Review*, *101*(3), 1–22.

Currie, J., & Almond D. (2011). Human capital development before age five. *Handbook of Labor Economics*, 1315–1486. doi:10.1016/s0169-7218(11) 02413-0

Currie, J., & Thomas, D. (1995, June). Does head start make a difference? *The American Economic Review*, *85*(3), 341–364.

Del Boca, D., Flinn, C., & Wiswall, M. (2014). Household choices and child development. *The Review of Economic Studies*, *81*(1), 137–85. doi:10.1093/restud/rdt026

Deming, D. J. (2017). The growing importance of social skills in the labor market. *The Quarterly Journal of Economics*, *132*(4), 1593–1640. doi:10.1093/qje/qjx022

Doherty, M. (2008). *Theory of mind: How children understand others' thoughts and feelings.* Hove: Psychology Press.

Duncan, G. J., Ziol-Guest, K. M., & Kalil, A. (2010). Early-childhood poverty and adult attainment, behavior, and health. *Child Development*, *81*(1), 306–25. doi:10.1111/j.1467-8624.2009.01396.x

Entwisle, D. R. (1995). The role of schools in sustaining early childhood program benefits. *The Future of Children*, *5*(3), 133–44. doi:10.2307/ 1602371

Goleman, D. (2009). *Emotional intelligence: Why it can matter more than IQ*. London: Bloomsbury.

Hair, N. L., Hanson, J. L., Wolfe, B. L., & Pollak, S. D. (2015). Association of child poverty, brain development, and academic achievement. *JAMA Pediatrics*, *169*(9), 822–29. doi:10.1001/jamapediatrics.2015.1475

Hanushek, E. A. (1986). The Economics of Schooling: Production and Efficiency in Public Schools. *Journal of Economic Literature*, *24*(3), 1141–1177.

Heckman, J. J. (2000). Policies to foster human capital. *Research in Economics*, *54*(1), 3–56. doi:10.1006/reec.1999.0225

Heckman, J. J., Moon, S. H., Pinto, R., Savelyev, P. A., & Yavitz, A. Q. (2010). Analyzing social experiments as implemented: A reexamination of the evidence from the High/Scope Perry Preschool Program. *Quantitative Economics*, *1*(1), 1–46. doi:10.3982/QE8

Heckman, J. J., & Raut, L. K. (2013). *Intergenerational long term effects of preschool: Structural estimates from a discrete dynamic programming model* (Working Paper No. 19077). National Bureau of Economic Research. doi:10.3386/w19077

———. (2016). Intergenerational long-term effects of preschool: Structural estimates from a discrete dynamic programming model. *Journal of Econometric*, *191*(1), 164–175. doi:10.1016/ j.jeconom.2015.10.001

Hellstrom, I. C., Dhir, S. K., Diorio, J. C., & Meaney, M. J. (2012). Maternal licking regulates hippocampal glucocorticoid receptor transcription through a thyroid hormone-serotonin-NGFI-A signalling cascade. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1601), 2495–2510. doi: 0.1098/rstb.2012.0223

Herrnstein, R., & Murray, C. (1994). *The bell curve: Intelligence and class structure in American life.* New York, NY: Free press. (1st Free Press paperbacks book).

Judd, K. L. (2002) The parametric path method: An alternative to Fair–Taylor and L–B–J for solving perfect foresight models. *Journal of Economic Dynamics and Control*, *26*(9), 1557–1583. doi:10.1016/S0165-1889(01)00085-9

Kahneman, D. (2013). *Thinking, fast and slow*. New York, NY: Farrar, Straus and Giroux.

Keane, M. P., & Wolpin, K. I. (1997). The career decisions of young men. *Journal of Political Economy*, *105*(3), 473–522. doi:10.1086/ 262080

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, *22*(1), 3–42. doi:10.1016/0304- 3932(88)90168-7

Mayer, J. D., Salovey, P., & Caruso, D. R. (2004). Emotional intelligence: Theory, findings, and implications. *Psychological Inquiry*, *15*(3), 197–215. doi:10.1207/s15327965pli1503_02

McCormick, K. (1989). *An equal chance: Educating at-risk children to succeed.* Alexandria, VA: National School Boards Association.

McEwen, B. S., & Gianaros, P. J. (2011). Stress- and Allostasis-induced brain plasticity. *Annual Review of Medicine*, *62*(1), 431–445. doi:10.1146/annurev-med-052209-100430

McEwen, B., & Morrison, J. (2013). The brain on stress: Vulnerability and plasticity of the prefrontal cortex over the life course. *Neuron*, *79*(1), 16–29. doi:10.1016/j.neuron.2013.06.028

Mezzacappa, E. (2017). Executive function. In *Reference module in neuroscience and biobehavioral psychology* (pp. 1–11). Amsterdam: Elsevier.

Mohanty, L. L., & Raut, L. K. (2009). Home ownership and school outcomes of children: Evidence from the PSID child development supplement. *American Journal of Economics and Sociology*, *68*(2), 465–89. doi:10.1111/j.1536-7150.2009.00635.x

Murgatroyd, C., & Spengler, D. (2011). Epigenetics of early child development. Frontiers in Psychiatry, *2*, 16. doi:10.3389/fpsyt.2011.00016

NETWORK, N. E. C. C. R. (2004). Affect dysregulation in the mother–child relationship in the toddler years: Antecedents and consequences. *Development and Psychopathology*, *16*(1). doi:10.1017/s0954579404044402

Nishimura, K., & Raut, L. K. (2007). School choice and the intergenerational poverty trap. *Review of Development Economics*, *11*(2), 412–420. doi:10.1111/j.1467-9361.2007.00411.x.

