Correlation, Consumption, Confusion, or Constraints: Why do Poor Children Perform so Poorly?

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HUMAN CAPITAL AND
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Motivation

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- Children from poor families perform much worse than children from better-off families
- Differences emerge early and persist/grow with age (Carneiro & Heckman 2002, Cunha, et al. 2006)

PIAT-Math Scores Ages 6-7

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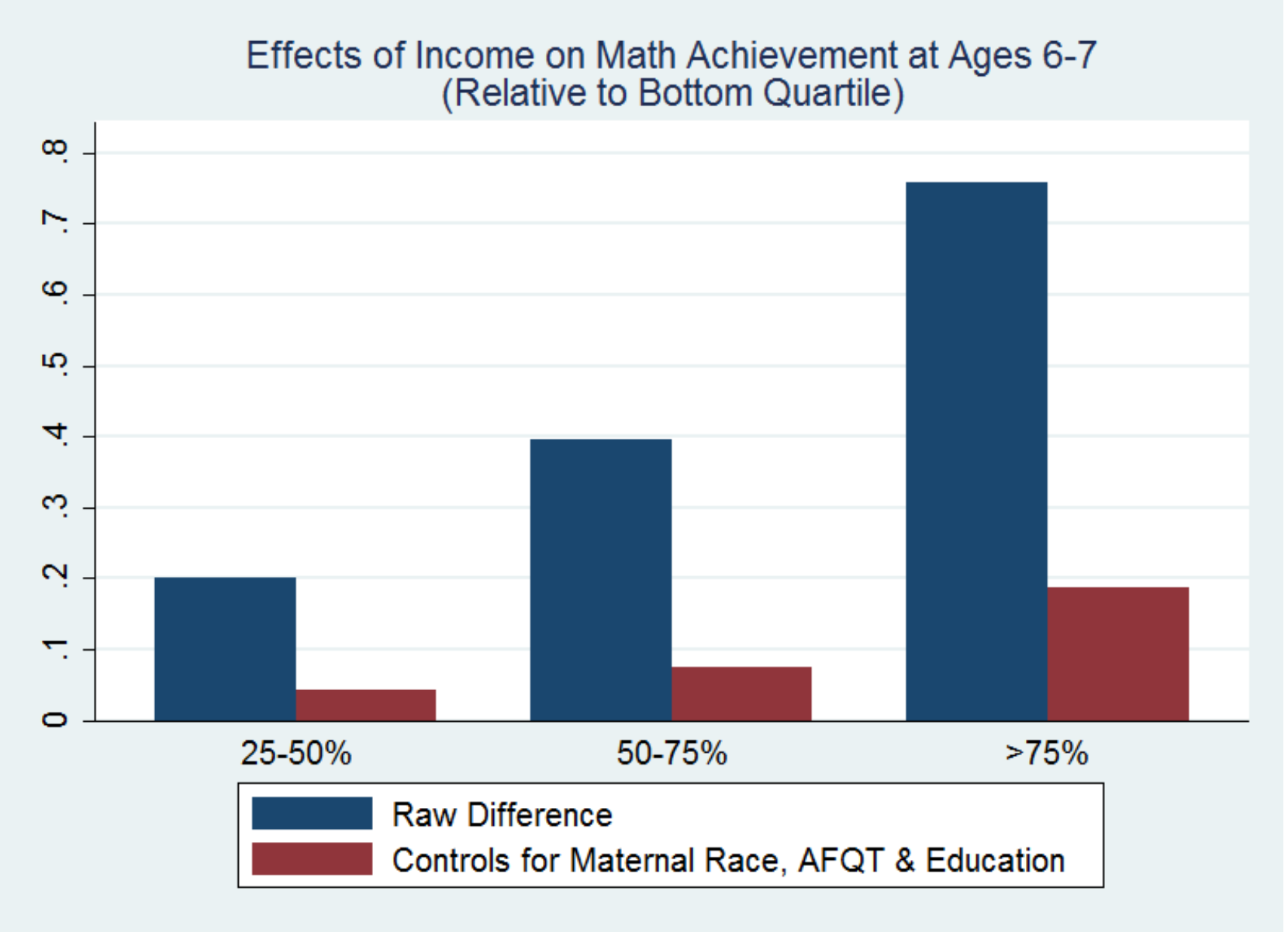

