Do skills/abilities matter? Findings from the National Longitudinal Surveys

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The Greatest Challenge: Sources of Information

For years, economists focused on the role of cognitive ability (IQ) as determinant of schooling, labor market and behavioral outcomes (Hernstein/Murray, 94)

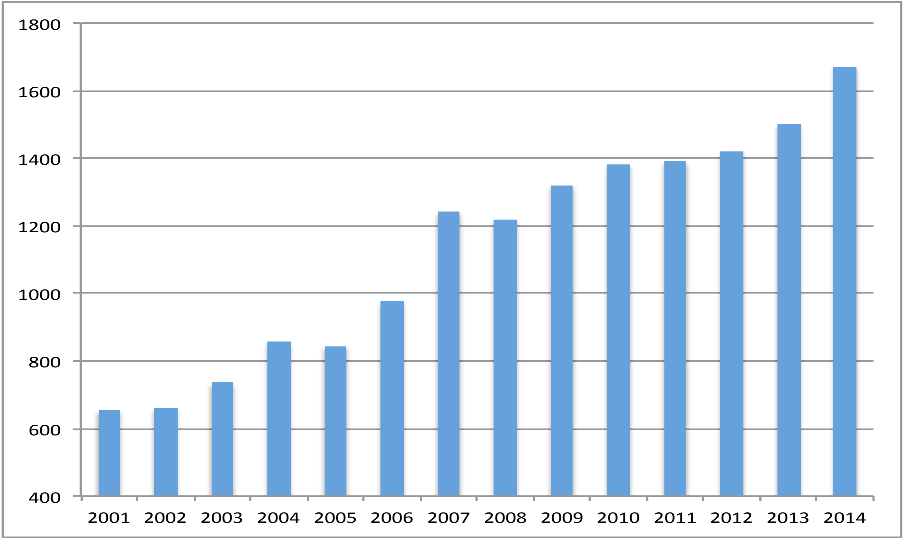
Recent Evidence: Non-cognitive capabilities might be more important (and relevant) than cognitive traits.

- However, empirical analysis has been restricted by available data. Most of the sources of information do not contain data on multiple skills.

The NLS have been the exception. They have fueled the academic debate in a wide range of topics. They have served as examples for more recent data collection efforts (STEP project, OECD new surveys, etc).

The Contribution of NLS to the subject

Number of articles with "Ability" and "NLS" by year from Google Scholar



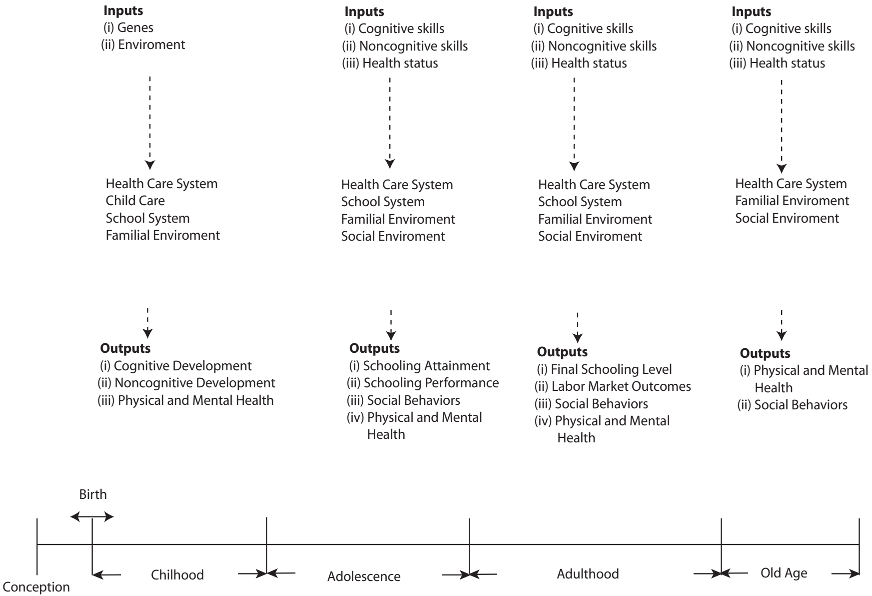
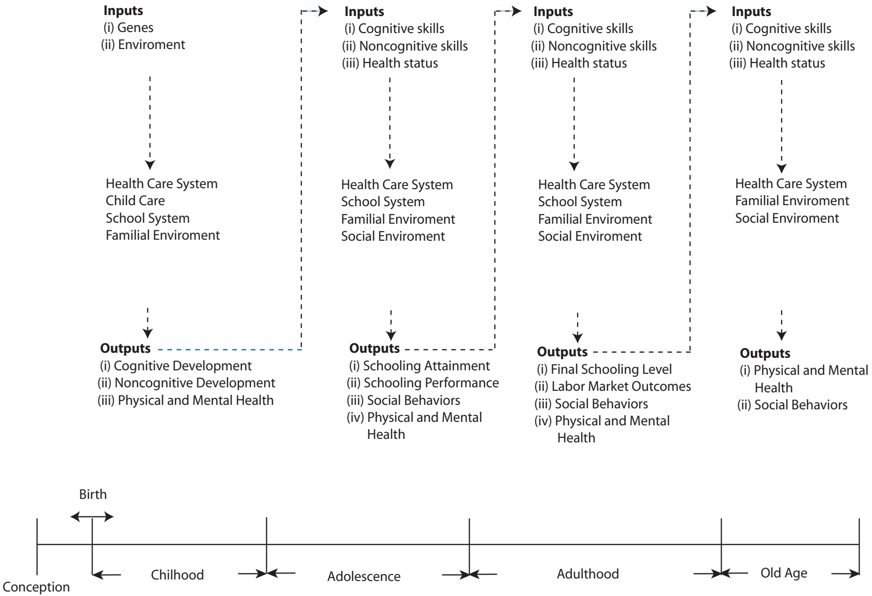


