# Human Capital Development: New Evidence on the Production of Socio-Emotional Skills

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# Online Appendix

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# A Identification and Estimation

For our main results we estimate Equations 2, 3 (for socio-emotional and cognitive skills, respectively) and 1 (for investments) in between the ages of 8-12, 12-15, and 15-19 following Agostinelli and Wiswall (2020). In this Online Appendix, we show how this is done for the more general case that allows for dynamic complementarity in the production functions of skills by including the term $\ln H_{j,t} \times \ln I_t$ for $j \in \{s,c\}$, as follows:[1]

(A1) $$\ln H_{s,t+1} = \rho^s_{1,t} \ln H_{s,t} + \rho^s_{2,t} \ln H_{c,t} + \alpha^s_{1,t} \ln P_s + \alpha^s_{2,t} \ln P_c + \gamma^s_t \ln I_t + \kappa^s_t \left(\ln H_{j,t} \times \ln I_t\right) + \eta^s_t$$

(A2) $$\ln H_{c,t+1} = \rho^c_{1,t} \ln H_{c,t} + \rho^c_{2,t} \ln H_{s,t} + \alpha^c_{1,t} \ln P_c + \alpha^c_{2,t} \ln P_s + \gamma^c_t \ln I_t + \kappa^c_t \left(\ln H_{j,t} \times \ln I_t\right) + \eta^c_t$$

Assuming that $\kappa^s_t = 0$ is equivalent to assuming the production function of socio-emotional skills is Cobb-Douglas, as in Equations 2, 3 (main text). If, however, $\kappa^s_t \neq 0$, investments can be more ($\kappa^s_t > 0$) or less ($\kappa^s_t < 0$) productive in children with higher stocks of skill. Put differently, $\kappa^s_t \neq 0$, captures any dynamic complementarities between already accumulated human capital and investments - the dynamic relationship between skills and investments that could result in the opening and widening of inequalities in human capital (Cunha, Heckman, and Schennach 2010).

The starting point in estimating this system is the identification of the initial period measurement parameters and the joint distribution of the initial conditions. Given that we have three measures of each of the latent variables in the initial period and have assumed full independence of the measurement errors, we are able to identify and estimate both. With the initial period measurement parameters and the joint distribution of the initial conditions recovered, Agostinelli and Wiswall (2020) show that the

[1] It is possible to include both ($\ln H_{s,t} \times \ln I_t$) and ($\ln H_{c,t} \times \ln I_t$) simultaneously. However, for estimation purposes we only include one interaction at a time due to the collinearity between the interaction terms.

technologies in Equations A1, A2 and 1 (main text) can be sequentially identified in each subsequent period.

Estimation of the model of human capital accumulation between the ages of 8 and 19 laid out in Section 2 consists of four main steps:

1. First, we estimate the joint distribution of the initial conditions.
2. We then estimate the investment function of Equation 1 and recover the investment measurement parameters in the first period.
3. Next, we estimate the production function and measurement parameters for socio-emotional and cognitive skill in period 1.
4. We then repeat steps 2 and 3 for periods 2 and 3.

We then estimate the measurement system of two domains of socio-emotional skill at age 22: task effectiveness and social skills. We impose normalizations on this measurement system that allow us to identify and estimate the flexible production functions - shown in Equation 4 - of these skills between the ages of 19 and 22.

## A.1 The Joint Distribution of Initial Conditions

The factor loadings of the measures of the initial conditions are retrieved by taking the ratio of the covariances of the observed measures. For example:

$$\text{(A3)} \qquad \lambda_{\theta,m,0} = \frac{\text{Cov}\left(Z_{\theta,m,0}, Z_{\theta,m',0}\right)}{\text{Cov}\left(Z_{\theta,1,0} Z_{\theta,m',0}\right)} \quad \forall m' \neq m$$

Imposing the normalization that the initial period latent variables all have a mean of zero, the measurement intercepts $\mu_{\theta,m,0}$, can be estimated by $\mathbb{E}(Z_{\theta,m,0})$. We then residualize measures as follows:

(A4) $$\tilde{Z}_{\theta,m,0} = \frac{Z_{\theta,m,0} - \mu_{\theta,m,0}}{\lambda_{\theta,m,0}} = \ln\theta_0 + \tilde{\varepsilon}_{\theta,m,0} = \ln\theta_0 + \frac{\varepsilon_{\theta,m,0}}{\lambda_{\theta,m,0}} \quad \forall m$$

The latent variables are then equivalent to:

(A5) $$\tilde{Z}^{*}_{\theta,m,0} = \tilde{Z}_{\theta,m,0} - \tilde{\varepsilon}_{\theta,m,0} = \ln\theta_0$$

Having identified and estimated the factor loadings, the theorem of Kotlarski (1967) can be applied to the set of residual measures, $\{\tilde{Z}_{\theta,m,0}\}_{m=1}^{M_{\theta,0}}$, to identify the distributions of $\ln\theta_0$ and $\varepsilon_{\theta,m,0}$ conditional on $\mathbf{I}_0$. This then allows identification of the joint distribution of the initial conditions and investments at $t = 0$. Agostinelli and Wiswall (2020) show that the production technologies are sequentially identified in each of the following periods $t = 0, \ldots, T$.

The diagonal and off-diagonal elements of the covariance matrix of the initial conditions can be estimated by

(A6) $$\frac{\text{Cov}(Z_{\theta,1,0}, Z_{\theta,2,0})\text{Cov}(Z_{\theta,1,0}, Z_{\theta,3,0})}{\text{Cov}(Z_{\theta,2,0}, Z_{\theta,2,0})} = \frac{\lambda_{\theta,2,0}\lambda_{\theta,3,0}\text{Var}(\ln\theta_0)^2}{\lambda_{\theta,2,0}\lambda_{\theta,3,0}\text{Var}(\ln\theta_0)} = \text{Var}(\ln\theta_0)$$

and

(A7) $$\text{Cov}(Z_{\theta,1,0}, Z_{\theta',1,0}) = \text{Cov}(\ln\theta_0, \ln\theta_0')$$

respectively. Since $\ln Y_0$ and $\ln Z_0$ are measured without error, their respective variance is easily computed, and their covariances with a given unobservable initial condition, $\theta_0$, are:

$$\text{Cov}(\ln Y_0, \ln\theta_0) = \text{Cov}(\ln Y_0, Z_{\theta,1,0})$$

Given the assumption that unobservables are mean zero in the initial period, the mean vector is

$$\mu_\Omega = (0, 0, 0, 0, 0, 0, \mu_{Y,0})$$

## A.2 Investment Functions

Substituting Equation 1 in to one measurement equation for investment in the first period gives the following expression:

$$Z_{I_0,m,0} = \mu_{I_0,m,0} + \lambda_{I_0,m,0}(\beta_{1,0} \ln H_{s,0} + \beta_{2,0} \ln H_{c,0} + \beta_{3,0} \ln P_s$$

(A8) $$+ \beta_{4,0} \ln P_c + \beta_{5,0} \ln Y_0 + \pi_0) + \varepsilon_{I_0,m,0}$$

Substituting the corresponding proxies of latent inputs in to the investment equations - $\tilde{Z}^*_{\theta,m,0}$ for each $\theta_0 \in \{H_{s,0}, H_{c,0}, P_s, P_c\}$- in to Equation A8 in place of the unobservables, this can be re-written as

$$Z_{I_0,m,0} = \mu_{I_0,m,0} + \lambda_{I_0,m,0}(\beta_{1,0}\tilde{Z}^*_{H_s,m,0} + \beta_{2,0}\tilde{Z}^*_{H_c,m,0} + \beta_{3,0}\tilde{Z}^*_{P_s,m}$$

(A9) $$+ \beta_{4,0}\tilde{Z}^*_{P_c,m} + \beta_{5,0}\ln Y_0 + \pi_0) + \varepsilon_{I_0,m,0}$$

and so

$$Z_{I_0,m,0} = \mu_{I_0,m,0} + \delta_{1,0}\tilde{Z}_{H_s,m,0} + \delta_{2,0}\tilde{Z}_{H_c,m,0} + \delta_{3,0}\tilde{Z}_{P_s,m}$$

(A10) $$+ \delta^j_{4,0}\tilde{Z}_{P_c,m} + \delta_{5,0}\ln Y_0 + \nu_0$$

where

$$\delta_{i,0} = \lambda_{I_0,m,0}\beta_{i,0} \quad \text{for} \quad i = 1,..,5$$

$$\nu_0 = \varepsilon_{I_0,m,0} + \lambda_{I_0,m,0}(\pi_0 - \beta_{1,0}\tilde{\varepsilon}_{H_s,m,0} - \beta_{2,0}\tilde{\varepsilon}_{H_c,m,0} - \beta^j_{3,0}\tilde{\varepsilon}_{P_s,m,0} - \beta^j_{4,0}\tilde{\varepsilon}_{P_c,m,0})$$

Since we are using error contaminated proxies for the latent inputs of Equation A10, $\mathbb{E}(\tilde{Z}_{\theta,m,0}\nu_{j,0}) \neq 0$. We therefore use all other measures of each latent variable as instruments to estimate the reduced form parameters in Equation A10. Given the assumptions on the measurement errors, $\mathbb{E}\left(Z_{\theta,m',0}\nu_{j,0}\right) = 0 \quad \forall\theta_0$ and $m' \neq m$, and so these alternative measures are valid instruments. With the CRS assumption we can recover the measurement and structural parameters of the investment equation as:

$$\beta_{i,0} = \frac{\delta_{i,0}}{\sum_{i=1}^{6} \delta_{i,0}} = \frac{\lambda_{I_0,m,0}\beta_{i,0}}{\sum_{i=1}^{6} \lambda_{I_0,m,0}\beta_{i,0}^{j}} \quad \text{for} \quad i = 1,..,5$$