PIAT-Reading Recognition Scores Ages 6-7

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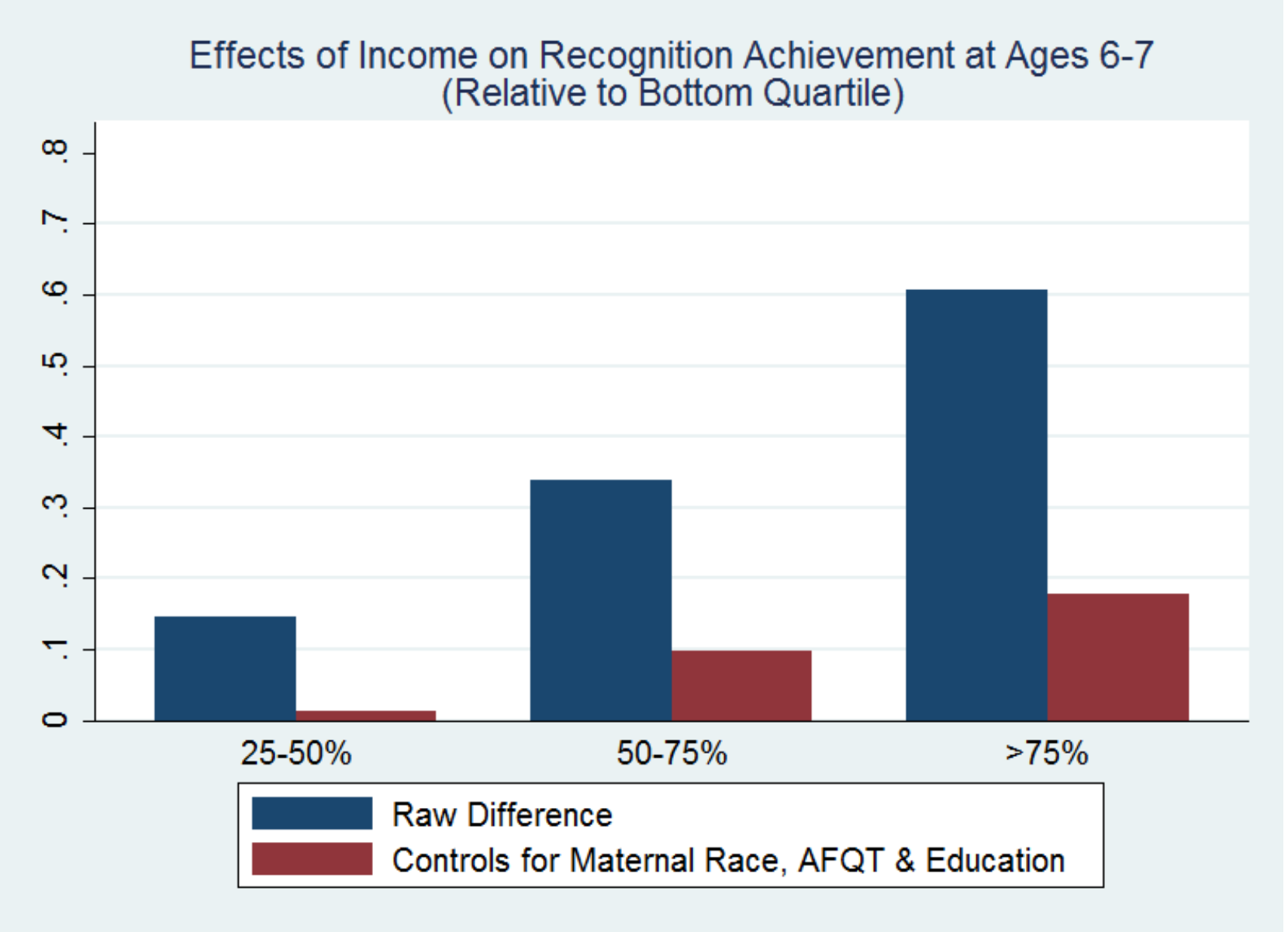
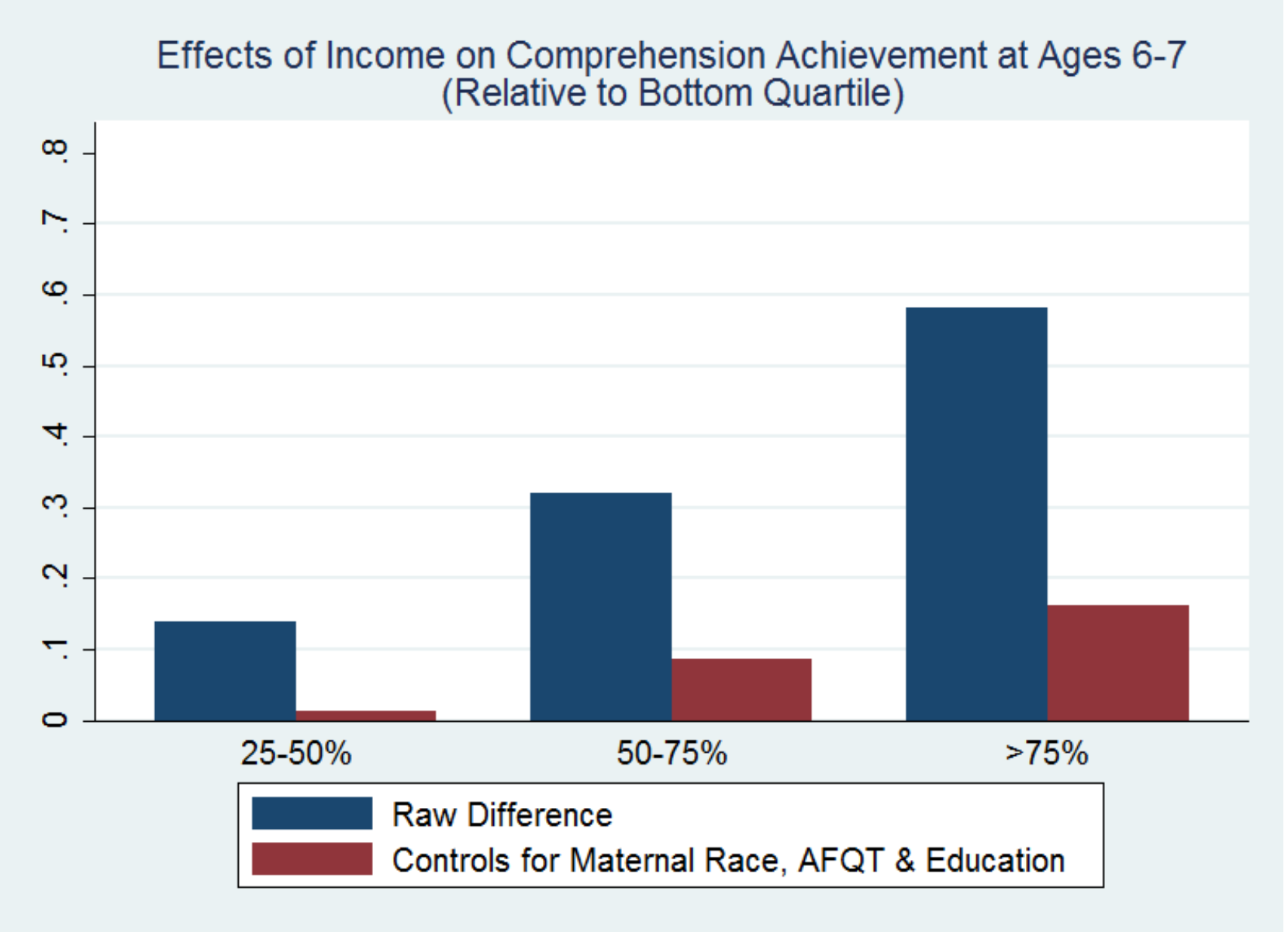


PIAT-Reading Comprehension Scores Ages 6-7



What leads to early skill gaps?

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- We consider a human capital investment framework where gaps arise from different investments and/or differential returns on investments

