The accumulation of human capital

Research and Policy Questions.

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I will use liberally material from studies with many co-authors.
Co-authors and research projects

I will use liberally material from studies with many co-authors.

- **The Colombia study:**
  - Attanasio, Fitszimons, Fernandez, Grantham-McGregor, Meghir, Rubio (BMJ. 2014) (impacts of a stimulation intervention)
  - Attanasio, Cattan, Fitzsimons, Meghir, Rubio (2017) (a model of the production function and investment)

- **Production function in observational data**
  - Attanasio, Meghir, Nix (2017) (Young Lives Data - India),
  - Attanasio, Meghir, Nix, Salvati (RED, 2017) (Young Lives Data in Ethiopia and Peru)

- **Beliefs and distorted production functions**
  - Attanasio, Cattan (in progress) - Data from Colombia
  - Attanasio, Cunha, Jervis (in progress) - Data from Colombia

- **Measuring cognitive development**
  - Hamadami, Grantham McGregor, Attanasio et al (Pediatrics, 2014), Bangladesh data
  - Attanasio et al. (JHR, 2017), Bogota Survey
Antecedents and Debts

Sally Grantham McGregor

- The Bangladesh study (Journal of Nutrition, 2006)
Antecedents and Debts

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- Jim Heckman and co-authors:
  - Models of Human Capital accumulation.
  - Latent Factor models
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- **Sally Grantham McGregor**
  - The Bangladesh study (Journal of Nutrition, 2006)

- **Jim Heckman and co-authors:**
  - Models of Human Capital accumulation.
  - Latent Factor models

- **Chuck Manski, Tom Juster**
  - Measurement: beyond revealed preferences
  - Expectations, beliefs, attitudes
Outline

1. Human Capital Accumulation: theory and policies
   1.1 The process of human capital
   1.2 Some Successful Interventions
   1.3 Known and Unknown

2. A theoretical framework

3. Using the model
   3.1 A Colombian intervention and its impacts
   3.2 Estimating the model and interpreting the impacts

4. Two Digressions
   4.1 Structural Models and RCTs
   4.2 Measurement

5. Conclusions
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5. Conclusions
A considerable amount of attention devoted to human capital accumulation and its importance

- In the process of growth and development
- To reduce inequality and increase equality of opportunities
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Human capital accumulation is a very complex process:

- Multidimensional
- Complex interactions
- Complex dynamics
- It starts very early in life
Human Capital Development

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- The early years are important and have long run consequences.
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  - Salient for policy
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- It starts very early in life

The early years are important and have long run consequences.

- Vulnerability / Malleability
- Salient for policy
- ... it does not mean every thing is fixed by age 3!
Multidimensionality

- Human capital is recognised as a multidimensional construct
  - Cognition
  - Socio-emotional skills
  - Health
Multidimensionality

- Human capital is recognised as a multidimensional construct
  - Cognition
  - Socio-emotional skills
  - Health

- Different domains are important for different reasons
  - They get compensated differently in the labour market
  - They play different roles in the accumulation process.
Returns to different skills

- Much evidence is being accumulated on the returns to different skills
  - Edit et al (2017) find that the returns to non-cognitive skills have increased in Sweden.
  - Campos Vasquez (2017) looks at the returns to cognitive and non-cognitive skills in Mexico.
  - Borghans et al. (2008) on the role of personality traits.
  - Heckman et al. (2006) The role of cognitive and non-cognitive skills.
  - Krishna and Krutikova (2013) on the returns to non cognitive skills in India.
Returns to different skills

P. Leighton (2017) looks at the returns to different domains in Latin America using CAF data.

<table>
<thead>
<tr>
<th>Table 4: Estimated effect of latent skills on log hourly earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>Cognitive</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Work ethic</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Strength of personality</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Cognitive sq.</td>
</tr>
<tr>
<td>Work ethic sq.</td>
</tr>
<tr>
<td>Strength of personality sq.</td>
</tr>
<tr>
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</tr>
<tr>
<td>Cognitive * Strength of personality</td>
</tr>
<tr>
<td>Work ethic * Strength of personality</td>
</tr>
<tr>
<td>Selection Correction</td>
</tr>
<tr>
<td>Sector Fixed Effects</td>
</tr>
<tr>
<td>Formality Control</td>
</tr>
<tr>
<td>Additional Controls</td>
</tr>
<tr>
<td>Observations</td>
</tr>
<tr>
<td>$R^2$</td>
</tr>
</tbody>
</table>

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors computed from bootstrapping of whole estimation procedure using 50 replications and reported in parentheses.
What happens in early life is very important.
- Krutikova and Bie Liller (2013) on the effect of fetal shocks on personality treats.