Figure 2. Human Development at Each Stage (inputs/ouputs)



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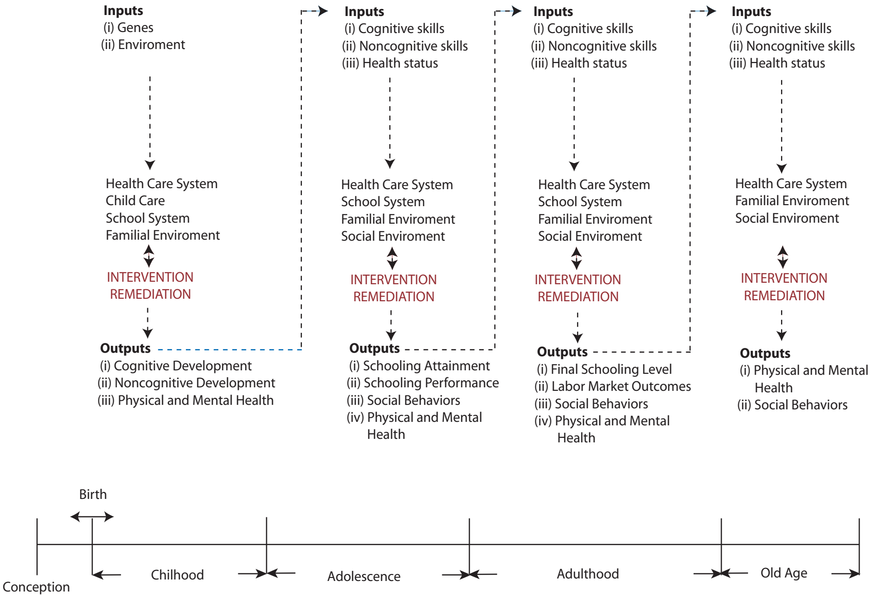


Figure 2. Human Development at Each Stage (inputs/ouputs)

Economic intuition

- A life cycle model of youth and adult decision making over horizon $\bar{T}$:

Agent maximizes

$$\int_0^{\overline{T}} \exp(-\rho t) U\left(c(t), \ell(t); \eta\right) dt$$

subject to dynamic constraints:

$$\begin{aligned} \overset{\bullet}{A}(t) &= Y(t)h(t)\ell(t) - P(t)'c(t) + rA(t), \\ \overset{\bullet}{h}(t) &= \varphi\left(h(t), I(t), \tau\right), \\ Y(t) &= R\left(h(t); \theta\right), \end{aligned}$$

and initial conditions $h(0)$, $A(0)$.