Ages 2-3 Investments

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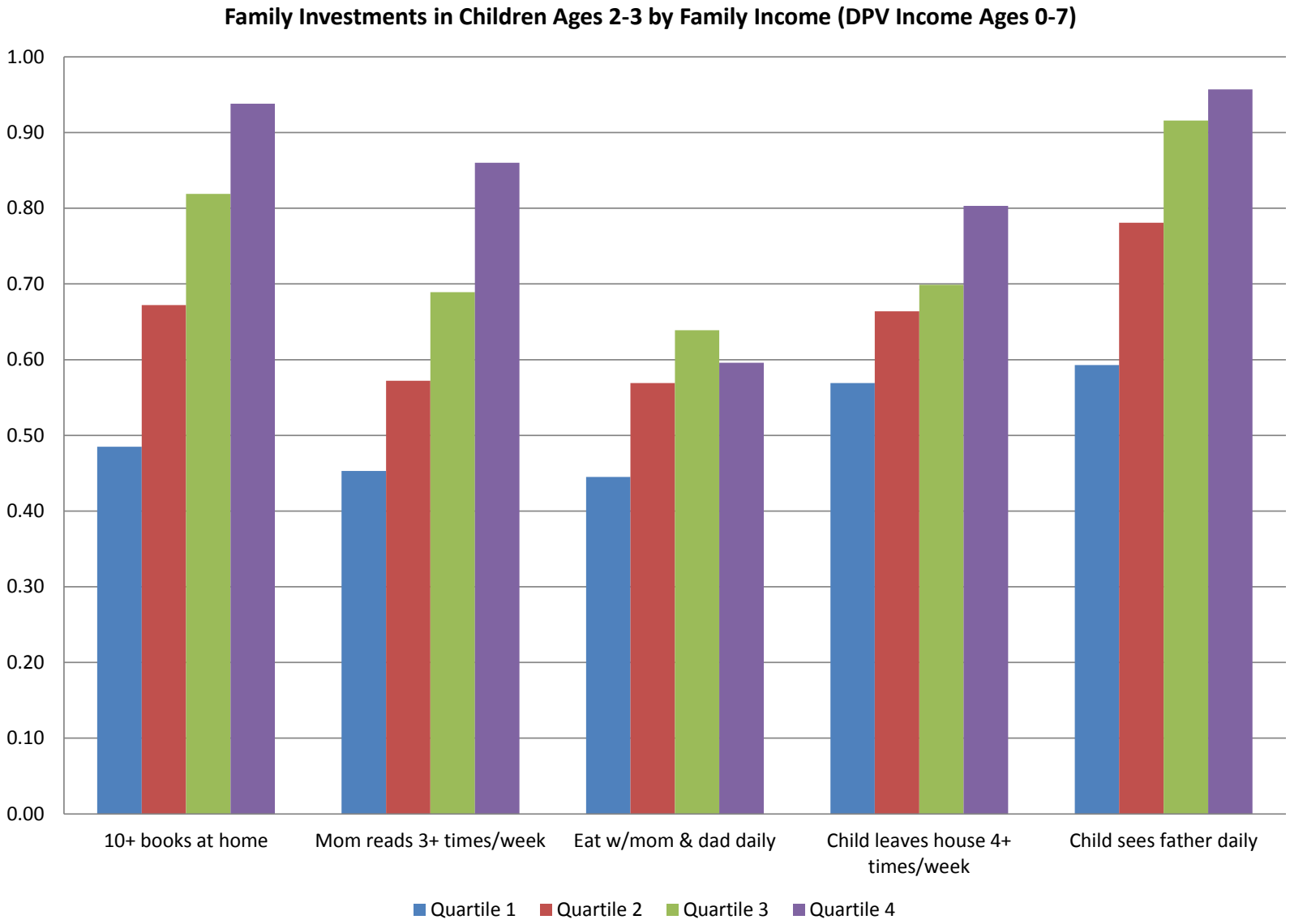

Ages 6-7 Investments

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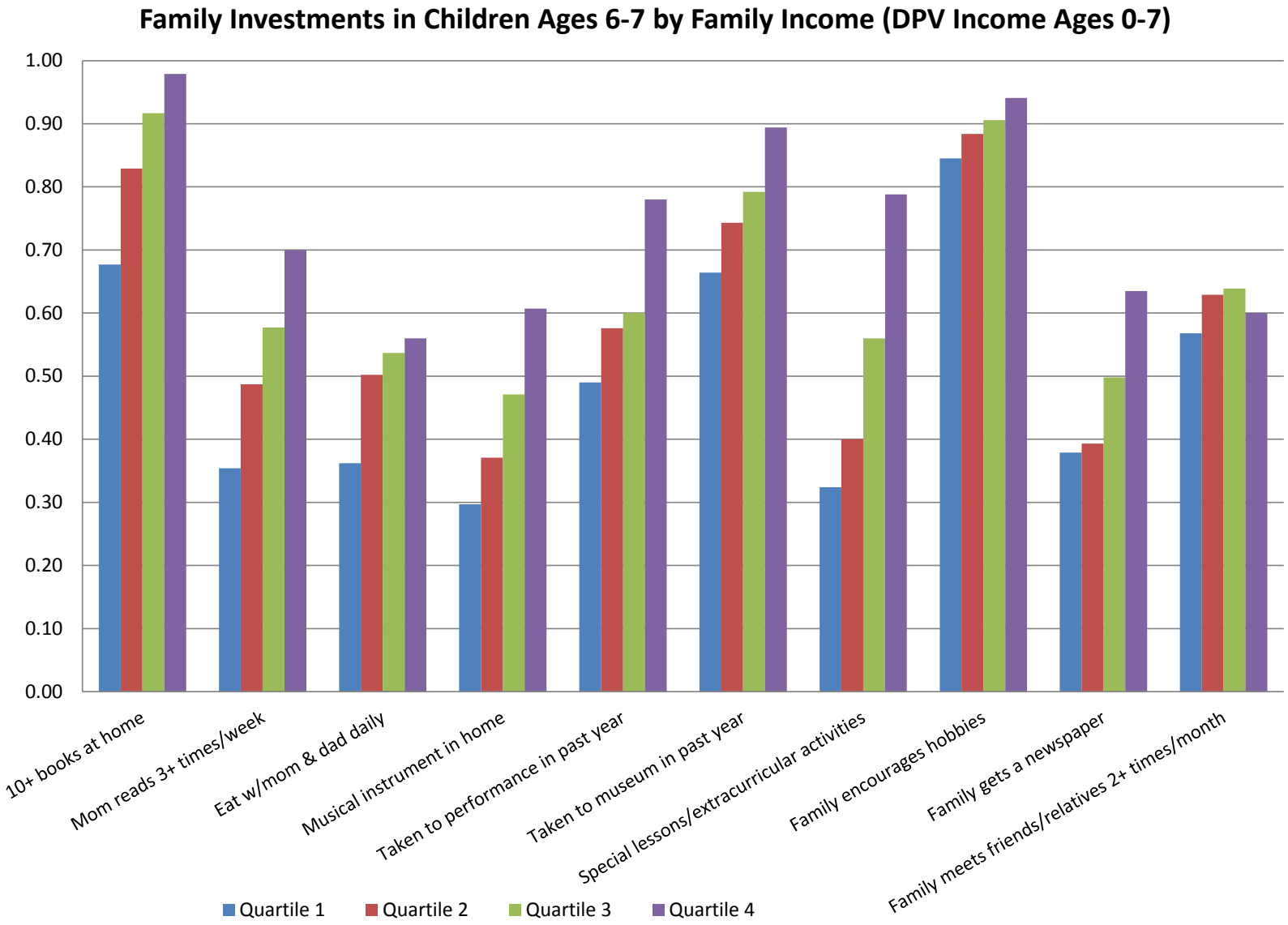