Noble, K. G., Houston, S. M., Brito, N. H., Bartsch, H., Kan, E., Kuperman, J. M., ... Sowell, E. R. (2015). Family income, parental education and brain structure in children and adolescents. *Nature Neuroscience*, *18*(5), 773–778. doi:10. 1038/nn.3983

Noble, K. G., Houston, S. M., Kan, E., & Sowell, E. R. (2012). Neural correlates of socioeconomic status in the developing human brain. *Developmental Science*, *15*(4), 516–527. doi:10.1111/j.1467- 7687.2012.01147.x

Plomin, R., & Deary, I. J. (2015). Genetics and intelligence differences: Five special findings. *Molecular Psychiatry*, *20*(1), 98–108. doi:10.1038/mp.2014. 105

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences*, *1*(4), 515–526. doi:10.1017/S0140525X00076512

Raut, L. K. (1990). Capital accumulation, income distribution and endogenous fertility in an overlapping generations general equilibrium model. *Journal of Development Economics*, *34*(1–2), 123–150. doi:10.1016/0304-3878(90) 90079-q

———. (1995). *Signaling equilibrium, intergenerational social mobility and long run growth*. Draft Presented at the Seventh World Congress of Econometric Society. doi:10.2139/ssrn.852924

———. (2003). *Long term effects of preschool investment on school performance and labor market outcome* (Labor and Demography 0307002). University Library of Munich.

Raut, L. K., & Tran, L. H. (2005). Parental human capital investment and old-age transfers from children: Is it a loan contract or reciprocity for Indonesian families? *Journal of Development Economics*, *77*(2), 389–414. doi:10. 1016/j.jdeveco.2004.04. 003

Reynolds, A. J., Ou, S.-R., & Temple, J. A. (2018) A multicomponent, preschool to third grade preventive intervention and educational attainment at 35 years of age. *JAMA Pediatrics*, *172*(3), 247–256. doi:10.1001/jamapediatrics.2017.4673

Reynolds, A. J., Temple, J. A., Robertson, D. L., & Mann, E. A. (2001). Long-term effects of an early childhood intervention on educational achievement and juvenile arrest. *JAMA*, *285*(18), 2339–2346. doi:10.1001/jama.285.18.2339

Ruffman, T., Slade, L., & Crowe, E. (2002). The relation between children's and mothers mental state language and theory-of-mind understanding. *Child Development*, *73*(3), 734–751. doi:10.1111/1467-8624.00435

Rust, J. (1994a). Estimation of dynamic structural models, problems and prospects: Discrete decision processes. In C. A. Sims (Ed.), *Advances in econometrics: Sixth World Congress* (Econometric Society Monographs, Vol. 2, pp. 119–70). Cambridge University Press. doi:10.1017/CCOL0521444608.004

Rust, J. (1994b). Structural estimation of Markov decision processes. In R. Engle & D. McFadden (Eds.), *Handbook of econometrics*. (Vol. 4, pp. 3081–3143). New York, NY: North-Holland. doi:10.1016/s1573-4412(05)80020-0

———. (1996). Numerical dynamic programming in economics. In H. M. Amman, D. A. Kendrick, & J. Rust (Eds.), *Handbook of computational economics* (Vol. 1, pp. 619–729). New York, NY: Elsevier. Retrieved from https://doi.org/10.1016/S1574-0021(96)01016-7

Schore, A. N. (2005). Back to basics: Attachment, affect regulation, and development of the right brain—Linking developmental neuroscience to pediatrics. *Pediatrics in Review*, *26*(6), 204–217. doi:10.1542/pir.26-6-204

Schore, J. R., & Schore, A. N. (2008). Modern attachment theory: The central role of affect regulation in development and treatment. *Clinical Social Work Journal*, *36*(1), 9–20. doi:10.1007/s10615-007-0111-7

Schweinhart, L. J., Barnes, H. V., & Weikart, D. (1993). *Significant benefits: The High/Scope Perry Preschool study through age 27*. Ypsilanti, MI: High/Scope Press.

Sommers, P. M., & Conlisk, J. (1979). Eigenvalue immobility measures for Markov chains. *The Journal of Mathematical Sociology*, *6*(2), 253–76. doi:10.1080/0022250x.1979.9989891

Traub, J. (2000, January 16). What no school can do. *The New York Times Magazine.* Retrieved from https://www.nytimes.com/2000/01/16/magazine/what-no-school-can-do.html

Winter, E. (2014). *Feeling smart: Why our emotions are more rational than we think*. New York, NY: Public Affairs.

Woolley, A. W., Chabris, C. F., Pentland, A., Hashmi, N., & Malone, T. W. (2010). Evidence for a collective intelligence factor in the performance of human groups. *Science*, *330*(6004), 686–688. doi:10.1126/science.1193147

Yoshikawa, H. (1995). Long-term effects of early childhood programs on social outcomes and delinquency. *The Future of Children*, *5*(3), 51. doi:10.2307/1602367