We then construct residual investment measures as:

$$\tilde{Z}_{I,m,0} = \frac{Z_{I,m,0} - \mu_{I,m,0}}{\lambda_{I,m,0}} = \ln I_0 + \tilde{\varepsilon}_{I,m,0}$$

and investment is equal to:

$$\tilde{Z}^{*}_{I_j,m,0} = \tilde{Z}_{I_0,m,0} - \tilde{\varepsilon}_{I,m,0} = \ln I_0 \qquad \text{(A11)}$$

## A.3 Production Functions

The parameters of Equations A1 and A2 are estimated in an identical manner. We show how this is done for Equation A1. We start by substituting Equation A1 in to that of an observable measurement of period 1 stock of socio-emotional skill, giving:

$$Z_{H_s,m,1} = \mu_{H_s,m,1} + \lambda_{H_s,m,1}(\rho^{s}_{1,0} \ln H_{s,0} + \rho^{s}_{2,0} \ln H_{c,0} + \alpha^{s}_{1,0} \ln P_s + \alpha^{s}_{2,0} \ln P_c$$

$$+ \gamma^{s}_{0} \ln I_0 + \kappa^{s}_{0}(\ln H_{s,0} \ln I_0) + \eta^{s}_{0}) + \varepsilon_{H_s,m,1} \qquad \text{(A12)}$$

Once again using the fact that, based on the measurement system laid out in Equation 6, $\tilde{Z}^*_{\theta,m,0} = \ln \theta_0$ for $\theta_0 \in \{H_{s,0}, H_{c,0}, P_s, P_c, I_0\}$, Equation A12 can be rewritten as

$$Z_{H_s,m,1} = \mu_{H_s,m,1} + \lambda_{H_s,m,1}(\rho^s_{1,0}\tilde{Z}^*_{H_{s,0},m,0} + \rho^s_{2,0}\tilde{Z}^*_{H_{c,0},m,0} + \alpha^s_{1,0}\tilde{Z}^*_{P_s,m,0} + \alpha^s_{2,0}\tilde{Z}^*_{H_c,m,0}$$

(A13) $$+ \gamma^s_0\tilde{Z}^*_{I_0,m,0} + \kappa^s_0(\tilde{Z}^*_{H_{s,0},m,0}\tilde{Z}^*_{I_0,m,0}) + \eta^s_0) + \varepsilon_{H_s,m,1} \quad ,$$

which can be re-arranged as:

$$Z_{H_s,m,1} = \mu_{H_s,m,1} + \phi^s_{1,0}\tilde{Z}_{H_{s,0},m,0} + \phi^s_{2,0}\tilde{Z}_{H_{c,0},m,0} + \chi^s_{1,0}\tilde{Z}_{P_s,m,0} + \chi^s_{2,0}\tilde{Z}_{H_c,m,0}$$

(A14) $$+ \tau^s_0\tilde{Z}_{I_0,m,0} + \psi^s_0(\tilde{Z}_{H_{s,0},m,0}\tilde{Z}_{I_0,m,0}) + \upsilon^s_1$$

where

$$\phi^s_{i,0} = \lambda_{H_s,m,1}\rho^s_{i,0} \qquad \text{for} \quad i = 1,2$$

$$\chi^s_{i,0} = \lambda_{H_s,m,1}\alpha^s_{i,0} \qquad \text{for} \quad i = 3,4$$

$$\tau^s_0 = \lambda_{H_s,m,1}\gamma^s_0$$

$$\psi^s_0 = \lambda_{H_s,m,1}\kappa^s_0$$

and

$$\upsilon_1^j = \varepsilon_{H_s,m,1} + \lambda_{H_j,m,1}[\eta_0^s - \rho_{1,0}^s\tilde{\varepsilon}_{H_{s,0},m,0} - \rho_{2,0}^s\tilde{\varepsilon}_{H_{c,0},m,0} - \alpha_{1,0}^s\tilde{\varepsilon}_{P_s,m,0} - \alpha_{2,0}^s\tilde{\varepsilon}_{P_c,m,0} - \gamma_0^s\tilde{\varepsilon}_{I_0,m,0}$$

$$- \kappa_0^s(\tilde{Z}_{H_{s,0},m,0}\tilde{\varepsilon}_{I_0,m,0} + \tilde{Z}_{I_0,m,0}\tilde{\varepsilon}_{H_{s,0},m,0} + \tilde{\varepsilon}_{H_{s,0},m,0}\tilde{\varepsilon}_{I_0,m,0})] \quad \text{(A15)}$$

As in the estimation of the production functions, all alternative measures of the inputs are used as instrumental variables with their validity implied by assumptions regarding the joint distribution of the unobservables and measurement errors. The assumption of CRS again allows the structural parameters of Equation A1 to be calculated as

$$\rho_{i,0}^s = \frac{\phi_{i,0}^s}{\phi_{1,0}^s + \phi_{2,0}^s + \chi_{1,0}^s + \chi_{2,0}^s + \tau_0^s + \psi_0^s} \qquad \text{for} \quad i = 1,2$$

$$\alpha_{i,0}^s = \frac{\chi_{i,0}^s}{\phi_{1,0}^s + \phi_{2,0}^s + \chi_{1,0}^s + \chi_{2,0}^s + \tau_0^s + \psi_0^s} \qquad \text{for} \quad i = 3,4$$

$$\gamma_0^s = \frac{\tau_0^s}{\phi_{1,0}^s + \phi_{2,0}^s + \chi_{1,0}^s + \chi_{2,0}^s + \tau_0^s + \psi_0^s}$$

$$\kappa_0^s = \frac{\psi_0^s}{\phi_{1,0}^s + \phi_{2,0}^s + \chi_{1,0}^s + \chi_{2,0}^s + \tau_0^s + \psi_0^s}$$

The denominator in each of the above equations gives the factor loading relating period 1 stock of socio-emotional skill to the observable measure $Z_{H_s,m,1}$. That is,

$$\lambda_{H_s,m,1} = \phi_{1,0}^s + \phi_{2,0}^s + \chi_{1,0}^s + \chi_{2,0}^s + \tau_0^s + \psi_0^s$$

Again, a residual measure of socio-emotional skill in period 1 can then be constructed as:

$$\tilde{Z}_{H_s,m,1} = \frac{Z_{H_s,m,1} - \mu_{H_s,m,1}}{\lambda_{H_s,m,1}} = \ln H_{s,1} + \tilde{\varepsilon}_{H_s,m,1}$$

and latent socio-emotional skill can be defined as being equal to:

$$\tilde{Z}^*_{H_j,m,1} = \tilde{Z}_{H_j,m,1} - \tilde{\varepsilon}_{H_j,m,1} = \ln H_{j,1}$$

The parameters of the cognitive production function and measurement system are estimated, and a residual measure of cognitive skill constructed, in the same way. An identical process for estimating the investment and production functions is then used in each subsequent period.

## A.4 Variance of Investment and Production Shocks

The variance of shocks to investment and production are estimated by as the covariance between the residual from Equations A10 and A14 with an alternative measure of their output, respectively. Alternative residual measures are constructed by estimating Equations A10 and A14 using $Z_{H_j,m',0}$ for $j \in \{s,c\}$ and $Z_{I_s,m',0}$ as outcomes and retrieving their measurement parameters. Given the assumptions on the measurement errors the variance of shocks can be estimated in each $t$ as:

$$\text{Cov}(\frac{\nu_t}{\lambda_{I,m,t}}, \tilde{Z}_{I,m',t}) = \text{Var}(\pi_t) = \sigma^2_{\pi,t}$$

and

$$\text{Cov}(\frac{\upsilon^j_t}{\lambda_{H_j,m,t}}, \tilde{Z}_{H_j,m',t}) = \text{Var}(\eta^j_t) = \sigma^2_{H_j,t}$$

## A.5 Signal to Noise Ratios

The proportion of the variance in an observable measure attributable to the latent variable it proxies as opposed to measurement error is estimated as a function of its measurement parameters and the variance of the unobservable. In the initial period, these are calculated as in Section A.1. In subsequent periods, they are recovered by estimating Equations A10 and A14 using each measure of investment and human capital as the dependent variable. The signal in, for example, a measure of socio-emotional skill at time *t*, is then given by

$$\text{(A16)} \qquad s_{H_{s,1},m,t} = \frac{\lambda^2_{H_{s,1},m,t} V(\ln H_{s,1})}{\lambda^2_{H_{s,1},m,t} V(H_{s,1}) + V(\varepsilon_{H_{s,1},m,t})} = \frac{\lambda^2_{H_{s,1},m,t} \mathrm{Cov}(\tilde{Z}_{H_{s,1},m,t}, \tilde{Z}_{H_{s,1},m',t})}{V(Z_{H_{s,1},m,t})}$$

## A.6 Socio-emotional Skills in Early Adulthood

For the measures of three domains of socio-emotional skill - task-effectiveness (t) and social skills (s) - at age 22 ($T + 1$) we estimate the measurement system laid out in Equation 6 imposing the following normalizations for $j \in \{t, s\}$:

$$E(\ln H^j_{s,T+1}) = 0$$

$$\lambda_{H^j_{s,1,T+1}} = 1$$

These normalizations fix the location and scale of each of these latent socio-emotional skills to one of their observable measures. They also allow us to estimate the measurement means as $E(Z_{H_s,m,T+1}) = \mu_{H_s,m,T+1}$. Given these measurement parameters, we take one measurement equation for socio-emotional skill $Z_{H^j_s,m,T+1}$ and substitute in to it Equation 4, giving:

$$Z_{H^j_s,m,T+1} = \mu_{H^j_s,m,T+1} + \lambda_{H^j_{s,m,T+1}}(\ln A_T + \rho^{s,j}_{1,T} \ln H_{s,T} + \rho^{s,j}_{2,T} \ln H_{c,T} + \eta^{s,j}_T) + \varepsilon_{H^j_s,m,T+1}$$

After substituting in to this Equation residual measures of period $T$ socio-emotional and cognitive skill and rearranging, we arrive at an expression similar to Equations A10 and A14:

$$\text{(A17)} \qquad Z_{H_s^j,m,T+1} = \mu_{H_s,m,T+1} + \phi_{1,T+1}^{s,j}\tilde{Z}^*_{H_s,m,T} + \phi_{2,T+1}^{s,j}\tilde{Z}^*_{H_c,m,T} + \lambda_{H^j_{s,m,T+1}} \ln A_T + \upsilon_{T+1}^{s,j}$$