- Cognitive and noncognitive skills can affect:

$$
\begin{aligned}
\text{preferences } \eta &= \left(f^C, f^N\right), \rho = \rho\left(f^C, f^N\right), \\
\text{human capital productivity } \tau &= \tau\left(f^C, f^N\right), \\
\text{direct market productivity } \theta &= \theta\left(f^C, f^N\right),
\end{aligned}
$$

and

$$
\begin{aligned}
h(0) &= h_0\left(f^C, f^N\right), \\
A(0) &= A_0\left(f^C, f^N\right).
\end{aligned}
$$

- This illustrates why these factors (f^C, f^N) should be able to explain a variety of outcomes.

Abilities

Cognitive and socio-emotional skills on:

- Education
- Salaries
- Labor experience
- Self-employment and entrepreneurship
- Social behavior (risky correlated behaviors):
  - Criminality (arrests and convictions)
  - Teenage pregnancy
  - Drug use
  - Cigarette smoking
  - Bullying and Cybercrime (Sarzosa and Urzua, 2015)

Evidence

- **Europe**: Occupational Labor Markets (association between capacities acquired during vocation school and those demanded by labor market) show better labor market indicators (e.g., Germany/Austria).
- **USA**: Multiple Capacities as cornerstone of labor demand. Cognitive or academic abilities are relevant, but socio-emotional abilities tend to dominate. Connection between employment and abilities. Periods of unemployment appear to be associated with permanent decreases in abilities.
- Defining, measuring and identifying different capacities is not trivial.

Evidence

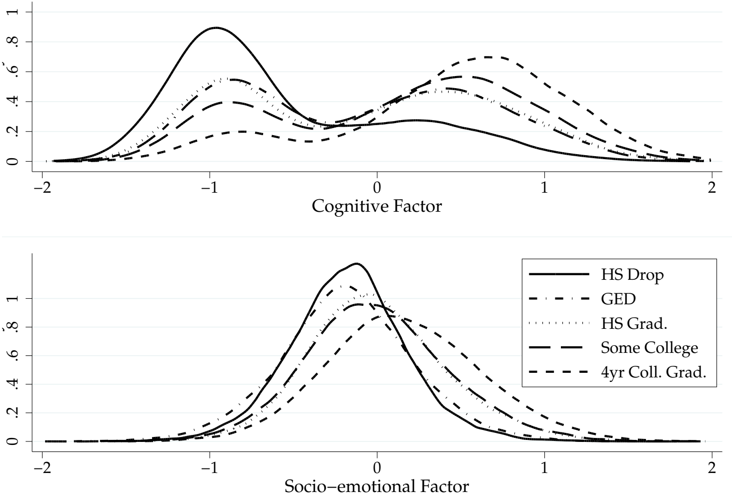
Hernestein and Murray (1994), Neal and Johnson (1996), Gottfredson (1997), Harting and Wigdor (1998), Cunha et. al. (2006), Cawley, Heckman, Vytlacil (2001), Conti et al (2010), Fergusson et al (2005), Carneiro and Heckman (2003), Armor and Roll (1994), Glewwe (2002), Kuncel et al (2004), Chown (1959), Heckman et al (2006), Urzua (2008), Conti et al (2010), Murnane et al (2000), Lazear (2003), Bowles and Gintis (1976), Klein et al (1991), Barrick and Mount (1991), Tett et al (1991), Borghans et al (2008), Maxwell (2007), Duncan and Dunifon (1998), Moss and Tilly (2000), Maxwell (2007), Duckworth et al (2007), Diaz. et. al (2010), Carneiro et at. (2007), Lindquist and Westman (2010), Van Praag et al. (2009), Brockhaus (1980), Hasemark (2003), Kaufman, et al (1995), Caliendo et al. (2007), Ekelund et al. (2005) and Stewart et al. (1999), Fairlie (2002), Dunn and Holtz-Eakin (2000), Burke et al (2001), Taylor (1996), Hamilton (2000), Eren and Sula (2012), Spector and O.Connell (1994), De Mel et al. (2008 and 2009), Benz and Frey (2008), Caliendo and Kritikos (2012), Hartog and Sluis (2010), Bassi et al (2012), Tambunlerchai(2011), Yamaguchi (2012), Boehm (2013), Heckman et. al. (2014), Seymour, et. al. (2014), Colen (2014), Houle and Keene (2014), Amato and Anthony (2014), Hernandez and Pressler (2014), Sarzosa and Urzua (2015), Prada (2015), Rodgers , et. al. (2015), Hendricks et. al. (2015), Johnson (2015), Chen (2105), Prada and Urzua (2016) and **many others**

Evidence in a nutshell

- Cognitive ability strongly predicts many outcomes, including labor market productivity, human capital accumulation and social behaviors (e.g., AFQT in NLSY79).
- Noncognitive abilities strongly predict labor market outcomes (self-esteem, locus of control, agreeableness), schooling attainment (consciousness), productivity (self-control and agreeableness) and even physical and mental health (locus of control).