Interactions between different domains are important
- Attanasio, Meghir and Nix (2016) (India), Attanasio, Meghir, Nix and Salvati (2017) (Ethiopia and Peru)
- Attanasio et al. (2017) Colombia
Dynamic process is complex

<table>
<thead>
<tr>
<th>Bangladesh - Cognitive development at 64 months</th>
<th>5th quintile of ses index</th>
<th>0.699</th>
<th>0.403</th>
<th>0.346</th>
<th>0.131</th>
</tr>
</thead>
<tbody>
<tr>
<td>Father ed. &gt; 12</td>
<td>(0.081)</td>
<td>(0.080)</td>
<td>(0.079)</td>
<td>(0.081)</td>
<td></td>
</tr>
<tr>
<td>Child dev. at 18 months</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.021)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child dev. at 7 months</td>
<td>(0.021)</td>
<td>(0.021)</td>
<td>(0.020)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>length growth 1</td>
<td>0.107</td>
<td>0.081</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td>(0.026)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>length growth 2</td>
<td>0.084</td>
<td>0.057</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
<td>(0.024)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>length growth 3</td>
<td>0.094</td>
<td>0.082</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.024)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOME at 18 month</td>
<td></td>
<td>0.008</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOME at 64 months</td>
<td></td>
<td>(0.004)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.041</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.006)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nb obs</td>
<td>1579</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Human development in developing countries.

- Children vulnerability and policy interventions can be particularly relevant in developing countries.
- According to the Lancet (2007, 2011) series, 250m children are at risk of not developing their full potential.
- The potential for effective interventions is large.
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- According to the Lancet (2007, 2011) series, 250m children are at risk of not developing their full potential.
- The potential for effective interventions is large.
- And yet the design and implementation of effective policies is very challenging.
Risk factors in developing countries.

- Bio factors and nutrition – undernutrition in perinatal period and early childhood, iron deficiency, iodine deficiency, other micro-nutrients deficits;
- Infectious diseases;
- Environmental factors – clean water, hygiene, health;
- Psycho-social factors – stimulation, parenting and responsiveness of care-givers, violence, maternal depression.
Developmental lags are associated with poverty: some evidence from Ecuador.

- The delay accumulated by age 6 by the poorest children is 3 s.d. of standardised scores.
- This is equivalent to a 2.5 years delay.

(Paxson and Schady, JHR 2007)
Developmental lags are associated with poverty: some evidence from Bangladesh.

- Developmental lags are significant already at 7 months of age
- By age 5 they are very large
  - (Hamadami, Grantham-McGregor, Attanasio et al, forthcoming in *Pediatrics*)
Developmental lags associated with poverty start early: some evidence from Bogota.

- Socioeconomic gradient significant at 12 months in Bogota.
- Delays evident in several domains.
  
  (Attanasio et al., *Journal of Human Resources*).
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Successful interventions

The fact that the early years are malleable and important implies that well designed and well targeted policies can have spectacular impacts.
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  - The Perry Pre-School Program
  - The Abecedarian Program
  - The Nurse Family Partnership
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  - The Nurse Family Partnership
  - The Jamaica Study
The Perry Pre-School program in Ypsilanti.

- 58 of 123 high risk children aged 3 and 4 were assigned to a high quality preschool program in the early 1960s.
- These children were followed into adulthood.
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Major Findings: High/Scope Perry Preschool Study at 40

<table>
<thead>
<tr>
<th></th>
<th>Program group</th>
<th>No-program group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrested 5+ times by 40</td>
<td>36%</td>
<td>55%</td>
</tr>
<tr>
<td>Earned $20K+ at 40</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>Graduated regular high school</td>
<td>45%</td>
<td>65%</td>
</tr>
<tr>
<td>Basic achievement at 14</td>
<td>15%</td>
<td>49%</td>
</tr>
<tr>
<td>Homework at 15</td>
<td>15%</td>
<td>61%</td>
</tr>
<tr>
<td>IQ 90+ at 5</td>
<td>28%</td>
<td>67%</td>
</tr>
</tbody>
</table>

The Carolina Abecedarian Project (ABC)