Substituting in our expression of ln $A_T$, this can be re-written as:

$$\text{(A18)} \qquad Z_{H_s^j,m,T+1} = \phi_{0,T+1}^{s,j} + \phi_{1,T+1}^{s,j}\tilde{Z}_{H^s,m,T} + \phi_{2,T+1}^{s,j}\tilde{Z}_{H_c,m,T} + \boldsymbol{x}_T'\omega_{T+1}^{s,j} + \upsilon_{T+1}^{s,j}$$

where:

$$\phi_{0,T+1}^{s,j} = \mu_{H_s,m,T+1} + \lambda_{H^j_{s,m,T+1}}\alpha_T$$

$$\phi_{i,T+1}^{s,j} = \lambda_{H^j_{s,m,T+1}}\rho_{i,T}^{s,j} \qquad \text{for } i = 1,2$$

$$\omega_{T+1}^{s,j} = \lambda_{H^j_{s,m,T+1}}\boldsymbol{\beta}$$

$$\upsilon_{T+1}^{s,j} = \varepsilon_{H_s^j,m,T+1} + \lambda_{H^j_{s,m,T+1}}(\eta_T^{s,j} - \rho_{1,T}^{s,j}\tilde{\varepsilon}_{H_s,m,T} - \rho_{2,T}^{s,j}\tilde{\varepsilon}_{H_c,m,T})$$

Given the normalizations on the period $T$ measurement system, both $\mu_{H_s,m,T+1}$ and $\lambda_{H^j_{s,m,T+1}}$ are known, and the location and scale of socio-emotional skill is anchored in one of its measures. Using the same instrumental variables strategy as when estimating the investment and production functions of periods 1-3, we can then recover $\alpha_T$, $\boldsymbol{\beta}$, and $\rho_{i,T}^{s,j}$ for $i$ = 1,2 without restriction of CRS. We estimate the returns to scale (RTS) as:

$$\frac{\phi^{s,j}_{2,T+1} + \phi^{s,j}_{1,T+1}}{\lambda_{H^j_{s,m,T+1}}} = \frac{\lambda_{H^j_{s,m,T+1}}(\rho^{s,j}_{1,T} + \rho^{s,j}_{2,T})}{\lambda_{H^j_{s,m,T+1}}}$$

## A.7 The Parameters of the Adult Outcome Equation

Substituting a residual measure of $T + 1$ task effectiveness and social skills, and a time $T$ measure of cognition in to Equation 11 gives:

(A19) $$O_{T+1} = \mu_o + \gamma^o_1 \tilde{Z}^*_{H^t_s,m,T+1} + \gamma^o_2 \tilde{Z}^*_{H^s_s,m,T+1} + \gamma^o_3 \tilde{Z}^*_{H_c,m,T} + \boldsymbol{x}'_{T+1}\boldsymbol{\delta} + \eta^o_{T+1}$$

As in estimating the production and investment equations across period 1-4, this can be rearranged as:

(A20) $$O_{T+1} = \mu_o + \gamma^o_1 \tilde{Z}_{H^t_s,m,T+1} + \gamma^o_2 \tilde{Z}_{H^s_s,m,T+1} + \gamma^o_3 \tilde{Z}_{H_c,m,T} + \boldsymbol{x}'_{T+1}\boldsymbol{\delta} + \nu^o_{T+1} \quad ,$$

where

(A21) $$\nu^o_{T+1} = \eta^o_{T+1} + \gamma^o_1 \varepsilon_{H^p_s,m,T+1} + \gamma^o_2 \varepsilon_{H^l_s,m,T+1} + \gamma^o_3 \varepsilon_{H_c,m,T}$$

Although we do not have to disentangle the factor loadings from the parameters of the outcome equation, we have an identical measurement error problem as in estimating Equations A10, A14 and A18.

Given we use indicators of risky behaviors as outcomes, we use a similar instrumental variable strategy and estimate a linear probability model using alternative measures of the two socio-emotional skill domains and cognition as instruments - but for binary outcomes with endogenous, continuous independent variables. We favor this method over maximum likelihood or control function methods for two main reasons. Firstly, consistency estimators based on these methods relies on full specification of the first stage equations and having continuously distributed endogenous variables (Blundell and

Powell 2004). The variables we use as proxies are not truly continuous (although we assume that the latent variables are), and we know we do not have a complete set of relevant instruments on the latent variables, so these assumptions are not satisfied. An estimator of an LPM using 2SLS will not be inconsistent, however, and only on standard IV assumptions i.e. that $\mathbb{E}(Z_{H_s^k,m',T+1}\nu_{j,0}) = 0 \quad \forall\, H_s^k$ and $m' \neq m$.

Secondly, an IV LPM makes no assumptions about the distribution of the measurement error, whereas ML/control function methods rely on joint normality of $\nu_{T+1}^{o}$ and in the error term in the first stage regressions. Given $\nu_{T+1}^{o}$ is an additive function of the measurement error and outcome equation error, this amounts to assuming that the measurement errors, outcome equation errors, and the errors in the first stage regressions are jointly normally distributed. As alluded to in the main body of this study, the methodology we use to estimate the investment and human capital production functions is robust to non-normal measurement errors (Agostinelli and Wiswall 2020), an added benefit given Laajaj and Macours (2019) find evidence that measurement error in socio-emotional skill measures is non-classical among samples in Kenya and Colombia.

# B Additional description of child assessments

The observable measures of child and parental human capital and investment in the Young Lives data are derived from both caregivers' and children's responses to survey questions across waves. In the case of cognitive skill, all measures are scores on tests administered as part of the survey. Below, we provide more detail on the types of measures used for each of the inputs in to and outputs of the human capital development process.

## Socio-Emotional Skill Measures

We do not use all of the socio-emotional measures available in the YL survey. Instead, where possible, we focus on those that can be described as reflecting children's Core Self-Evaluation (CSE) - those that predominantly ask questions about the children themselves, and their evaluation of aspects of their personality. For example, we excluded commonly used measures of subjective wellbeing such as Cantril's ladder (Cantril 1965), and measures of children's trust in others or their social networks. We also use measures in some rounds but not in others because their sub-items changed over time. This is the case, for example, with measures of pride and self-esteem, which change substantially after age 15.

### Early Socio-Emotional Skills

In the initial period at age eight, the children are not directly asked questions so we used caregivers' responses to 25 questions designed to measure five aspects of the children's socio-emotional skills: emotional symptoms, conduct issues, inattention, peer/relationship problems, and pro-social behavior. Each of these subscales contains five questions about whether a child exhibits certain behaviors. In the survey, the possible responses caregivers could provide were *yes*, *sometimes*, and *no*. We assign numerical responses and sum within the five subscales, giving us five measures of socio-emotional skill.

**Young Lives Psychosocial Scales**

Across its rounds, the Young Lives survey has adapted several commonly used scales designed to measure specific psychosocial characteristics. At ages 12, 15, 19, and 22 we use a measure of *pride and self-esteem*, based on Rosenberg (1965) scale. This scale poses statements to children about their self-confidence as it relates to their belongings, home, abilities, work, and achievements. For example, the following statements are contained in the scale:

- *I feel proud the show my friends or other visitors where I live*;

- *I am often proud because I do have the right books, pencils, and other equipment for school*;

- *I am proud of my achievement at school*; and

- *The job I do makes me feel proud*.

The children are then asked to what degree these statements represent their beliefs. At age 12, possible responses are on a three-point scale of *no*, *yes*, or *more or less*, respectively. At ages 15, 19, and 22 possible responses were on a five-point scale from *strongly agree* to *strongly disagree*. After being assigned a numeric value, responses were summed to give each child a pride/self-esteem "score". We also use a scale measuring agency at ages 12, 15, 19, and 22. This scale is based on Rotter (1966) and Bandura (1993), and poses a number of statements to children about the degree of control they have over their life. For example, the scale includes statements such as:

- *If I try hard I can improve my situation in life*;

- *I like to make plans for my future studies and work*; and

- *If I study hard at school I will be rewarded by a better job in the future.*

The possible responses across ages are the same as in the case of the pride and self-esteem scale. Again, once assigned a numeric value, these responses are summed to give each child an agency/self-efficacy score. More information on the selection, construction, and validity of all of these scales can be found in Yorke and Ogando (2018).

**General Self-Efficacy**

At ages 19 and 22 we utilize a newly added self-efficacy measure from the Young Lives data. This measure is based on the *general self-efficacy* scale of Jerusalem and Schwarzer (1979), which is designed to measure individuals' belief in their self-determination and ability to cope with adversity. Again, the scale consists of statements that children are asked to agree/disagree with. It contains statements such as:

- *I can always manage to solve difficult problems if I try hard enough*;
- *It is easy for me to stick to my aims and accomplish my goals*; and
- *I can solve most problems if I invest the necessary effort*.

Responses to these statements are on a four-point scale from *strongly agree* to *strongly disagree*. These responses are assigned numeric values and then summed to prove a general self-efficacy "score" which we use as a measure of socio-emotional skill. Yorke and Ogando (2018) provides more detailed information on the selection and construction of this scale in the Young Lives data.

**Marsh Self-Description**

At ages 19 and 22, we also use subscales of the Marsh Self-Description Questionnaires measuring general self-esteem, peer relations, and parent relations. Each subscale is comprised of eight statements about self-concept in the respective domain. They subscales are based heavily on the proposed multidimensional structure of self-concept of Shavelson, Hubner, and Stanton (1976). These statements are presented to children, who are then asked to what extent they agree or disagree with them. As examples, the general self-esteem scale includes the statement *a lot of things about me are good*; the peer relations scale a statement that *I get along with other kids easily*; and the parent relations scale that *my* *parents understand me*. Once again, the possible responses to these statements range from *strongly agree* to *strongly disagree*, which we assign numeric values and sum within subscales to derive scores for each. York and Ogando (2018) provides more detailed information on theoretical concepts underpinning the Marsh Self-Description Questionnaires and the validity of their structure.