Investment Factor Scores Ages 0-7

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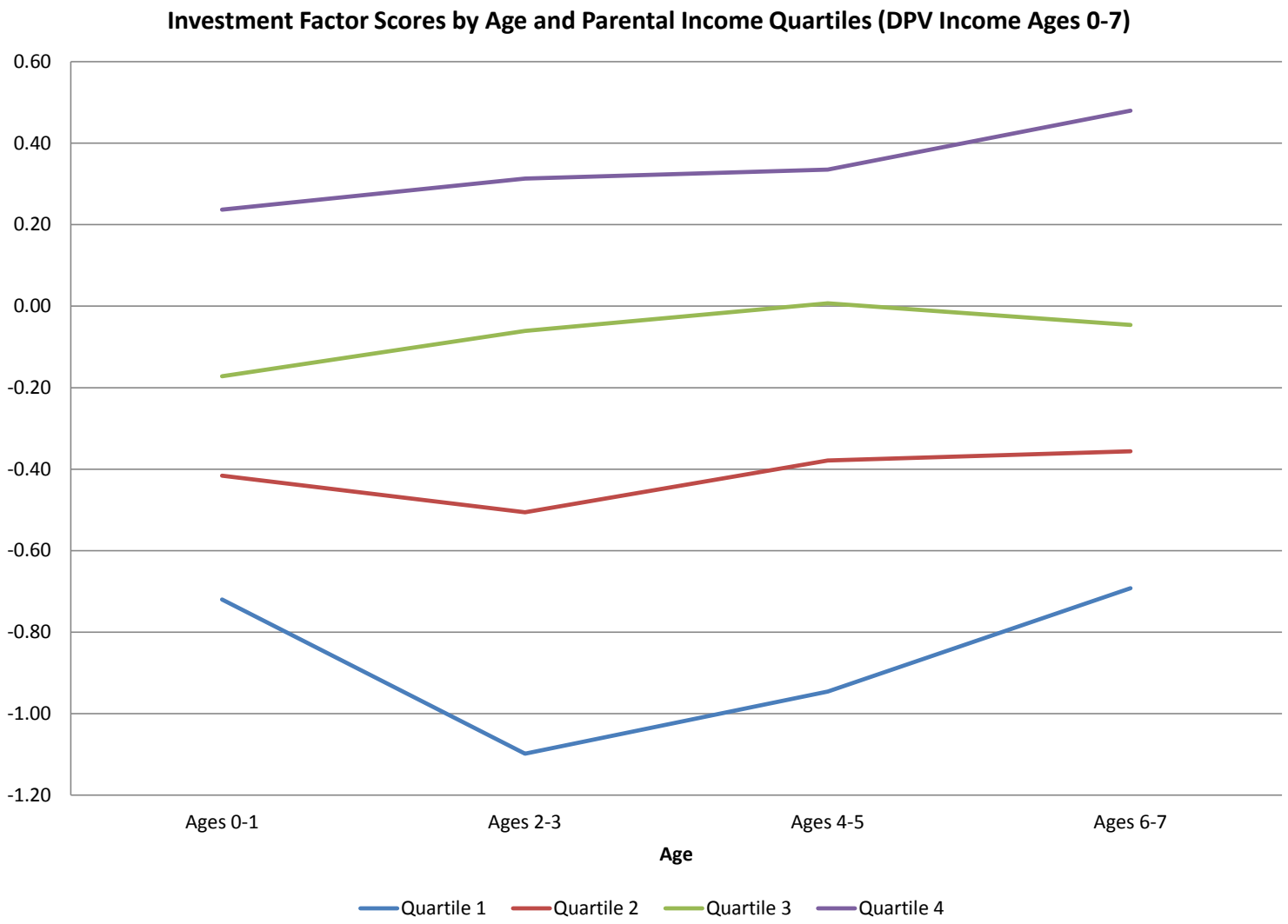
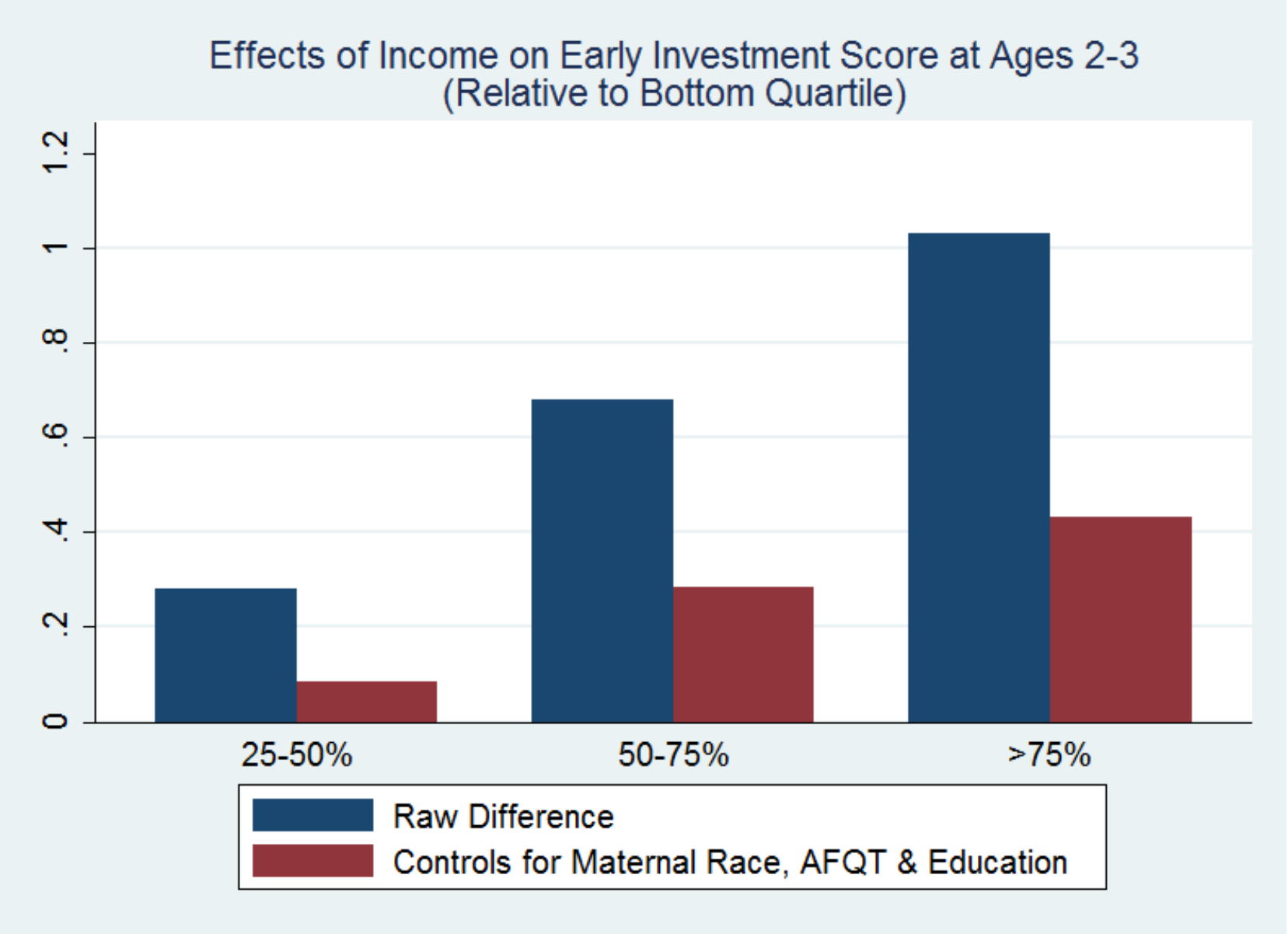
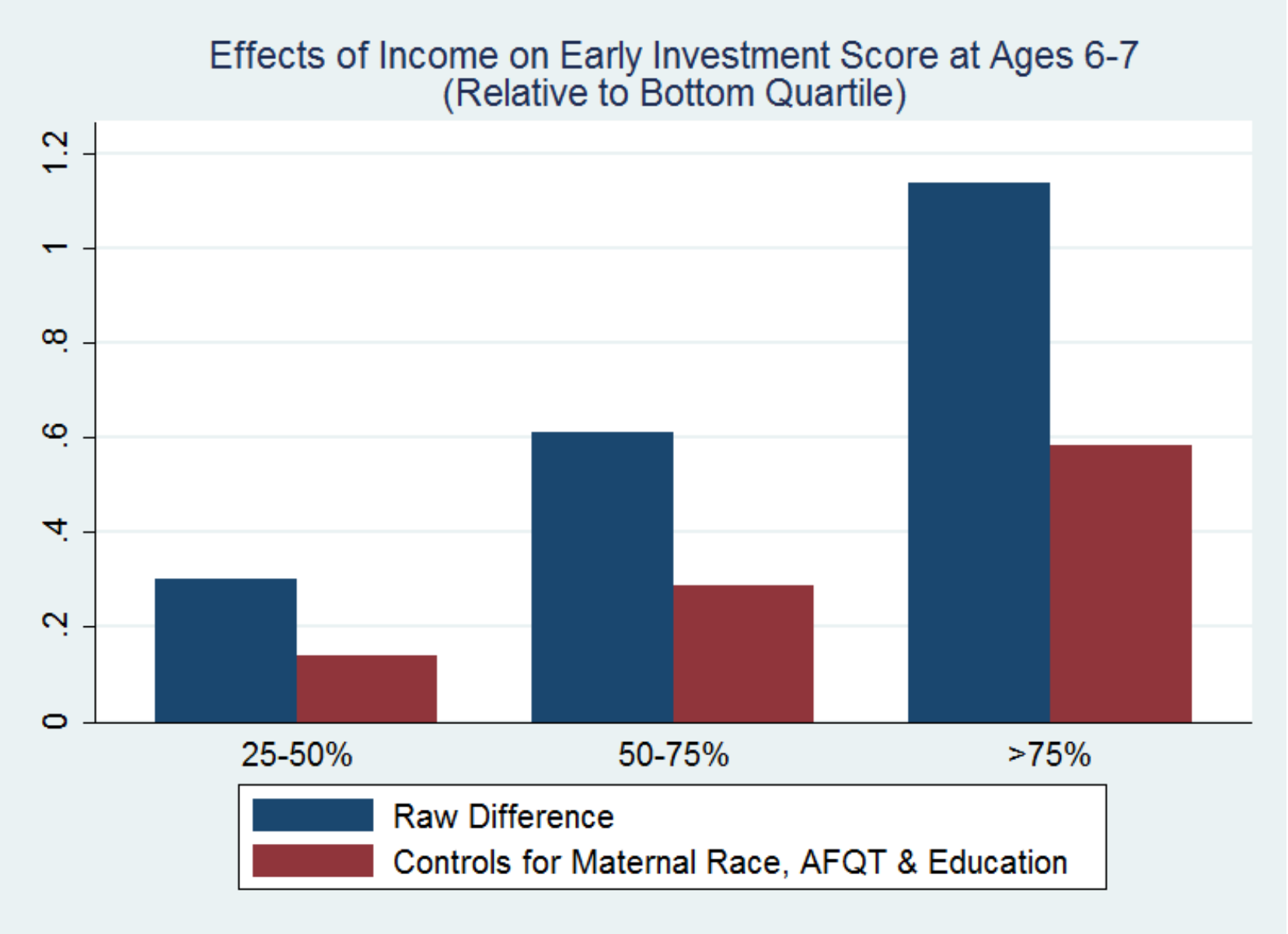