Empirical Results

Figure 2. Ability Levels by Schooling Level



Cognitive and socio-emotional abilities have significant associations with education

Figure 3. College Graduation

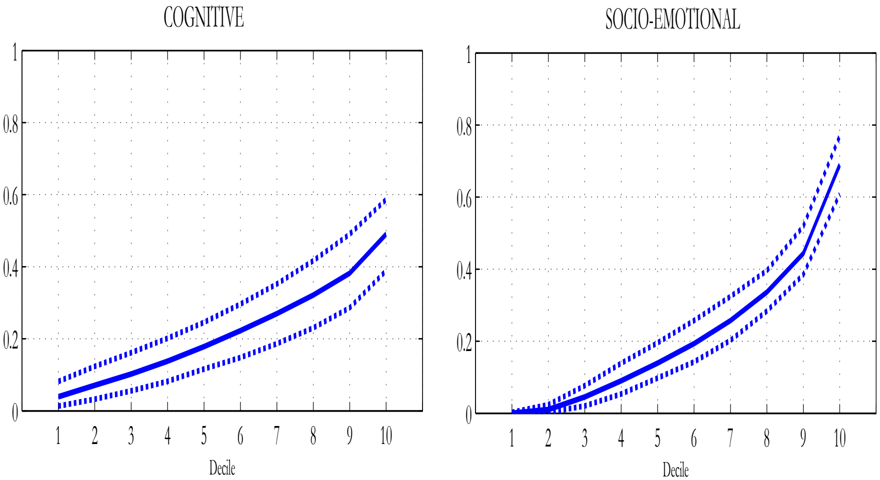


Figure 5. Mean Log Wages by Age 30 - Males
i. By Decile of Cognitive and Non-Cognitive Factors

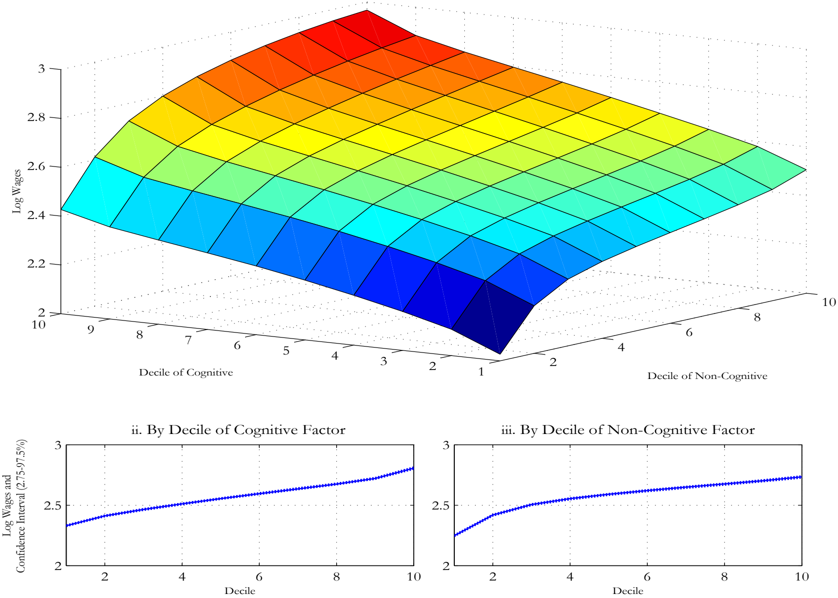


Figure 8. Mean Log Wages of High School Graduates by Age 30 - Males
i. By Decile of Cognitive and Non-Cognitive Factors