### Duckworth and Quinn Grit Scale

At age 22, we use measures of two aspects of "grit" as designed by Duckworth and Quinn (2009). These subscales are shortened versions of those first proposed in Duckworth et al. (2007) and are designed to measure what they define as *consistency of interest* and *perseverance of effort*. As with the vast majority of the psychometric measures we use, these assessments involve presenting children with several statements - in this case four - about the relevant aspect of grit, then asking them the extent to which they agree the statements describe themselves. Respectively, the consistency of interest and perseverance of effort scales contain statements such as *I often set a goal but choose to pursue a different one*, and *I finish whatever I begin*. Responses to the statements are on a five-point scale, from *not like me at all* to *very much like me*. We sum responses within each group to construct scores for each aspect of grit.

### Review of Personal Effectiveness with Locus of Control (ROPELOC)

At age 22, we also make use of two, three-question subscales from the ROPELOC measuring their leadership and cooperative teamwork abilities (Richards, Ellis, and Neill 2002). The two scales contain questions statements such as *I am seen as a capable leader* and *I am good at cooperating with team members*, respectively. Children are asked to what extent they agree these statements describe themselves, with possible responses being on a four-point scale from *strongly agree* to *strongly disagree*. After being assigned numeric values, we use the sum of responses within each sub-scale as measure of their ability in each domain.

**Big Five Inventory**

Also at age 22, we use two components of the Big Five Inventory - conscientiousness and neuroticism. The subscales are part of the larger inventory which also seeks to measures openness, agreeableness, and extraversion. They contain eight and nine statements, respectively, and respondents are asked the extent to which they agree that these statements describe them. For example, the statements representing conscientiousness include:

- *I am someone who does a thorough job*;
- *I am someone who tends to be organized*; and
- *I am someone who makes plans and follows through with them*

Similarly, the statements indicating neuroticism include:

- *I am someone who is relaxed, handles stress well*;
- *I am someone who is emotionally stable, not easily upset*; and
- *I am someone who gets nervous easily*.

Responses are on a five-point scale from *strongly agree* to *strongly disagree* and are assigned a numeric value. The responses are summed within each of the two components to give children a score for conscientiousness and neuroticism.

## B.1 Cognitive Skill

The YL data survey contains cognitive assessments at every age except 22. As with the socio-emotional skill measures, the assessments administered differ across ages based on suitability, however the measures cover the same three broad domains of cognitive skills: language ability and fluid intelligence, or reasoning.

## Reading and Writing Levels

At ages 8 and 12, the writing level of children in the older cohort was assessed by asking them to read from aloud from cards containing three lines, the first containing individual letters (e.g.: T, A, H), the second a word (e.g.: Hat), and the third a simple sentence (e.g.: The sun is hot). The children were given a score of 1 if they could read the sentence, 0.66 if they could read the word, and 0.33 if they could read the letters, and 0 if they could not read anything.

For the writing assessment, interviewers read aloud a sentence which children were asked to transcribe. For example, children might have been asked to write down the sentence "*The sun is hot*". Sentences were adapted based on the country in which the test was administered to ensure comprehension. If children could write the sentence down easily they were awarded 1 point, and were awarded 0.5 or 0 points, respectively, if they wrote it down with errors or could not write it at all.

## Raven's Colored Progressive Matrices

At age eight, children are administered the Raven's colored progressive matrices test Raven (1958). This assessment involves showing children patterns with missing blocks, and asking them to identify which block from a choice of six completes it. The test as administered in the YL survey has 36 items, asked in order of difficulty. A child's raw score in the test is calculated as the total number of correct responses.

## Peabody Picture Vocabulary Test (PPVT)

The PPVT was administered to children in age ages 12 and 15, and is designed to measure receptive vocabulary in children as young as 2.5 years old. The test involves presenting children with cards depicting four different scenarios, and asking them which picture best shows a sentence or word read aloud by the examiner. The questions become increasingly difficult, with the starting point of the test determined by the child's age.

### YL Math Test

The YL also contains a math test to measure "mathematical achievement". For the older Peruvian cohort, this test was administered at ages 12, 15, and 19. At age 12 it consisted of 10 mathematics questions from the International Association for the Evaluation of Educational Achievement's (IEA) 2003 Trends in International Mathematics and Science Study[2]. Children's raw scores were simply the total number of correct answers.

At age 15, the test was expanded to include 30 questions in two sections, one with 20 questions on mathematics (addition, division etc.) and another with ten problem solving questions. At age 19, the test was further altered to account for differences in competencies across countries. Questions were grouped into three "booklets" of increasing difficulty, and children started on the second, intermediate booklet. If they performed well on intermediate skills they then answered questions on advanced skills, whereas if they performed poorly they moved on to answer questions on basic skills. Revollo and Scott (2022) describes the tests and their internal and external validity in detail.

### YL Reading Comprehension/Language Test

At age 19, children's reading comprehension was tested in a similar manner to their mathematical achievement at the same age, described above. Comprehension questions were grouped into three booklets: (1) basic comprehension, (2) intermediate comprehension, and (3) advanced comprehension. Children started with questions in booklet two, and progressed to booklets one or three depending on their performance. The items administered were country specific in that they described or asked about day-to-day activities or situations that commonly occur in Peru. Revollo and Scott (2022) describes the design of the reading comprehension test in detail.

### Cloze Language Test

[2] https://timss.bc.edu/timss2003i/released.html last accessed 21 November, 2022.

At age 15, the children were administered the Cloze reading comprehension test, developed by the Development Analysis Group in Peru (GRADE - Grupo de Análisis para el Desarrollo). It is made up of 24 items of increasing difficulty that asked children to fill in missing words in a sentence.

# C Additional Tables and Figures

## C.1 Additional Descriptive Figures and Tables

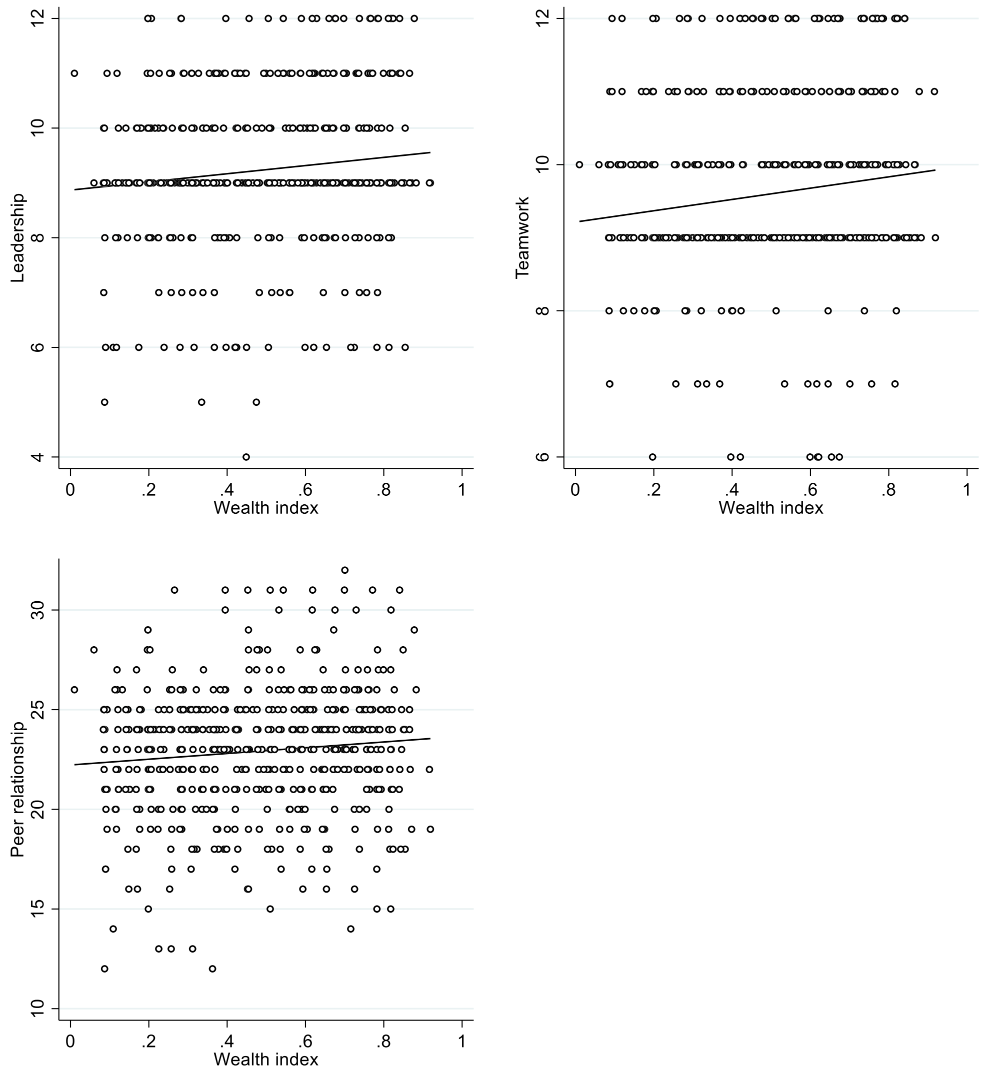


**Figure C1**

*The Correlation between Measures of Social Skills at Age 22 and Household Wealth at Age 8*

**Note:** The measures, clockwise from top left, are of leadership qualities, ability to work in a team, and quality of relationships with peers, and are described in detail in Online Appendix B. The wealth index is constructed to range between 0 and 1 and is an average of three subindices: housing quality, access to services, and ownership of certain consumer durables. See Briones (2017) for further details.