- ABC was designed as a social experiment to test the impacts of high quality early years education.
- 111 disadvantaged children in Chapel Hill randomly assigned between treatment (57) and control (54).
- Two stages: early years (0 to 5) and school age years (6-8)
- Very intense early: cognitive and stimulation activities as well as supervised playing for a full 8-hours day!
- Emphasis on language, cognitive skills and self-regulation.
The ABC impacts on health: Biomedical Sweep (Mid 30s)


<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Treatment</th>
<th>Condit.</th>
<th>Blk. IPW P.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
<td>TE</td>
<td>p-val</td>
</tr>
<tr>
<td>Systolic Blood Pressure (mmHg)</td>
<td>143.333</td>
<td>125.789</td>
<td>24.828</td>
<td>0.018</td>
</tr>
<tr>
<td>Diastolic Blood Pressure (mmHg)</td>
<td>92.000</td>
<td>78.526</td>
<td>19.220</td>
<td>0.024</td>
</tr>
<tr>
<td>Hypertension (S.&gt;140 &amp; D.&gt;90)</td>
<td>0.444</td>
<td>0.105</td>
<td>0.537</td>
<td>0.010</td>
</tr>
<tr>
<td>Hypertension (S.&gt;140 or D.&gt;90)</td>
<td>0.556</td>
<td>0.211</td>
<td>0.404</td>
<td>0.038</td>
</tr>
<tr>
<td>Obesity &amp; Hypertension</td>
<td>0.500</td>
<td>0.111</td>
<td>0.529</td>
<td>0.016</td>
</tr>
<tr>
<td>Severe Obesity &amp; Hypertension</td>
<td>0.375</td>
<td>0.000</td>
<td>0.502</td>
<td>0.005</td>
</tr>
<tr>
<td>Hypertension &amp; Dyslipidemia</td>
<td>0.333</td>
<td>0.000</td>
<td>0.435</td>
<td>0.006</td>
</tr>
<tr>
<td>Metabolic Syndrome (NCEP Def.)</td>
<td>0.250</td>
<td>0.000</td>
<td>0.465</td>
<td>0.007</td>
</tr>
<tr>
<td>Framingham Risk Score</td>
<td>7.043</td>
<td>4.889</td>
<td>3.253</td>
<td>0.038</td>
</tr>
</tbody>
</table>

Notes: The fourth column “Condit. TE” presents the conditional treatment effect controlling for cohort, number of siblings, mother’s IQ and high-risk index at birth, and accounting for attrition using IPW.
The Jamaica study.

- 129 stunted children, aged between 9 and 24 months at baseline were randomly divided into 4 groups:
  - Stimulation group;
  - Nutrition group;
  - Nutrition + Stimulation group;
  - Control group.

- The intervention lasted 2 years and the children were observed:
  - at the end of the intervention;
  - at age 7-8;
  - at age 11-12;
  - at age 17-18;
  - at age 22-23.
The Jamaica study.

The results were stunning:
(Grantham Mc Gregor et al., Lancet 1991)
The results were stunning: (Walker et al., Lancet 2005)
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What we know and what we don’t.

- Over the last few decades we have learned much:
What we know and what we don’t.

Over the last few decades we have learned much:

- Early years are key;
- Human capital is a multidimensional object and its different dimensions are all important;
- Nutrition is important;
- Stimulation is key to child development and might be more effective than nutrition;
- The household environment is crucial, especially in the early years;
- There are important dynamic interactions.
... and yet there is much we do not know!
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- We still do not understand the role of genes and epigenetics and how they affect multiple aspects of development.
- We still do not fully understand how nutrition affect the development of cognitive and non-cognitive skills
What we know and what we don’t.

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- We still do not fully understand how the dynamics of the process;
- We still do not fully understand how the process changes with age.
What we know and what we don’t.

... and yet there is much we do not know!

- We still do not understand what determines investment in human capital.
  - What do parents do?
  - What constraints do they face?
  - How are resources allocated within the family?
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- We still do not know how to build cost effective interventions: from efficacy to effectiveness.
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The Production Function of Human Capital

from Cunha, Heckman and Schennach (2010)

\[ H_{t+1} = g_t(H_t, X_t, Z_t, e_{t+1}) \]

- **\( H_t \)** is Human Capital (including cognition \( c \), socio-emotional dev. \( s \) and health \( h \) capital).
- **\( Z_t \)** are background variables (either fixed or time varying) (including mother \( m \), father \( f \) and other \( r \)).
- **\( X_t \)** are Investments in HK (including materials \( M \) and time \( T \)).
- **\( e_{t+1} \)** are shocks.