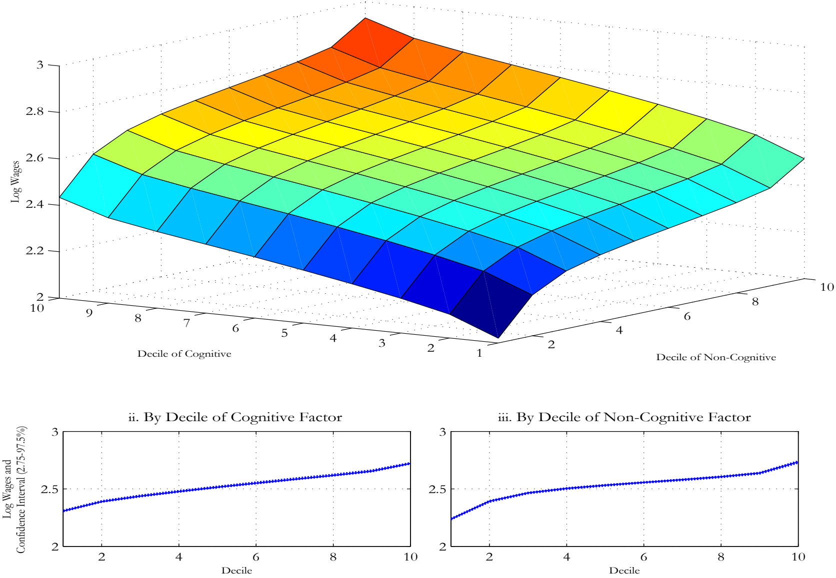
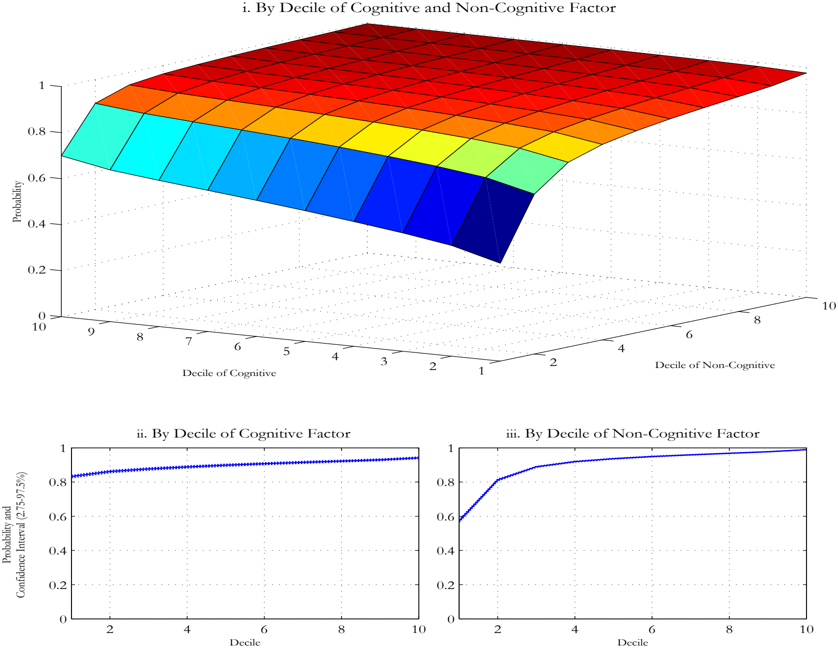


Figure 10. Probability of Employment by Age 30 - Males



Beyond levels: Explaining gaps and disparities

Consider for example a model for the analysis of racial differentials:

$$\ln Y = \varphi Black + \sum_{s=1}^{S} \phi_s D_s(\mathbf{T}) + \gamma \mathbf{T} + U$$

where φ is:

$$\varphi = E[\ln Y^B - \ln Y^W | \mathbf{T}, \{D_s\}_{s=1}^{S}]$$

Thus, we can analyze how "the gap" change if we eliminate racial differences in abilities.

Table 1. Returns to Ability (NLSY79)

Age	Cognitive		Socio-emotional	
	Afro-american	Whites	Afro-american	White
<12 Years of Education				
23-27	3%	8%	6%	3%
33-37	9%	7%	12%	7%
12 Years of Education				
23-27	14%	7%	6%	2%
33-37	15%	7%	19%	7%

Conclusions:

- Both dimensions are "priced" in the market
- Socio-emotional returns are larger among minorities
- Positive association between returns and education

How malleable cognitive and non-cognitive skills are?