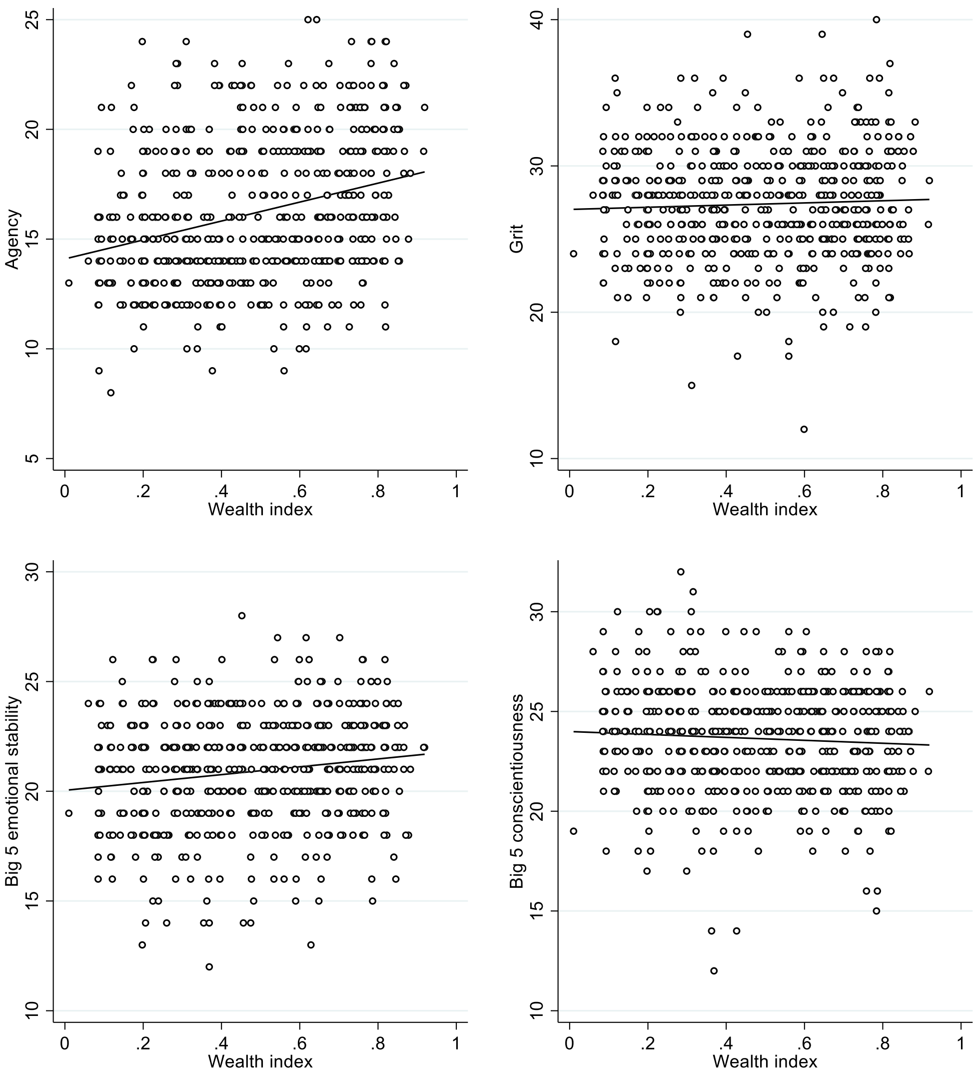


**Figure C2**

*The Correlation between Measures of Task Effectiveness Skills at Age 22 and Household Wealth at Age 8*

**Note:** The measures, clockwise from top left, are of agency, grit, emotional stability, and conscientiousness, and are are described in detail in Online Appendix B. The wealth index is constructed to range between 0 and 1 and is an average of three subindices: housing quality, access to services, and ownership of certain consumer durables. See Briones (2017) for further details.

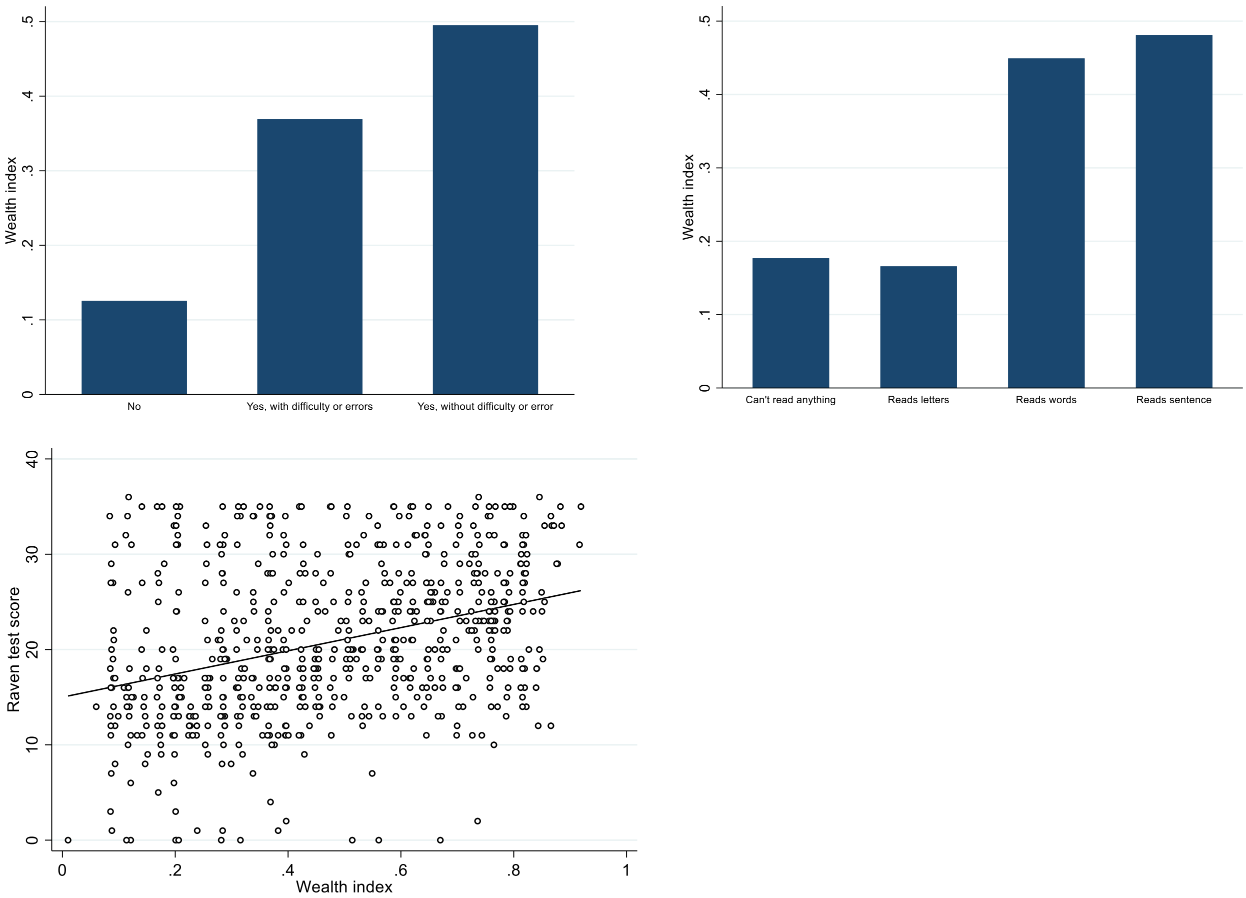


**Figure C3**

*The Correlation between Cognitive Skill Measures and Household Wealth at Age Eight*

**Note:** The measures, clockwise from top left, are of the child's writing ability, reading ability, and score on the Ravens progressive matrices test, and are described in detail in Online Appendix B. The wealth index is constructed to range between 0 and 1 and is an average of three subindices: housing quality, access to services, and ownership of certain consumer durables. See Briones (2017) for further details.

## C.2 Summaries of Observable Measures Used in Estimations

**Table C1**
*Summary Statistics of Observable Socio-Emotional Skill Measures Used in Estimating Investment and Production Functions*

| | Mean | sd | Max. | Min. | Unique values |
|---|---|---|---|---|---|
| **Age 8** | | | | | |
| Conduct issues* | 12.263 | 2.210 | 15 | 5 | 11 |
| Hyperactivity* | 9.752 | 2.469 | 15 | 5 | 11 |
| Pro-sociality | 14.013 | 1.587 | 15 | 5 | 10 |
| Emotional regulation* | 10.513 | 3.080 | 15 | 5 | 11 |
| Peer problems* | 11.815 | 2.212 | 15 | 5 | 11 |
| **Age 12** | | | | | |
| Pride & self-esteem | 12.415 | 2.646 | 16 | 2 | 14 |
| Agency | 6.911 | 1.364 | 10 | 2 | 9 |
| **Age 15** | | | | | |
| Pride & self-esteem | 22.936 | 2.905 | 30 | 14 | 17 |
| Agency | 18.168 | 2.054 | 25 | 11 | 14 |
| **Age 19** | | | | | |
| Agency | 18.865 | 2.088 | 25 | 12 | 14 |
| Self-esteem | 24.778 | 2.335 | 32 | 16 | 17 |
| Self-efficacy | 30.205 | 3.274 | 40 | 8 | 21 |
| Peer relationships | 22.748 | 3.255 | 32 | 10 | 21 |
| **Age 22: task effectiveness** | | | | | |
| Agency | 16.181 | 3.275 | 25 | 8 | 18 |
| Grit | 27.393 | 3.730 | 40 | 12 | 25 |
| Big 5 emotional stability | 25.428 | 4.002 | 36 | 8 | 26 |
| Big 5 conscientiousness | 33.064 | 3.323 | 44 | 21 | 23 |
| **Age 22: social skills** | | | | | |
| Leadership | 9.228 | 1.281 | 12 | 4 | 9 |
| Teamwork | 9.586 | 1.172 | 12 | 6 | 7 |
| Peer relationships | 22.921 | 3.124 | 32 | 12 | 21 |

**Notes:** The measures in this table are those of socio-emotional skill used to estimate the human capital production and investment functions. From left to right, the columns contain the aspect of socio-emotional skill the measures capture, their sample mean and standard deviation (sd), and the maximum, minimum and number of unique values in the sample. A * indicates the order of a measure was reversed from negative to positive so that a higher value indicates more skill.