▸ factor score weights

Ages 2-3 Investment Factor Score



Ages 6-7 Investment Factor Score



Potential Mechanisms

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We study the following potential mechanisms/theories:

- Intergenerational correlation in ability
  - Becker & Tomes (1979, 1986)
- 'Consumption' value of schooling
  - college choices (Carneiro, Heckman & Vytlacil 2011, Keane & Wolpin 2001)
- Poor information
  - disadvantaged mothers under-estimate productivity of early investments (Cunha, Elo & Culhane 2013)
- Borrowing constraints
  - intergenerational and lifecycle constraints
  - Becker & Tomes (1979, 1986), Caucutt & Lochner (2013), Cunha (2006)

Sorting These Theories Out

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- How can we sort amongst these possibilities?
- Which of these mechanisms or theories can explain a wide range of other related empirical regularities?
  - briefly summarize evidence
  - develop related predictions from different theories

Context: Evidence on Child Development

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- First-born children receive more early investments and education; have higher cognitive achievement (Black, Devereux & Salvanes 2005, Lehmann, Nuevo-Chiquero, & Vidal-Fernandez 2013, Pavan 2014, Price 2008)
  - differences are apparent very early (but not at birth)

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  - differences are apparent very early (but not at birth)
- Marginal returns to early childhood investments are high, especially for economically disadvantaged children
  - summaries by Cunha, et al. (2006), Blau & Currie (2006), Karoly, et al. (1998)
  - private IRR for Perry Preschool $\approx 8\%$ (Heckman, et al. 2010)
  - Cunha, Heckaman & Schennach (2010) show optimal allocation of investment expenditures provides more to young disadvantaged children

Context: Evidence on Child Development

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- Exogenous increases in parental income improve cognitive achievement, IQ, health (Dahl & Lochner 2012, Duncan, Morris & Rodrigues 2012, Loken 2010, Loken, Mogstad & Wiswall 2012, Milligan & Stabile 2011)
  - effects appear to be greater for more disadvantaged children
  - income increases expenditures on education-related investments (Milligan & Stabile 2014)
  - permanent income shocks increase investments but transitory shocks do not (Carneiro & Ginja 2014)
  - Cunha, et al. (2010) estimate significant effects of current income on investments ages 1-14