- A world in which skills are non-malleable offers no hope for policies or interventions aimed at boosting skills (skills vs endowments).
- For cognitive skills the evidence suggests the existence of early critical periods (childhood) during which these skills change/evolve.
- Cognitive skills seem then stable during adulthood and they decline at older ages (55 or older). Between 60 and 80% of cognitive abilities measure during adulthood can be explained by genetic factors (intergenerational transmission of skills).

Economists focused on the role of skills as determinant of schooling, labor market and behavioral outcomes.

Next challenge is to identify the mechanisms behind the production function of skills, skill formation (Cunha and Heckman, 2008; using CNLSY79)

- Beyond early years.
- Schooling system: Primary, secondary (technical?)?
- Training programs for adults

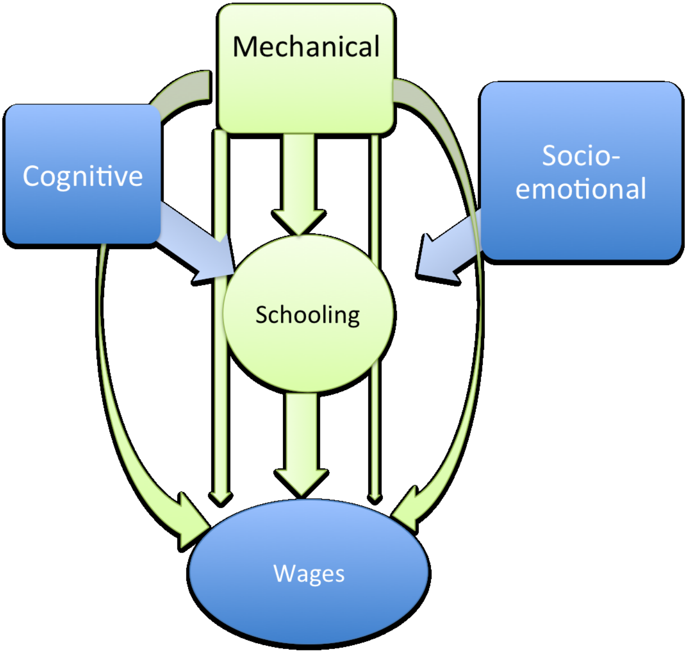
Additionally, we need more cost-benefit analyses coming from public policies.

Are There Other Dimensions of Ability?

The evidence demonstrates independent and important roles for cognitive and socio-emotional skills: Determine schooling attainment, labor market outcomes and social behavior.

The following slides examine the role of a particular dimension of ability **"Mechanical Ability"**

- Unlike standard constructs, it reduces the probability of attending a four-year college, while presenting positive reward on the labor market.
- We find that for individuals with very high levels of mechanical ability but low levels of cognitive and socio-emotional ability, not going to college is associated with higher expected hourly wage.


Mechanical
Cognitive
Socio-
emotional
Schooling
Wages

Technical Composites of the ASVAB in NLSY79

Three section of questions used to create Military Occupational Specialty (MOS) scores

Mechanical comprehension section

Ability to solve simple mechanics problems and understand basic mechanical principles

Technical Composites of the ASVAB in NLSY79

Three section of questions used to create Military Occupational Specialty (MOS) scores

Mechanical comprehension section

Ability to solve simple mechanics problems and understand basic mechanical principles

- Electronics information section
  Covers topics relating to the principles of electronics and electricity.
- Automotive and shop information
  Technical knowledge, skills and aptitude for automotive maintenance and repair wood and metal shop practices.

Correlations: Residuals

Table: Correlation Cognitive and Socio emotional with Technical Composites of the ASVAB

	Auto	**Mech**	**Elect**	**AFQT**	**SocioE**
Auto	1.00				
Mech	0.63	1.00			
Elect	0.62	0.63	1.00		
AFQT	0.34	0.44	0.46	1.00	
SocioE	0.12	0.15	0.15	0.18	1.00

Note: The table displays the correlations of the residuals of test scores on mother's and father's education, cohort dummies, family income, number of siblings. AFQT is a proxy cognitive measure. It represents the standardized average over the ASVAB score in six of the ten components: math knowledge, arithmetic reasoning, word knowledge, paragraph comprehension, numerical speed and coding speed. Socio-emotional is the standardized average of the scores for the Rotter and Rosenberg tests