All variables are multidimensional:

\[
\begin{align*}
H_t &= \{ \theta^c_t, \theta^s_t, \theta^h_t \} \\
Z_t &= \{ \theta^m_t, \theta^f_t, \theta^r_t \} \\
X_t &= \{ \theta^M_t, \theta^T_t \}
\end{align*}
\]
The Investment Problem

- Parents choose investment to maximise utility that depends on Human Capital and Consumption
  - subject to a budget constraint
  - subject to (their perception of) the production function

\[
\begin{align*}
\max_{\{C_t, x_t\}} & \quad U(C_t, H_{t+1}) \\
\text{s.t.} & \quad C_t + P_t^x X_t = Y_t \\
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\]

- Investment could be in commodities or time.
- Could easily add labour supply choices
- Could easily add inter-temporal dimension, independently of the process of HK
Many of the variables in this model are not directly observed.
Issues: what we do observe?

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- Cunha et al. (2010) propose a useful latent factor approach.
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The structural model is complemented with a measurement system

\[ m_{jt}^{kj} = \alpha_t^{kj_1} \theta_t^j + \epsilon_t^{kj}, \quad j = \{c, s, h, m, f, r, M, T\}, \quad k = \{1, 2, \ldots\} \]
A theoretical framework

Issues: what we do observe?

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- We need at least two measurements to identify the distribution of unobservable latent factors.
- Some exclusion restrictions are required.
- Some independence of measurement error is required.
Issues: Endogeneity of Investment

- Parents choose investment in reaction to shocks.
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- The structural framework we sketched suggests a solution.
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- One can derive an Investment Function:

\[ X_t = f_t(Y_t, P_t, Z_t, e_t) \]
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- One can estimate the investment equation together with the production function
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- One can derive an Investment Function:

  \[ X_t = f_t(Y_t, P_t, Z_t, e_t) \]

- One can estimate the investment equation together with the production function
- ... or approximate it and use a control function approach
Issues: Endogeneity of Investment

- Notice the role played by the variables $P_t, Y_t$ in the investment function: they are excluded from the production function.

- One can use a contra function approach to estimate the role investment plays in the production function.
Issues: Endogeneity of Investment

- Notice the role played by the variables $P_t, Y_t$ in the investment function: they are excluded from the production function.
- One can use a contra function approach to estimate the role investment plays in the production function.
- The parameters of the investment function will depend on:
  - The parameters of the utility function
  - The parameters of the production function as perceived by the parents
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   3.1 A Colombian intervention and its impacts
   3.2 Estimating the model and interpreting the impacts

4. Two Digressions
   4.1 Structural Models and RCTs
   4.2 Measurement

5. Conclusions
We now use the model to analyse the data from a RCT designed to evaluate a stimulation intervention.

I will briefly describe the intervention.

I will report the impacts.

I will show how we use the data from the intervention to estimate the production function of human capital at early years.

I will discuss why this is useful.
Outline

1. Human Capital Accumulation: theory and policies
  1.1 The process of human capital
  1.2 Some Successful Interventions
  1.3 Known and Unknown

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5. Conclusions
An early years stimulation intervention in Colombia


- The intervention consists of home visits targeted at children aged 12 to 24 months at baseline.
- It adapted Grantham-McGregor Jamaican curriculum to the Colombian context.
- One hour weekly visits by a visitor who interacts with mother and child and develops an integrated and well structured curriculum.
- Focus on cognition, language, fine motor skills.
An early years stimulation intervention in Colombia

- Innovations relative to the Jamaica study:
  - The intervention was delivered by local women (rather than health workers), identified through a pre-existing welfare program.
  - The intervention was implemented on a large scale, attempting to design a scalable program.
  - It lasted 18 months.
  - We collected rich data to be used to explain the impacts of the intervention.
An early years stimulation intervention in Colombia

- Innovations relative to the Jamaica study:
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  - The intervention was implemented on a large scale, attempting to design a scalable program.
  - It lasted 18 months.
  - We collected rich data to be used to explain the impacts of the intervention.