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  - Cunha, et al. (2010) estimate significant effects of current income on investments ages 1-14
- Income at earlier ages appears to be more important for investment, achievement, and educational attainment (Caucutt & Lochner 2006, 2013, Pavan 2014)
  - Carneiro & Heckman (2002) find no significant differences for college attendance

Theory: One Base Framework, 4 Mechanisms

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- Mostly focus on key implications of different mechanisms for:
  - investment behavior
  - marginal returns on investment
  - human capital outcomes
  - investment/human capital responses to income changes
- Also, discuss role of dynamic complementarity in some cases
- Compare predictions with evidence/literature

Basic Framework

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- Three stages of life:
  - *Early childhood:* i_1 (may be a vector) and c_1
  - *Late childhood:* i_2 and c_2
  - *Adulthood:* work and consume
- Period utility, $u(c)$ is strictly increasing, strictly concave and satisfies Inada conditions
- Discount time at rate $\beta \in (0, 1)$
- 'Parental' income in childhood periods: y_1 and y_2
- Human capital investment prices: p_1 and p_2
- Tastes for early investments, νi_1
- Gross rate of return on assets is $R = \beta^{-1} \geq 1$

Human Capital Production

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- Early investments produce $h_2 = g(i_1)$
- Human capital upon adulthood is:

$$h_3 = \theta f(h_2, i_2)$$

  - θ reflects ability to learn

Assume:

- Investments are productive: $f_1 > 0$ and $f_2 > 0$
- Strict concavity: $f_{11} < 0$, $f_{22} < 0$, and $f_{12}^2 < f_{11} f_{22}$
- $f_{12} > max\left\{f_{22}\left(\frac{f_1}{f_2}\right), f_{11}\left(\frac{f_2}{f_1}\right)\right\}$

General Decision Problem

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$$\max_{c_1,c_2,i_1,i_2,a_2,a_3} E[u(c_1) + \nu i_1 + \beta u(c_2) + \beta^2 V_3(a_3, h_3)]$$

subject to budget constraints:

$$a_{j+1} = Ra_j + y_j - p_j i_j - c_j \quad \text{for } j = 1, 2,$$

where $a_1 = 0$, $h_2 = g(i_1)$, and $h_3 = \theta f(h_2, i_2)$

- $V_3(\cdot, \cdot)$ reflects the value function for young adults
- Written as a lifecycle problem but can be mapped into an intergenerational model with altruism (Caucutt & Lochner 2013)
  - y_1 and y_2 reflect parental income flows during early and late childhood
  - Define DPV of parental income: $Y \equiv y_1 + R^{-1} y_2$

Intergenerational Ability Correlation

Assumptions

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- Three-period problem: $V_3(a, h) = u(Ra + h)$
- Full information, no uncertainty
- $h_2 = i_1$ (a scalar)
- Normalize prices $p_1 = p_2 = 1$
- No tastes for investment: $\nu = 0$
- **Intergenerational ability correlation implies that $\boldsymbol{Cov(Y, \theta) > 0}$**
  - Focus on effects of ability

Analytical Results

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- MR on investments equal the interest rate for everyone:

$$\begin{aligned} \frac{\partial h_3}{\partial i_1} &= \theta f_1(i_1^*, i_2^*) = R^2 \\ \frac{\partial h_3}{\partial i_2} &= \theta f_2(i_1^*, i_2^*) = R \end{aligned}$$

- i_1, i_2, and h_3 are strictly increasing in ability
- Investments and the MR on investments do not depend on parental income y_1, y_2

Empirical Implications

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- If $Cov(Y, \theta) > 0$, then child investments, human capital and wages should be positively correlated with DPV of parental income Y
- Timing of income only relevant to the extent that it is correlated with child ability
  - if ability is positively correlated with income growth, then we should expect early parental income to be *less* correlated with child investments and human capital than late parental income
- MR on investments should equal return on savings
  - uncorrelated with parental income and ability
- Exogenous changes in parental income should not affect child investments or human capital

Consumption Value of Investment

Basics

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- **Non-zero consumption value of early investment: $\nu \neq 0$**
- Other assumptions same as in previous framework
- FOCs for consumption and investment imply:

$$\begin{aligned} \theta f_1(i_1, i_2) &= \left[1 - \frac{\nu}{u'(c)}\right] R^2 \\ \theta f_2(i_1, i_2) &= R \end{aligned}$$

Analytical Results

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- For $\nu > 0$:
  - MR on early investment is strictly less than the return on savings and strictly decreasing in DPV of parental income, Y
  - i_1 and h_3 are strictly increasing in Y
  - i_2 is increasing in Y if and only if $f_{12}(i_1^*, i_2^*) \geq 0$
- $\nu < 0$ yields opposite predictions

Empirical Implications

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Tastes for investment ($\nu > 0$):

- Positive effects of parental income on child investment, test scores, and education
- Higher MR on early investments for poor children
- MR on early investments $<$ return on savings
- Timing of income is irrelevant

Empirical Implications

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Tastes for investment ($\nu > 0$):

- Positive effects of parental income on child investment, test scores, and education
- Higher MR on early investments for poor children
- MR on early investments $<$ return on savings
- Timing of income is irrelevant

Perhaps, $\nu < 0$ for low-income families

- Can yield low investments and high MR to investment for poor
- Negative effects of parental income on investment, test scores, and education among poor
- Timing of income is irrelevant

Confusion

Different forms of Confusion

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We consider two different ways poor families may be confused or mis-informed:

- Subjective uncertainty about return to investment
  - unbiased priors
- Incorrect prior knowledge about return to investment
  - no subjective uncertainty, but potentially wrong beliefs about productivity of early investments

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- Subjective uncertainty about return to investment
  - unbiased priors
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  - no subjective uncertainty, but potentially wrong beliefs about productivity of early investments

Assume $\nu = 0$ and $V_3(a, h) = u(Ra + h)$

I. Uncertainty about Final Returns

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- **θ is uncertain and realized after investments are made**
  - uncertainty about general ability
  - uncertainty about labor market returns to skill
  - no insurance
- No distortion between i_1 and i_2, but overall investment spending is affected
- Define 'indirect production function':

$$h(e) \equiv \max_{i_1, i_2} \left\{ f(i_1, i_2) \middle| p_1 i_1 + R^{-1} p_2 i_2 \leq e \right\}$$

- e reflects total expenditures on investment
- $h(\cdot)$ is increasing and concave

Implications

$$E[\theta]h'(e) + \underbrace{\frac{\text{Cov}(u'(c_3), \theta)}{E[u'(c_3)]}}_{<0} h'(e) = R^2$$

- Expected MR on investments exceed the return on savings

$$E\left[\frac{\partial h_3}{\partial(p_1 i_1)}\right] > R^2 \quad \text{and} \quad E\left[\frac{\partial h_3}{\partial(p_2 i_2)}\right] > R$$