Roy Framework

$$Y = \begin{cases} Y(0) = \mu_0 + \varepsilon_0 & \text{if } D = 0 \\ Y(1) = \mu_1 + \varepsilon_1 & \text{if} D = 1 \end{cases}$$

$$D = \mathbf{1}\{Z\gamma + \varepsilon_D \geq 0\}$$

- Not assuming normality on $\varepsilon_0, \varepsilon_1, \varepsilon_D$, imposing instead:

$$\varepsilon_0 = \lambda_0^C \theta_C + \lambda_0^M \theta_M + \lambda_0^S \theta_S + e_0$$
$$\varepsilon_1 = \lambda_1^C \theta_C + \lambda_1^M \theta_M + \lambda_1^S \theta_S + e_1$$
$$\varepsilon_D = \lambda_D^C \theta_C + \lambda_D^M \theta_M + \lambda_D^S \theta_S + e_D$$

- Assuming

$$e_0 \perp e_1 \perp e_D \text{ and } (\theta_C, \theta_M, \theta_S) \perp (e_0, e_1, e_D)$$

$$e_0 \sim N(0, \sigma_0^2), e_1 \sim N(0, \sigma_1^2), \text{and } e_D \sim N(0, 1)$$

Identification: Measurement System $T_i = [C_i, S_i, M_i]'$

- Use test scores to identify parameters of the distribution of cognitive, mechanical and socio-emotional factors.
- Each set of testS affected by own factor for cognitive and socio-emotional ability.

$$C_i = X_{C,i}\beta_C + \lambda_C^c \theta_{C,i} + e_{C,i}$$

$$S_i = X_{S,i}\beta_S + \lambda_S^s \theta_{S,i} + e_{S,i}$$

- For vector of mechanical test scores:

$$M_i = X_{M,i}\beta_M + \lambda_{M_l}^c \theta_{c,i} + \lambda_M^M \theta_{M,i} + e_{M,i}$$

Likelihood Function

- We observe $\{Y_i, T_i, D_i\}$ for $i = 1, ..., N$, with $Y_i = D_i Y_{1,i} + (1 - D_j) Y_{0,i}$
- Key Insight: Conditional on unobserved abilities, ε_0,ε_1, and ε_D and ε_T are mutually independent. Thus,

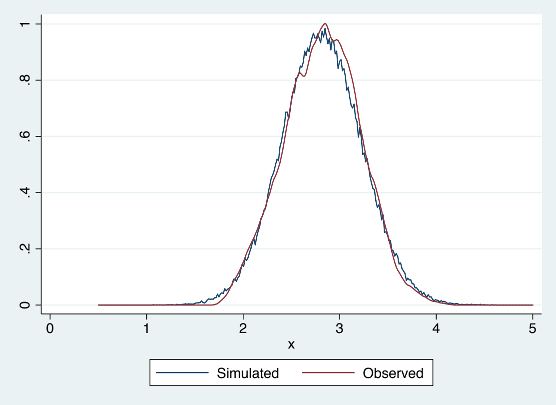
$$\prod_{i=1}^{N} f(Y_i, T_i, D_i | X, X_T, Z) = \prod_{i=1}^{N} \int f(Y_i, T_i, D_i | X, X_T, Z, \theta) dF(\theta)$$

where we can write

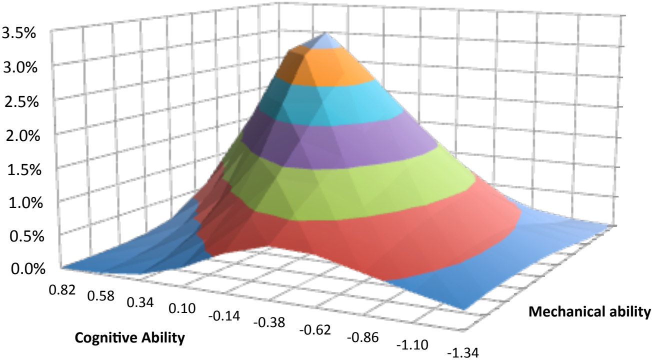
$$f(Y_i, T_i, D_i | X, X_T, Z, \theta) = f(Y_i, D_i | X, Z, \theta) f(T_i | X_T, \theta)$$