- The intervention was evaluated through a Cluster RCT.
- Randomization was across 96 small towns in 3 regions.
- The resulting data is one of the largest RCT in this field: 1400 children in 96 clusters;
  - Effective sample size, taking into account ICC, 880
The intervention’s impacts

- The intervention had some significant impacts on cognitive development and receptive language.
- The cognitive impact fills half of the gap between top and bottom wealth quintiles in Bogotà.
- These effects were very robust.
Impacts along the distribution - cognition
First Hint at Mechanisms: Increased Parental Investment in Children

<table>
<thead>
<tr>
<th></th>
<th>Home Made Toys</th>
<th>Bought Toys</th>
<th>Play Materials</th>
<th>Play Activities (previous 3 days)</th>
<th>Books for Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stimulation</strong></td>
<td>0.914***</td>
<td>0.284*</td>
<td>0.556***</td>
<td>0.564***</td>
<td>0.0188</td>
</tr>
<tr>
<td></td>
<td>(0.180)</td>
<td>(0.134)</td>
<td>(0.128)</td>
<td>(0.152)</td>
<td>(0.081)</td>
</tr>
<tr>
<td><strong>Stim + Micronutrients</strong></td>
<td>0.719***</td>
<td>0.167</td>
<td>0.452***</td>
<td>0.731***</td>
<td>0.140</td>
</tr>
<tr>
<td></td>
<td>(0.189)</td>
<td>(0.133)</td>
<td>(0.137)</td>
<td>(0.153)</td>
<td>(0.087)</td>
</tr>
<tr>
<td><strong>Micronutrients</strong></td>
<td>0.0886</td>
<td>0.337*</td>
<td>0.213</td>
<td>0.217</td>
<td>0.104</td>
</tr>
<tr>
<td></td>
<td>(0.187)</td>
<td>(0.151)</td>
<td>(0.167)</td>
<td>(0.153)</td>
<td>(0.087)</td>
</tr>
</tbody>
</table>

n = 1329; *significant at 5%; **significant at 1%
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Incorporating the role of the intervention in the framework

- We now use the theoretical framework to interpret these results.

- from Attanasio, Cattan, Fitzsimons, Meghir and Rubio (2017)
Incorporating the role of the intervention in the framework

- We now use the theoretical framework to interpret these results.
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- The purpose is to establish how the intervention obtained the observed impacts.
We now use the theoretical framework to interpret these results.

from Attanasio, Cattan, Fitzsimons, Meghir and Rubio (2017)

The purpose is to establish how the intervention obtained the observed impacts.

Within the production function approach, the intervention could have affected the formation of skills:

- By shifting the distribution of investments
- By shifting the productivity of the inputs
Incorporating the role of the intervention in the framework

- We consider the impact of stimulation ($\kappa = 1$) vs. no stimulation ($\kappa = 0$) and let the investment functions and the production functions to depend on the intervention.

- The investment functions are specified as:

$$
\ln(I_{i,t}^\tau) = \lambda_{\kappa,0}^\tau + \lambda_{\kappa,1}^\tau \ln(\theta_{i,t}^c) + \lambda_{\kappa,2}^\tau \ln(\theta_{i,t}^s) + \lambda_{\kappa,3}^\tau \ln(\theta_{m,c}^m) + \\
\lambda_{\kappa,4}^\tau \ln(\theta_{m,s}^m) + \lambda_{\kappa,5}^\tau \ln(Z_{i,t}) + u_{i,t}^\tau, \quad \tau = M, T
$$

- where $Z$ are variables that determine investment but have no direct impact in the production function:
  - Prices, wages
  - Family resources
  - Family composition (but we do allow them in the prod. fun.)
Using the model  
Estimating the model and interpreting the impacts

Incorporating the role of the intervention in the framework

- The production function we estimate is:

\[
\theta_{i,t+1}^j = \left[ A_{i,t}^j \gamma_{1,\kappa} \theta_{i,t}^c \rho_j + \gamma_{2,\kappa} \theta_{i,t}^s \rho_j + \gamma_{3,\kappa} \theta_{i,t}^{m,c} \rho_j + \gamma_{4,\kappa} \theta_{i,t}^{m,s} \rho_j + \gamma_{5,\kappa} \theta_{i,t+1}^M \rho_j + \gamma_{6,\kappa} \theta_{i,t+1}^T \rho_j \right] \frac{1}{\rho_j} e^{\eta_{i,t}^j} \quad j = c, s
\]

The joint distribution of factors \((\theta_{t+1}, \theta_t, I_{t+1}, P)\) is allowed to differ between the treatment and control samples.
Using the model
Estimating the model and interpreting the impacts