- Under-investment due to uninsurable risk
- Investment is increasing in parental income Y if $u(\cdot)$ exhibits decreasing absolute risk aversion
  - timing of income irrelevant

II. Subjective Uncertainty about Productivity of Early Investment

- **Subjective uncertainty about productivity of i_1**
  - $h_2 = wi_1$
  - **Beliefs $\tilde{w} \sim F_{\tilde{w}}(\cdot)$ with $E(\tilde{w}) = w$**
- w is learned after i_1 is invested, but before i_2
- Assume risk neutrality to focus on production uncertainty: $u(c) = c$
- Optimal i_2 conditional on h_2 solves $\theta f_2\Big(h_2, i_2(h_2)\Big)/p_2 = R$
- Optimal i_1 solves

$$\theta E\Big[\tilde{w} f_1\Big(\tilde{w} i_1, i_2(\tilde{w} i_1)\Big)\Big]/p_1 = R^2$$

Implications

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- A mean-preserving spread in distribution of $\tilde{w}$ reduces i_1 if $\tilde{w} f_1\Big(\tilde{w} i_1, i_2(\tilde{w} i_1)\Big)$ is concave in $\tilde{w}$
  - true for CES $f(\cdot)$ if the elasticity of sub. ≥ 1
- Lower $i_1 \rightarrow$ higher MR on i_1
- Lower $i_1 \rightarrow$ lower i_2 (if $f_{12} > 0$) and lower h_3
- No direct effect of parental income, y_1 or y_2, on investment behavior
  - unless income changes information

III. Incorrect Prior Knowledge about Productivity of Early Investment

- Assume early investment consists of n activities: $\boldsymbol{i}_1 = \big(i_1(1), \ldots, i_1(n)\big)$ and $\boldsymbol{p}_1 = \big(p_1(1), \ldots, p_1(n)\big)$
- Interim production function:

$$h_2 = g(\boldsymbol{i}_1) = \left(\sum_{j=1}^{n} [w(j) i_1(j)]^{\phi} \right)^{\frac{1}{\phi}}, \quad \phi < 1$$

- Unit cost ("price") of early investment, h_2:

$$q = \left(\sum_{j=1}^{n} \left[\frac{w(j)}{p_1(j)} \right]^{\frac{\phi}{1-\phi}} \right)^{\frac{-(1-\phi)}{\phi}}$$

- Early investment expenditure: $e_1 = \boldsymbol{p}_1 \cdot \boldsymbol{i}_1 = q \cdot h_2$

Effects of Incorrect Beliefs

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- **Individuals have wrong beliefs about $w(\cdot)$: $\tilde{w}(\cdot) \neq w(\cdot)$**
- For $\tilde{q} = q$, there is no effect of incorrect beliefs on early investment expenditure e_1 but less human capital h_2 would be produced
  - follows directly from the definition of output maximization
- Early investment spending e_1 is lower under $\tilde{w}$ if and only if $\tilde{q} > q$ (assumes demand elasticity > 1)
  - also implies lower h_2
- Lower $h_2 \rightarrow$ lower i_2 (if $f_{12} > 0$) and lower h_3
- actual MR to e_1 is tricky
  - low h_2 suggests high MR
  - inefficient allocation reduces MR

Systematic Downward Bias

- Suppose belief $\tilde{w}$ proportionally under-estimates productivity of all activities
  - $\tilde{w}(j) = \eta w(j)$ for $\eta < 1$
- Individuals with belief $\tilde{w}$ invest less in all activities and have lower h_2
  - only level of early investments are distorted, not their relative expenditure proportions
- Lower $h_2 \rightarrow$ lower i_2 (if $f_{12} > 0$) and lower h_3
- Higher MR to i_1 and e_1

Non-systematic Bias

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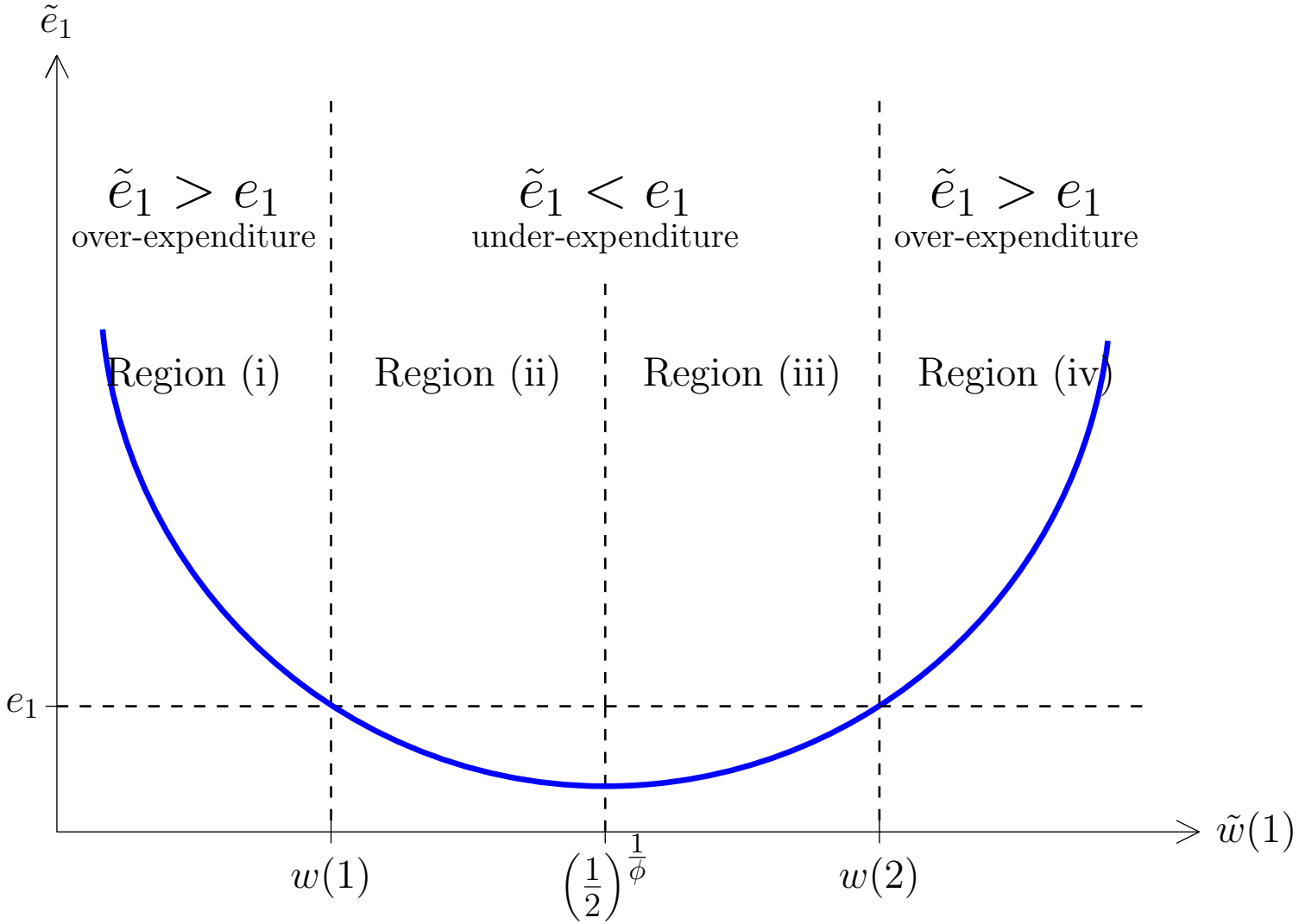
- Misinformation need not lead to under-investment
- Consider the following example with $n = 2$
  - normalize $p_1(1) = p_1(2)$
  - assume $i_1(1)$ is less efficient, i.e. $w(1) < w(2)$
  - assume $w(1)^\phi + w(2)^\phi = \tilde{w}(1)^\phi + \tilde{w}(2)^\phi = 1$, so no average bias in productivity beliefs
- Let $\tilde{e}_1$ and e_1 be total investment expenditures under beliefs $\tilde{w}$ and w