Empirical Results

Goodness of Fit: Overall Distribution of Wages

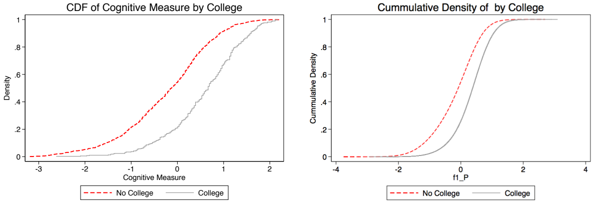


Joint Distribution Cognitive and Mechanical Ability



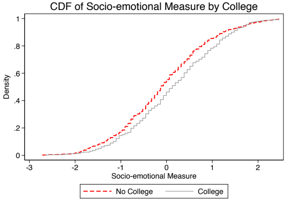
$\sigma_{\theta^M} = 0.58,\ \sigma_{\theta^c} = 0.73,\ \sigma_{\theta^S} = 0.89,\ COV(\theta^c, \theta^m) = 0.21,\ \rho_{\theta^c\theta^m} = 0.52$

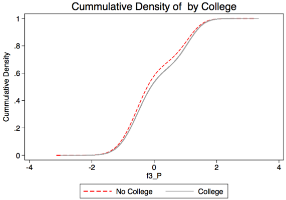
Distribution Measurements vs Estimated Cognitive Ability: Marginal CDF



$$\sigma_{\theta^c} = 0.73, \; COV(\theta^c, \theta^m) = 0.21, \; \rho_{\theta^c\theta^m} = 0.52$$

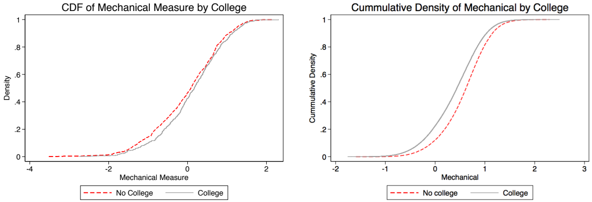
Distribution Measurements vs Estimated Socio-emotional Ability: Marginal CDF





$$\sigma_{\theta^S} = 0.89, \ COV(\theta^C, \theta^S) = 0, \ COV(\theta^M, \theta^S) = 0,$$

Distribution Measurements vs Estimated Mechanical Ability: Marginal CDF



$$\sigma_{\theta^M} = 0.58,\ COV(\theta^C, \theta^M) = 0.21,\ \rho_{\theta^C\theta^M} = 0.52$$

Annual Earnings

Effect of 1 SD of each ability: Mechanical has Positive Returns

Table: Annual Earnings: Estimated Marginal Effects

	Cognitive	**Mechanical**	**Socio-emotional**
Overall	0.130***	0.062***	0.055***
"College"=0 (w0)			
"College"=1 (w1)			

Note: Standard errors in parenthesis. We control for cohort dummies as well as geographical controls for region and urban residence at age 25. Earnings include salary and wages from all jobs reported in the past calendar year. Estimates correspond to the log of the average of earnings between ages 25 and 30.

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Effect of 1 SD of each ability: Mechanical has Positive Returns

Table: Annual Earnings: Estimated Marginal Effects

	Cognitive	**Mechanical**	**Socio-emotional**
Overall	0.130***	0.062***	0.055***
College=0 (w0)	0.049***	0.083***	0.048***
College=1 (w1)	0.144***	0.048***	0.058***

Note: Standard errors in parenthesis. We control for cohort dummies as well as geographical controls for region and urban residence at age 25. Earnings include salary and wages from all jobs reported in the past calendar year. Estimates correspond to the log of the average of earnings between ages 25 and 30.

Heterogeneity: Effect of Education by Ability Levels

For Those Who Decided to Attend Four-year College $E[Y_1 - Y_0 | D = 0]$

Mechanical	**Quintile 1**		**Quintile 5**		**Quintile 10**	
Low C - Low S	0.048	**	0.019	*	-0.030	*
Low C - High S	0.060	***	0.017	*	-0.022	*
High C - Low S	0.248	***	0.237	***	0.188	***
High C - High S	0.274	***	0.215	***	0.212	***

Wrapping up

- Evidence suggest independent and important roles for cognitive and socio-emotional traits
- NLS have been "the" building block of this research agenda
- But we are far from understanding the economic mechanisms behind these roles (discount factors, time preference parameters, prices, etc)
- The influence of NLS will continue. However, to maximize its impact it must also evolve: New cohorts, new dimensions, new variables, administrative records, etc,
- Old and new hungry customers will be waiting...