Latent Factors distributions: child development

(a) Children’s cognitive skill at follow-up
(b) Children’s non-cognitive skill at follow-up
Using the model

Estimating the model and interpreting the impacts

Latent Factors distributions: investments

(e) Material investment

(f) Time investment
### The Investment Functions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mat investment</th>
<th>Time investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treat</td>
<td>0.204</td>
<td>0.333</td>
</tr>
<tr>
<td></td>
<td>[0.038,0.365]</td>
<td>[0.155,0.48]</td>
</tr>
<tr>
<td>Baseline cognition</td>
<td>0.13</td>
<td>0.067</td>
</tr>
<tr>
<td></td>
<td>[0.016,0.246]</td>
<td>[-0.044,0.18]</td>
</tr>
<tr>
<td>Baseline SE</td>
<td>-0.032</td>
<td>0.021</td>
</tr>
<tr>
<td></td>
<td>[-0.133,0.087]</td>
<td>[-0.083,0.145]</td>
</tr>
<tr>
<td>Mother’s cognition</td>
<td>0.754</td>
<td>0.367</td>
</tr>
<tr>
<td></td>
<td>[0.582,0.939]</td>
<td>[0.162,0.498]</td>
</tr>
<tr>
<td>Mother’s SE</td>
<td>0.071</td>
<td>0.024</td>
</tr>
<tr>
<td></td>
<td>[-0.008,0.139]</td>
<td>[-0.06,0.108]</td>
</tr>
<tr>
<td>Number of kids</td>
<td>-0.129</td>
<td>-0.134</td>
</tr>
<tr>
<td></td>
<td>[-0.18,-0.077]</td>
<td>[-0.186,-0.072]</td>
</tr>
<tr>
<td>Toy prices</td>
<td>-0.095</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>[-0.168,-0.027]</td>
<td>[-0.085,0.037]</td>
</tr>
<tr>
<td>Food price</td>
<td>0.096</td>
<td>0.042</td>
</tr>
<tr>
<td></td>
<td>[0.006,0.178]</td>
<td>[-0.026,0.121]</td>
</tr>
<tr>
<td>Conflict</td>
<td>-0.011</td>
<td>-0.096</td>
</tr>
<tr>
<td></td>
<td>[-0.08,0.063]</td>
<td>[-0.139,-0.032]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank test</td>
<td>0.011</td>
</tr>
<tr>
<td>Cragg-Donald test</td>
<td>0.019</td>
</tr>
</tbody>
</table>

**Joint Significance Tests - p-values**

- Toy price, Food price, Conflict: 0.028, 0.008
- Toy price, Food price, Conflict, Treat: 0.001, 0.001
### The Production Functions: cognitive skills

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFP * Treament</td>
<td>0.084</td>
<td>0.058</td>
</tr>
<tr>
<td></td>
<td>[-0.025, 0.192]</td>
<td>[-0.116, 0.389]</td>
</tr>
<tr>
<td>Baseline cognition</td>
<td>0.67</td>
<td>0.651</td>
</tr>
<tr>
<td></td>
<td>[0.589, 0.77]</td>
<td>[0.542, 0.794]</td>
</tr>
<tr>
<td>Baseline SE</td>
<td>-0.004</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>[-0.091, 0.087]</td>
<td>[-0.095, 0.147]</td>
</tr>
<tr>
<td>Mother’s cognition</td>
<td>0.217</td>
<td>-0.059</td>
</tr>
<tr>
<td></td>
<td>[0.089, 0.35]</td>
<td>[-0.428, 0.509]</td>
</tr>
<tr>
<td>Mother’s SE</td>
<td>0.106</td>
<td>0.081</td>
</tr>
<tr>
<td></td>
<td>[0.031, 0.173]</td>
<td>[-0.032, 0.166]</td>
</tr>
<tr>
<td>Number of kids</td>
<td>0.041</td>
<td>0.081</td>
</tr>
<tr>
<td></td>
<td>[-0.01, 0.092]</td>
<td>[-0.066, 0.154]</td>
</tr>
<tr>
<td>Material investment</td>
<td>0.08</td>
<td>0.577</td>
</tr>
<tr>
<td></td>
<td>[0.016, 0.157]</td>
<td>[0.02, 1.179]</td>
</tr>
<tr>
<td>Time investment</td>
<td>0.04</td>
<td>-0.167</td>
</tr>
<tr>
<td></td>
<td>[-0.051, 0.129]</td>
<td>[-1.23, 0.312]</td>
</tr>
</tbody>
</table>