**Table C2**
*Summary Statistics of Observable Cognitive Skill Measures Used in Estimating Investment and Production Functions*

| | Mean | sd | Max. | Min. | Unique values |
|---|---|---|---|---|---|
| **Age 8** | | | | | |
| Ravens score | 20.822 | 8.062 | 36 | 0 | 37 |
| Writing level | 2.418 | 0.709 | 3 | 1 | 3 |
| Reading level | 3.582 | 0.968 | 4 | 1 | 4 |
| **Age 12** | | | | | |
| Math score | 5.754 | 1.774 | 8 | 0 | 9 |
| PPVT score | 72.025 | 15.554 | 106 | 10 | 71 |
| Writing level | 2.845 | 0.394 | 3 | 1 | 3 |
| Reading level | 3.934 | 0.387 | 4 | 1 | 4 |
| **Age 15** | | | | | |
| Math score | 13.139 | 5.722 | 29 | 0 | 29 |
| PPVT score | 96.924 | 17.300 | 125 | 13 | 72 |
| Cloze score | 14.706 | 5.658 | 24 | 0 | 25 |
| **Age 19** | | | | | |
| Math score | 16.960 | 5.611 | 28 | 1 | 28 |
| Language score | 15.926 | 3.718 | 24 | 3 | 20 |

**Notes:** The measures in this table are those of cognitive skill used to estimate the human capital production and investment functions. From left to right, the columns contain either the name of the test through which skill was measured of the aspect of cognition the test captured, their sample mean and standard deviation (sd), and the maximum, minimum and number of unique values in the sample.

**Table C3**

*Summary Statistics of Observable Investment and Parental Skill Measures Used in Estimating Investment and Production Functions*

| | Mean | sd | Max. | Min. | Unique values |
|---|---|---|---|---|---|
| **Age 12** | | | | | |
| Per-child expenditure on books | 1.341 | 2.822 | 65 | 0 | . |
| Per-child expenditure on uniforms | 1.028 | 3.135 | 76 | 0 | . |
| Hours studying | 2.950 | 1.282 | 8 | 0 | 9 |
| Hours in school | 4.776 | 1.585 | 12 | 0 | 11 |
| **Age 15** | | | | | |
| Per-child expenditure on books | 1.670 | 1.821 | 20 | 0 | . |
| Per-child expenditure on uniforms | 1.302 | 1.841 | 27 | 0 | . |
| Food groups | 22.436 | 4.038 | 32 | 3 | 27 |
| Hours studying | 2.079 | 1.168 | 7 | 0 | 8 |
| Hours in school | 5.908 | 1.966 | 11 | 0 | 10 |
| **Age 19** | | | | | |
| Educational expenditure | 0.537 | 1.729 | 36 | 0 | . |
| Per-child non-food expenditure | 4.508 | 6.514 | 55 | 0 | . |
| Food groups | 8.914 | 1.923 | 14 | 3 | 12 |
| Hours in school | 3.565 | 3.645 | 15 | 0 | 16 |
| Hours studying | 1.473 | 1.852 | 12 | 0 | 11 |
| **Parental socio-emotional skill** | | | | | |
| Agency | 12.974 | 2.030 | 15 | 7 | 9 |
| Pride & agency | 14.458 | 1.154 | 15 | 8 | 8 |
| Cantril's ladder | 4.848 | 2.044 | 9 | 1 | 9 |
| **Parental cognitive skill** | | | | | |
| Education | 7.235 | 4.523 | 16 | 0 | 16 |
| Can read newspaper | 2.604 | 0.713 | 3 | 1 | 3 |
| Can understand things written in Spanish | 2.502 | 0.787 | 3 | 1 | 3 |

**Notes:** The measures in this table are those of investment and parental human capital used to estimate the human capital production and investment functions. From left to right, the columns contain a description of the investment or human capital measures, their sample mean and standard deviation (sd), and the maximum, minimum and number of unique values in the sample. Variables with missing number of unique values are continuous.

## C.3 Results of Initial Exploratory Factor Analysis (EFA) Across Ages 8-19

As part of our EFA, we first examine whether our observable measures have enough variation to capture sufficient variation in the latent variables we use as inputs/outputs of the production and investment functions. To do so, we first analyze the extent of the shared variation in the observable measures, and retain/discard their underlying factors based on their eigenvalues and a parallel analysis as proposed by Horn (1965). The measures we use in this EFA at each age described in the previous section of this Online Appendix, and were those that best met the principal of Core Self-Evaluation (CSE).

The parallel analysis first involves randomly simulating data of the same dimension as that being analyzed. For example, if preforming an EFA on six variables measuring characteristics of $N$ individuals, the resulting simulated dataset would be $N \times 6$. The eigenvalues of the correlation matrix among the randomly simulated data are then calculated and compared with those from the factors underlying the actual data. Horn (1965) suggests retaining factors from the actual data as long as their eigenvalues are larger than those from the randomly generated correlation matrix. To complement this, we generate scree plots as proposed by Cattell (1966), plotting the eigenvalues of factors in order of magnitude.[3]

Figure C4 shows one of these plots for initial cognitive and socio-emotional skill. Using Horn (1965)'s rule-of-thumb, the figure would suggest these measures have enough variation to retain at most four factors. Cattell (1966) suggests retaining only the factors whose eigenvalues are larger than that of the factor at which the first large drop in eigenvalue occurs. In Figure C4 the first major drop in eigenvalue occurs at Factor 3. Additionally, Kaiser (1960) suggests keeping only a number of factors greater or equal to the number of eigenvalues greater than one, which is true for only two latent factors in Figure C4. Together, these criteria suggest that these measures are rich enough to capture at least the two underlying factors we ex-ante believe to be underlying the measures. We repeat this analysis in each round, grouping observables as those measuring child human capital, investments, or parental skills.

[3] To conduct this analysis, we use Philip B. Ender's -fapara- package in Stata.

Having verified the measures share meaningful variation with which to capture their underlying factor, we then establish the relationship between each measure and retained factor by estimating their factor loadings. Tables C4 and C5 show the rotated factor loadings and unique variance associated with each measure of human capital and investment respectively in each period. We rotate the factor loadings obtained from an EFA using the *oblique quartimin* rotation, which enables us to obtain a vector of factor loadings allowing for underlying factors to be correlated and so the loadings accurately capture the extent to which observables group around factors. For children's human capital (Table C4) there is a clear divide between those the we ex-ante believe to measure socio-emotional versus cognitive skill. For example, in the initial period the emotional conduct measures do load heavily on Factor 2 - which we define as the socio-emotional factor - whereas the cognitive assessments load heavily on Factor 1 - the cognitive factor. There are a couple of slight exceptions to this, however. Agency appears to load on both factors in periods 2 and 3, albeit to a much larger extent on the socio-emotional factors. The same is true for self-efficacy in period 3. This is perhaps unsurprising given the relationship between measures of this type a cognitive skill. We retain these measures given that they are highly correlated with cognition, and are measures of particular interest to the questions of this paper. Although, informed by the data, we only retain one factor for investments, Table C5 shows the estimated rotated factor loadings and unique variance associated with each measure of investment across periods. These are useful in that they provide an ex-ante approximation to the extent of signal in each measure.

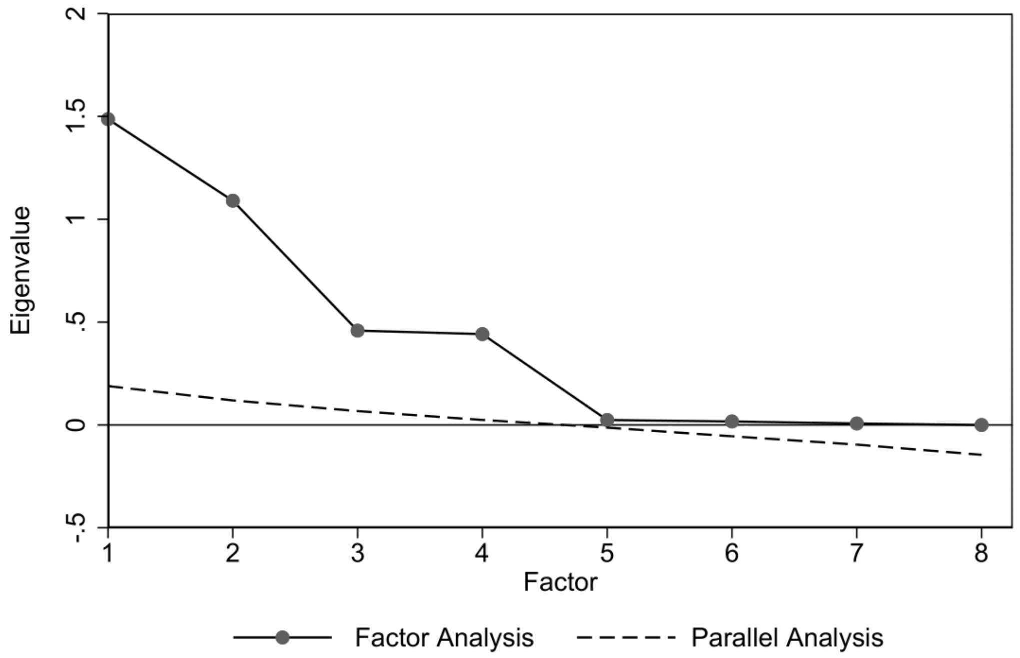


**Figure C4**

*Eigenvalues from EFA and Parallel Analysis of Initial (Age Eight) Child Socio-Emotional and Cognitive Skill Measures*

**Note:** The solid line connects the eigenvalues of the factors underlying 8 measures of socio-emotional (5 measures) and cognitive skill (3) at age eight in the YL survey. The dotted line connects the eigenvalues of the 8 factors underlying randomly simulated data of the same dimension (i.e. $N \times 8$). This figure was generated using Philip B. Ender's *-fapara-* package in Stata.

**Table C4**
*Factor Loadings and Unique Variance of Observable Cognitive and Socio-Emotional Skill Measures*

| | Factor 1 | Factor 2 | Uniqueness |
|---|---|---|---|
| **Age 8** | | | |
| Conduct issues | 0.019 | 0.605 | 0.630 |
| Emotional symptoms | 0.055 | 0.450 | 0.788 |
| Hyperactivity | -0.035 | 0.620 | 0.621 |
| Peer problems | -0.007 | 0.274 | 0.925 |
| Prosociality | 0.026 | 0.185 | 0.964 |
| Ravens test score | 0.389 | -0.063 | 0.852 |
| Writing level | 0.790 | -0.048 | 0.385 |
| Reading level | 0.750 | 0.067 | 0.418 |
| *N* | 606 | | |
| **Age 12** | | | |
| Agency | -0.011 | 0.316 | 0.904 |
| Pride | 0.002 | 0.853 | 0.270 |
| Current position on ladder | 0.023 | 0.096 | 0.988 |
| Math test score | 0.618 | 0.068 | 0.568 |
| PPVT score | 0.904 | -0.020 | 0.202 |
| *N* | 630 | | |
| **Age 15** | | | |
| Agency | 0.083 | 0.296 | 0.902 |
| Pride | -0.001 | 1.324 | -0.752 |
| Cantril's ladder | 0.092 | 0.114 | 0.977 |
| Emotional problems | 0.162 | 0.053 | 0.970 |
| Math test score | 0.691 | -0.043 | 0.525 |
| PPVT score | 0.832 | 0.025 | 0.305 |
| Cloze test score | 0.851 | -0.001 | 0.277 |
| *N* | 588 | | |
| **Age 19** | | | |
| Agency | 0.189 | 0.330 | 0.829 |
| Self-efficacy | 0.676 | 0.123 | 0.494 |
| Self-esteem | 0.780 | -0.034 | 0.401 |
| Peer relationships | 0.672 | -0.064 | 0.562 |
| Cantril's ladder | 0.320 | -0.049 | 0.902 |
| Emotional problems | 0.262 | 0.013 | 0.930 |
| Math test score | 0.007 | 0.782 | 0.386 |
| Language test score | -0.013 | 0.860 | 0.265 |
| *N* | 561 | | |

**Notes:** The table contains rotated factor loadings and the proportion of variance in each cognitive and socio-emotional skill measure not shared with all others after retaining two factors from an initial exploratory factor analysis. Two factors were retained based on the assumption the measures proxy two latent concepts, socio-emotional and cognitive skill and the rules-of-thumb for factor retention proposed by Kaiser (1960), Horn (1965), and Cattell (1966). Factor loadings were obtained through an oblique quartimin rotation.

**Table C5**
*Factor Loadings and Unique Variance of Observable Investment Measures*

| | Factor 1 | Uniqueness |
|---|---|---|
| **Age 12** | | |
| Per child book expenditure | 0.584 | 0.659 |
| Per child uniform expenditure | 0.285 | 0.919 |
| Per child non-food expenditure | 0.332 | 0.890 |
| Hours studying | 0.155 | 0.976 |
| Hours in school | 0.327 | 0.893 |
| Food groups | 0.543 | 0.705 |
| *N* | 593 | |
| **Age 15** | | |
| Per child book expenditure | 0.734 | 0.462 |
| Per child uniform expenditure | 0.419 | 0.824 |
| Per child non-food expenditure | 0.338 | 0.886 |
| Hours studying | 0.405 | 0.836 |
| Hours in school | 0.416 | 0.827 |
| Food groups | 0.427 | 0.818 |
| *N* | 526 | |
| **Age 19** | | |
| Education expenditure | 0.319 | 0.898 |
| Non-food expenditure (soles) | 0.051 | 0.997 |
| Hours studying | 0.626 | 0.609 |
| Hours in school | 0.881 | 0.223 |
| Food groups | 0.080 | 0.994 |
| *N* | 618 | |

**Notes:** The table contains rotated factor loadings and the proportion of variance in each investment measure not shared with all others after retaining one factors from an initial exploratory factor analysis. One factor was retained based on the assumption the measures proxy one latent investment and the rules-of-thumb for factor retention proposed by Kaiser (1960), Horn (1965), and Cattell (1966). Factor loadings were obtained through an oblique quartimin rotation.

## C.4 Results of EFA on Age 22 Socio-emotional Skill Measures

At age 22, as was the case between ages 8-19, we again first used the principal of CSE to select measures, excluding those that were measuring subjective wellbeing or relied on assessments of their feelings/reactions to the behavior of others. This meant, for example, excluding Cantril's ladder (Cantril et al. 1965) and measures of trust and respondents' relationship with their parents, as well as measures of pride and self-esteem that had changed substantially from earlier rounds.

We were then left with eight measures of leadership qualities, quality of relationships with peers, ability to work in a team, self-efficacy, agency, grit, and the Big 5 emotional stability and conscientiousness scales. Ex-ante, we divided these into two groups, with the former three seemingly best representing social skills, and the latter five task effectiveness. With these measures we first confirmed they shared sufficient variation to extract as in the preceding periods - Figure C5 plots the eigenvalues of the factors underlying the measures alongside those from a parallel analysis as outlined in the previous subsection. It shows that, using the same rules-of-thumb as in the EFA of measures at previous ages, the data supports extracting either one or two factors. Although the eigenvalue of the second factor is below one - another commonly used threshold to decide upon extraction (Kaiser, 1960) - we chose to extract two factors in order to disaggregate socio-emotional skills into two domains.

Table C6 then shows the estimated rotated factor loadings and unique variance that correspond to each retained measure and factor at age 22. It shows that, with the exception of self-efficacy, our ex-ante beliefs about the groupings of the skill measures are borne out in the data - leadership qualities, quality of relationships with peers, and ability to work in a team load heavily on the first factor, whereas agency, grit, and the Big 5 emotional stability and conscientiousness scales load heavily on the second.

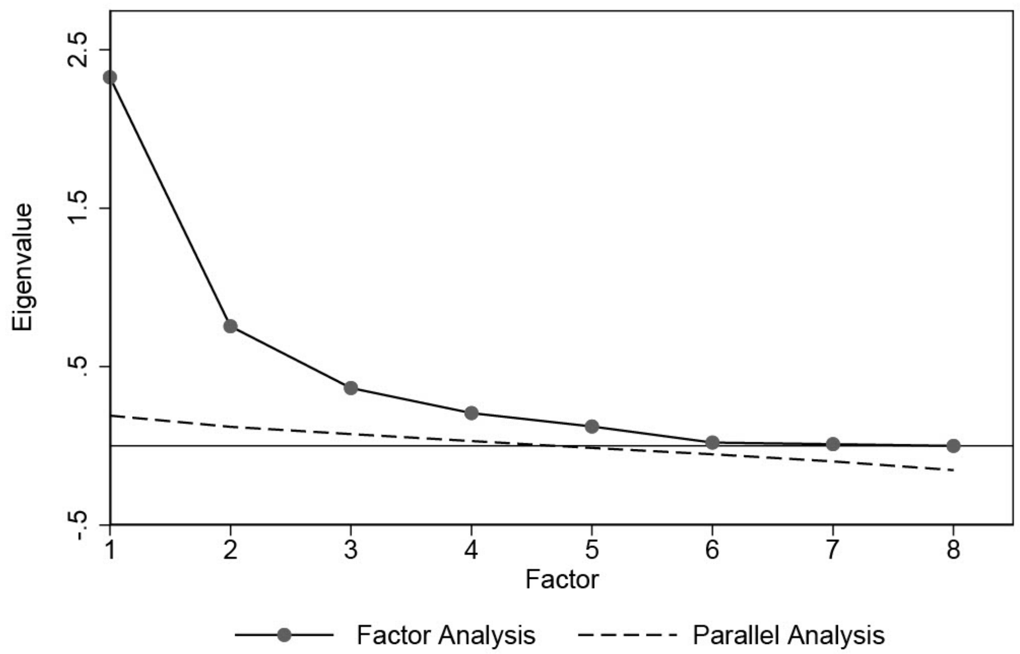


**Figure C5**

*Eigenvalues from EFA and Parallel Analysis of Age 22 Socio-Emotional Skill Measures*

**Note:** The solid line connects the eigenvalues of the factors underlying 8 measures of socio-emotional skill at age 22 in the YL survey. The dotted line connects the eigenvalues of the 8 factors underlying randomly simulated data of the same dimension (i.e. $N \times 8$). This figure was generated using Philip B. Ender's *-fapara-* package in Stata.

**Table C6**
*Factor Loadings and Unique Variance of Observable Socio-Emotional Skill Measures at Age 22*

| | Factor 1 | Factor 2 | Uniqueness |
|---|---|---|---|
| **Social skills** | | | |
| Leadership | 0.668 | 0.004 | 0.551 |
| Peer relationships | 0.648 | -0.091 | 0.648 |
| Teamwork | 0.583 | 0.062 | 0.609 |
| **Task effectiveness** | | | |
| Agency | 0.106 | 0.364 | 0.807 |
| Self-efficacy | 0.703 | 0.054 | 0.454 |
| Grit | -0.040 | 0.643 | 0.617 |
| Big 5 neuroticism | -0.047 | 0.498 | 0.780 |
| Big 5 conscientiousness | 0.161 | 0.512 | 0.607 |
| *N* | 596 | | |

## C.5 Additional Production Function Estimates

**Table C7**

*Variance Covariance Matrix of the Initial Conditions*

| | ln $H_{s,0}$ | ln $H_{c,0}$ | ln $P_s$ | ln $P_c$ | ln $Y_0$ |
|---|---|---|---|---|---|
| ln $H_{s,0}$ | 1.774 | | | | |
| ln $H_{c,0}$ | 0.663 | 8.762 | | | |
| ln $P_s$ | 0.135 | 2.737 | 0.036 | | |
| ln $P_c$ | -0.373 | 9.499 | 1.930 | 12.869 | |
| ln $Y_0$ | -0.019 | 0.621 | 0.114 | 0.590 | 1.141 |