**Goodness-of-fit: Gap in output between treated and control**

(a) Measured in the data: 0.121
(b) Predicted by the model: 0.114, 0.120, 0.125, 0.073, 0.078
### The Production Functions: Socioemotional Skills

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TFP * Treatment</strong></td>
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<td>-0.092</td>
</tr>
<tr>
<td></td>
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<td>[-0.322, 0.155]</td>
</tr>
<tr>
<td><strong>Baseline cognition</strong></td>
<td>0.105</td>
<td>0.072</td>
</tr>
<tr>
<td></td>
<td>[0.018, 0.192]</td>
<td>[-0.013, 0.209]</td>
</tr>
<tr>
<td><strong>Baseline SE</strong></td>
<td>0.51</td>
<td>0.503</td>
</tr>
<tr>
<td></td>
<td>[0.403, 0.659]</td>
<td>[0.384, 0.668]</td>
</tr>
<tr>
<td><strong>Mother’s cognition</strong></td>
<td>-0.073</td>
<td>-0.113</td>
</tr>
<tr>
<td></td>
<td>[-0.218, 0.049]</td>
<td>[-0.47, 0.316]</td>
</tr>
<tr>
<td><strong>Mother’s SE</strong></td>
<td>0.036</td>
<td>0.044</td>
</tr>
<tr>
<td></td>
<td>[-0.058, 0.119]</td>
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</tr>
<tr>
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<td>0.131</td>
</tr>
<tr>
<td></td>
<td>[0.047, 0.153]</td>
<td>[0.016, 0.235]</td>
</tr>
<tr>
<td><strong>Material investment</strong></td>
<td>0.142</td>
<td>-0.068</td>
</tr>
<tr>
<td></td>
<td>[0.06, 0.256]</td>
<td>[-0.642, 0.455]</td>
</tr>
<tr>
<td><strong>Time investment</strong></td>
<td>0.119</td>
<td>0.589</td>
</tr>
<tr>
<td></td>
<td>[-0.006, 0.213]</td>
<td>[-1.69, 1.295]</td>
</tr>
</tbody>
</table>

**Goodness-of-fit: Gap in output between treated and control**

<table>
<thead>
<tr>
<th></th>
<th>(a) Measured in the data</th>
<th>0.082</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b) Predicted by the model</td>
<td>0.0566</td>
<td>0.0903</td>
</tr>
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- We have shown the impacts of a cluster RCT.
- As such they are simple to obtain and easy to explain.
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- What is the use of the structural model?
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- What is the use of the structural model?
- It helps us to understand the mechanisms through which the program operates.
- These are key for the design of policy.
Why a structural model?

- The structure we have built is also a useful way to synthetise much information.
Two Digressions  Structural Models and RCTs

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- The structure we have built is also a useful way to synthetise much information.
- Notice that we do not use the RCT to identify the production function or the investment rule.
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- This makes necessary the use of an 'instrumental variable' approach to take into account the role of parental investment.
Why a structural model?

- The structure we have built is also a useful way to synthetise much information.
- Notice that we do not use the RCT to identify the production function or the investment rule.
- This makes necessary the use of an 'instrumental variable' approach to take into account the role of parental investment.
- We therefore need exogenous sources of variation in the determinants of investment.
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  4. It might be worthwhile to go beyond the standard ‘revealed preference’ approach.
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  3. Theory should inform the development of suitable measures.
  4. It might be worthwhile to go beyond the standard ‘revealed preference’ approach.

- I will give some examples of these issues.
Measuring child development is hard

- Measuring young children development accurately is very hard.
- Some of the measures that are considered the ‘gold standard’ are very expensive
  - The Bayleys scales of infant development (BSID) take about 1.5 hours to administer
  - They need to be administered by a specially trained psychologist
  - They cannot be administered in the child’s home but in standardised settings.
- Unfortunately alternative ‘cheap’ measures can be very noisy.
How good are cheap measures?

Results from Araujo, Attanasio, and Rubio-Codina (2014, in progress)

Correlations with Bayley Cognition

6 - 18 meses
19 - 30 meses
31 - 42 meses

0.111
0.044
0.329
0.114
0.166
0.376
0.315
0.234
0.367
0.169
0.368
0.392
0.189
0.332
0.429

ASQ3 Res. Problemas (0.160)
ASQ3 Comunicación (0.218)
Battelle Cognitivo (0.302)
Battelle Lenguaje (0.308)
Denver Mot. Fina (0.316)
Denver Lenguaje (0.274)
Two Digressions

Measurement

How good are cheap measures?