**Table C8**

*Mean Vector of the Initial Conditions*

| ln $H_{s,0}$ | ln $H_{c,0}$ | ln $P_s$ | ln $P_c$ | ln $Y_0$ |
|---|---|---|---|---|
| ( 0 | 0 | 0 | 0 | 6.25 ) |

**Table C9**
*Estimates of Socio-Emotional Production Function Parameters with Interacted Investment and Cognitive Skill*

| | Period 1<br>*Ages 8-12* | Period 2<br>*Ages 12-15* | Period 3<br>*Ages 15-19* |
|---|---|---|---|
| **Lagged human capital** | | | |
| ln $H_{s,t\text{-}1}$ | -0.001 | 0.128 | 0.021* |
| | (0.142) | (0.676) | (0.011) |
| | [-0.235,0.233] | [-0.984,1.240] | [0.003,0.039] |
| ln $H_{c,t\text{-}1}$ | 0.671*** | 1.099* | 0.750** |
| | (0.186) | (0.613) | (0.311) |
| | [0.364,0.977] | [0.090,2.107] | [0.238,1.262] |
| **Parental human capital (fixed over time)** | | | |
| ln $P_s$ | 0.179 | -0.530 | 0.074 |
| | (0.114) | (1.168) | (0.246) |
| | [-0.010,0.367] | [-2.452,1.392] | [-0.332,0.479] |
| ln $P_c$ | 0.049 | 0.045 | -0.063 |
| | (0.033) | (0.137) | (0.051) |
| | [-0.005,0.104] | [-0.180,0.270] | [-0.147,0.020] |
| **Investments** | | | |
| ln $I_{t\text{-}1}$ | 0.444*** | 0.218 | 0.369 |
| | (0.140) | (0.331) | (0.456) |
| | [0.215,0.674] | [-0.327,0.763] | [-0.381,1.118] |
| ln $I_{t\text{-}1}$ × ln $H_{c,t\text{-}1}$ | -0.342** | 0.041 | -0.150 |
| | (0.150) | (0.506) | (0.469) |
| | [-0.589,-0.096] | [-0.791,0.874] | [-0.921,0.621] |
| $\sigma^2_{\eta_n}$ | 5.36 | 3.83 | .538 |
| N | 571 | 606 | 570 |

**Notes:** Standard errors are in parentheses, and 90% confidence intervals are in square brackets. Both are calculated using the delta method. $t$ - 1 = ages 8, 12, 15, and 19 for the three columns respectively. The output in each column is socio-emotional skill. The inputs in the left column are lagged child socio-emotional skill and cognitive skill; parental socio-emotional and cognitive skill; and investment and its interaction with lagged human capital. All inputs are treated as unobservable. The observables used as measures of each are discussed in Online Appendix Tables B. Online Appendix A outlines the method used to obtain all estimates in the table.

**Table C10**

*Estimates of Socio-Emotional Production Function Parameters with Interacted Investment and Socio-Emotional Skill*

| | Period 1 *Ages 8-12* | Period 2 *Ages 12-15* | Period 3 *Ages 15-19* |
|---|---|---|---|
| **Lagged human capital** | | | |
| ln $H_{s,t\text{-}1}$ | 0.394 | -3.261 | 0.026 |
| | (0.372) | (27.330) | (0.020) |
| | [-0.219,1.006] | [-48.215,41.693] | [-0.007,0.060] |
| ln $H_{c,t\text{-}1}$ | 0.309* | 6.466 | 0.798** |
| | (0.169) | (40.804) | (0.321) |
| | [0.031,0.588] | [-60.651,73.583] | [0.269,1.326] |
| **Parental human capital (fixed over time)** | | | |
| ln $P_s$ | 0.208 | -3.937 | 0.023 |
| | (0.152) | (24.868) | (0.307) |
| | [-0.043,0.458] | [-44.841,36.967] | [-0.482,0.529] |
| ln $P_c$ | 0.069 | 0.452 | -0.047 |
| | (0.047) | (3.139) | (0.039) |
| | [-0.008,0.147] | [-4.712,5.616] | [-0.110,0.017] |
| **Investments** | | | |
| ln $I_{t\text{-}1}$ | 0.359** | 0.054 | 0.184 |
| | (0.164) | (2.481) | (0.160) |
| | [0.088,0.629] | [-4.026,4.135] | [-0.079,0.448] |
| ln $I_{t\text{-}1}$ × ln $H_{s,t\text{-}1}$ | -0.339 | 1.226 | 0.015 |
| | (0.280) | (9.525) | (0.028) |
| | [-0.799,0.122] | [-14.442,16.894] | [-0.032,0.062] |
| $\sigma^2_{\eta_n}$ | 1.45 | 28 | 1.1 |
| N | 571 | 606 | 570 |

**Notes:** Standard errors are in parentheses, and 90% confidence intervals are in square brackets. Both are calculated using the delta method. $t$ - 1 = ages 8, 12, 15, and 19 for the three columns respectively. The output in each column is socio-emotional skill. The inputs in the left column are lagged child socio-emotional skill and cognitive skill; parental socio-emotional and cognitive skill; and investment and its interaction with lagged human capital. All inputs are treated as unobservable. The observables used as measures of each are discussed in Online Appendix Tables B. Online Appendix A outlines the method used to obtain all estimates in the table.

**Table C11**

*Estimates of Cognitive Production Function Parameters with Interacted Investment and Cognitive Skill*

| | Period 1<br>*Ages 8-12* | Period 2<br>*Ages 12-15* | Period 3<br>*Ages 15-19* |
|---|---|---|---|
| **Lagged human capital** | | | |
| $\ln H_{s,t\text{-}1}$ | 0.086 | -0.061 | 0.006 |
| | (0.070) | (0.135) | (0.005) |
| | [-0.029,0.201] | [-0.283,0.161] | [-0.002,0.015] |
| $\ln H_{c,t\text{-}1}$ | 0.699*** | 0.645*** | 1.074*** |
| | (0.097) | (0.118) | (0.223) |
| | [0.540,0.858] | [0.451,0.838] | [0.707,1.441] |
| **Parental human capital (fixed over time)** | | | |
| $\ln P_s$ | 0.102* | 0.262* | -0.047 |
| | (0.062) | (0.152) | (0.148) |
| | [0.001,0.204] | [0.012,0.512] | [-0.290,0.195] |
| $\ln P_c$ | 0.026 | -0.015 | -0.041 |
| | (0.017) | (0.017) | (0.032) |
| | [-0.003,0.054] | [-0.043,0.012] | [-0.094,0.012] |
| **Investments** | | | |
| $\ln I_{t\text{-}1}$ | 0.426*** | 0.161*** | 0.424 |
| | (0.078) | (0.059) | (0.517) |
| | [0.297,0.555] | [0.063,0.258] | [-0.427,1.275] |
| $\ln I_{t\text{-}1} \times \ln H_{c,t\text{-}1}$ | -0.339*** | 0.009 | -0.416 |
| | (0.085) | (0.090) | (0.558) |
| | [-0.479,-0.199] | [-0.138,0.157] | [-1.335,0.502] |
| $\sigma^2_{\eta_c}$ | .0468 | .403 | .519 |
| N | 568 | 600 | 555 |

**Notes:** Standard errors are in parentheses, and 90% confidence intervals are in square brackets. Both are calculated using the delta method. $t$ - 1 = ages 8, 12, and 15 for the three columns respectively. The output in each column is cognitive skill. The inputs in the left column are lagged child socio-emotional skill and cognitive skill; parental socio-emotional and cognitive skill; and investment and its interaction with lagged human capital. All inputs are treated as unobservable. The observables used as measures of each are discussed in Online Appendix B. Online Appendix A outlines the method used to obtain all estimates in the table.

**Table C12**
*Estimates of Cognitive Production Function Parameters with Interacted Investment and Socio-Emotional Skill*

| | Period 1 *Ages 8-12* | Period 2 *Ages 12-15* | Period 3 *Ages 15-19* |
|---|---|---|---|
| **Lagged human capital** | | | |
| ln $H_{s,t\text{-}1}$ | 0.016 | -0.312 | 0.002 |
| | (0.333) | (0.412) | (0.005) |
| | [-0.532,0.564] | [-0.990,0.365] | [-0.006,0.010] |
| ln $H_{c,t\text{-}1}$ | 0.458*** | 0.853*** | 0.925*** |
| | (0.126) | (0.286) | (0.113) |
| | [0.251,0.665] | [0.382,1.324] | [0.739,1.111] |
| **Parental human capital (fixed over time)** | | | |
| ln $P_s$ | 0.308** | 0.266 | -0.039 |
| | (0.120) | (0.185) | (0.094) |
| | [0.111,0.505] | [-0.038,0.571] | [-0.194,0.117] |
| ln $P_c$ | 0.022 | -0.006 | -0.017 |
| | (0.026) | (0.021) | (0.015) |
| | [-0.020,0.065] | [-0.041,0.028] | [-0.042,0.008] |
| **Investments** | | | |
| ln $I_{t\text{-}1}$ | 0.126 | 0.126 | 0.133* |
| | (0.164) | (0.090) | (0.073) |
| | [-0.143,0.395] | [-0.022,0.274] | [0.014,0.253] |
| ln $I_{t\text{-}1}$ × ln $H_{s,t\text{-}1}$ | 0.070 | 0.073 | -0.005 |
| | (0.217) | (0.109) | (0.009) |
| | [-0.288,0.427] | [-0.106,0.252] | [-0.019,0.010] |
| $\sigma^2_{\eta_c}$ | .00841 | .315 | .563 |
| N | 568 | 600 | 555 |

**Notes:** Standard errors are in parentheses, and 90% confidence intervals are in square brackets. Both are calculated using the delta method. $t$ - 1 = ages 8, 12, and 15 for the three columns respectively. The output in each column is cognitive skill. The inputs in the left column are lagged child socio-emotional skill and cognitive skill; parental socio-emotional and cognitive skill; and investment and its interaction with lagged human capital. All inputs are treated as unobservable. The observables used as measures of each are discussed in Online Appendix B. Online Appendix A outlines the method used to obtain all estimates in the table.

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