Results from Araujo, Attanasio, and Rubio-Codina (2014, in progress)

Correlations with Bayley Expressive Language

Correlación

6 - 18 meses 19 - 30 meses 31 - 42 meses

ASQ3 Comunicación (0.406)
Denver Lenguaje (0.470)
Battelle Lenguaje (0.472)
MacArthur Leng. Exp.* (0.475)

* 8 - 30 meses
New technologies

- Much is happening and new tools are being developed.
- Some examples:
New technologies

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- Some examples:
  - Anne Fernald’s eye tracking test seems to be very predictive of later academic outcomes. (Fernald et al. Dev. Psych. 2006)
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New technologies

- Much is happening and new tools are being developed.
- Some examples:
  - Anne Fernald’s eye tracking test seems to be very predictive of later academic outcomes. (Fernald et al. Dev. Psych. 2006)
  - LENA technology to record and analyse words exposure
- There might be some low hanging fruits to be reaped.
Theory should inform the choice of measurement tools

- Appropriate measurement tools can solve identification problems.
Theory should inform the choice of measurement tools

- Appropriate measurement tools can solve identification problems.
- This is obvious when some specific ‘unobservables’ become (partially) observable.
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- This is obvious when some specific ‘unobservables’ become (partially) observable.
- There is a more subtle sense in which appropriate design can help identification.
- In the factor models we have used, non-parametric identification requires multiple measures with uncorrelated measurement errors.
- This has been discussed in the literature:
  - Schennach (ECA, 2004)
  - Browning and Crossley (2009) "Are Two Cheap, Noisy Measures Better Than One Expensive, Accurate One?," AEA P&P
Theory should inform the choice of measurement tools

- The assumption of uncorrelated measurement errors in different measures can be made realistic by specific design:
  - In the case of the Colombia study we have different measures of cognitive development (Bayleys’ scales, MacArthur Language tests, ASQ, etc.)
  - Some of them are administered by different individuals in different days.
  - Some of them are based on the observation of the child, other are based on maternal reports.

- Additional examples can be constructed with respect to the loading of different factors.
Beyond revealed preferences: observing unobservables

Another dimension in which measurement tools can be developed is by eliciting individual responses on:

- tastes, preferences, attitudes
- expectations
- beliefs
Beyond revealed preferences: observing unobservables

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  - tastes, preferences, attitudes
  - expectations
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- This approach involves often going beyond ‘revealed preferences’.

- In addition to choices, questionnaires elicit other dimensions often based on hypotheticals.
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  - tastes, preferences, attitudes
  - expectations
  - beliefs

- This approach involves often going beyond ‘revealed preferences’.

- In addition to choices, questionnaires elicit other dimensions often based on hypotheticals.

- This approach has not been used in the profession....

- ... but it has been pioneered by a number of scholars:
  - Tom Juster and researchers in Michigan
  - Chuck Manski on subjective expectations.
  - Willingness to pay.
Flavio Cunha has been asking questions about the return to parenting investment in Philadelphia (Cunha et al., 2014)
Beyond revealed preferences: observing unobservables

- Flavio Cunha has been asking questions about the return to parenting investment in Philadelphia (Cunha et al., 2014)
- In collaboration with Flavio Cunha we have been eliciting beliefs on the returns to parenting in Colombia.
Beyond revealed preferences: observing unobservables

- Flavio Cunha has been asking questions about the return to parenting investment in Philadelphia (Cunha et al., 2014)
- In collaboration with Flavio Cunha we have been eliciting beliefs on the returns to parenting in Colombia.
- … tomorrow’s seminar
1. Human Capital Accumulation: theory and policies
   1.1 The process of human capital
   1.2 Some Successful Interventions
   1.3 Known and Unknown

2. A theoretical framework

3. Using the model
   3.1 A Colombian intervention and its impacts
   3.2 Estimating the model and interpreting the impacts

4. Two Digressions
   4.1 Structural Models and RCTs
   4.2 Measurement

5. Conclusions
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  - How to build scalable interventions?
- A research agenda:
  - Better measurement tools.
  - Use of structural models to identify the production function and parental behaviour.
  - Instrumental to the design of effective policies.