Implications for Investment Expenditures



Misinformation and Human Capital

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Better information can even lead to lower levels of final human capital if, for example,

- different early investment activities are similarly productive
- early investment activities are sufficiently substitutable
- early and late investments are sufficiently substitutable
- beliefs are strongly biased towards one activity at expense of the other

$\rightarrow$ over-investment in one activity due to misperceptions can more than compensate for under-investment in the other

Summarizing Implications of Confusion

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Uncertainty (resolved after school) and risk aversion

- Leads to lower investment levels
- Expected MR on investments exceed return on savings
- Decreasing absolute risk aversion implies positive effects of parental income Y on investments
  - MR higher for low income families
- Timing of income is irrelevant

Summarizing Implications of Confusion

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Poor may have greater subjective uncertainty about productivity of irreversible early investments

- If elasticity of subs. between early and late investments > 1, then
  - (even risk neutral) poor will have lower early investment levels
  - lower investments imply a high MR to early investment
  - also imply lower i_2 (if $f_{12} > 0$) and h_3
  - better information should reduce these inefficiencies
    - later siblings should perform better
- Changes in parental income would have no effect on investments (without risk aversion)

Summarizing Implications of Confusion

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Poor may hold incorrect beliefs about productivity of different early investment activities

- Under-estimating the productivity of all investment activities
  - under-investment in all $i_1(j)$
  - lower h_2 and h_3
  - lower i_2 if and only if $f_{12} > 0$
  - poor should have high MR on early investments
  - better information should reduce these inefficiencies
    - later siblings should perform better
  - changes in parental income should not affect investments

Summarizing Implications of Confusion

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- Under-estimating the productivity of some activities and over-estimating the productivity of others
  - should see poor invest more in some activities, less in others
  - can lead to under- or over-expenditure on early investments, higher or lower human capital levels
  - better information need not increase educational expenditures or raise human capital levels
  - changes in parental income should not affect investments

Borrowing Constraints

Assumptions

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- Full information, no uncertainty
- $h_2 = g(i_1) = i_1$, where i_1 is a scalar
- Normalize prices $p_1 = p_2 = 1$
- No tastes for investment: $\nu = 0$
- **Incorporate borrowing constraints:**

$$\begin{aligned} a_2 &\geq -L_1 \\ a_3 &\geq -L_2 \end{aligned}$$

Adulthood

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- Consider effects of constraints during both childhood and adulthood
- Let $V_3(a_3, h_3)$ reflect the value function from the asset allocation problem for individuals that live $T-2$ periods as an adult
- Assume human capital exogenously grows in adulthood:

$$h_t = \Gamma_t h_3, \quad \Gamma_3 = 1$$

Defining $V_3(a_3, h_3)$

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$$V_3(a_3, h_3) = \max_{c_3,...,c_T} \sum_{t=3}^{T} \beta^{t-3} u(c_t)$$

subject to budget constraints

$$a_{t+1} = Ra_t + h_t - c_t \quad \text{for } t = 3, ..., T,$$

$a_{T+1} = 0$, and borrowing constraints

$$a_{t+1} \geq -L_t \quad \text{for } t = 3, ..., T-1.$$

If borrowing constraints in adulthood do not bind, we have:

$$V_3(a, h) = v(Ra + \chi h), \quad \chi = \sum_{t=3}^{T} R^{3-t} \Gamma_t$$

FOCs

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- Assets: $u'(c_j) \geq \beta R u'(c_{j+1})$, the inequality is strict if and only if the borrowing constraint for that period binds
- Investment:

$$\begin{aligned} u'(c_1) &= \beta^2 \left[\frac{\partial V_3(a_3, h_3)}{\partial h_3}\right] \theta f_1(i_1, i_2) \\ u'(c_2) &= \beta \left[\frac{\partial V_3(a_3, h_3)}{\partial h_3}\right] \theta f_2(i_1, i_2) \end{aligned}$$

- Combining asset and investment FOCs yields:

$$\frac{f_1(i_1, i_2)}{f_2(i_1, i_2)} = \frac{u'(c_1)}{\beta u'(c_2)} \geq R$$

- If unconstrained: $\chi \theta f_1(i_1, i_2) = R^2$ and $\chi \theta f_2(i_1, i_2) = R$

Analytical Results: Role of Constraints

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- Binding borrowing constraints in *current or any future* period:
  - imply a high MR on investments:

$$\frac{\partial(\chi h_3)}{\partial i_1} = \chi\theta f_1(i_1^*, i_2^*) > R^2$$
$$\frac{\partial(\chi h_3)}{\partial i_2} = \chi\theta f_2(i_1^*, i_2^*) > R$$

  - lead to under-investment in at least one period

Analytical Results: Effects of Parental Income

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- If early constraint is non-binding, investments depend only on PDV of parental income, $Y = y_1 + R^{-1}y_2$
- When early constraint binds, the timing of income matters and dynamic complementarity determines responses
  - i_1 is always increasing in y_1
  - i_1 is decreasing in y_2 when only the early constraint binds (later income exacerbates the constraint)
  - If both early and late constraints bind, then i_1 and i_2 are both increasing in y_1 and y_2 if and only if there is sufficient dynamic complementarity ▸ Cond. 1

Empirical Implications

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If poor families are borrowing constrained...

- Poor should make lower early and late investments
- Poor should have high MR on investments
  - relative to return on savings
  - relative to rich
- Increases in family income should increase investments
  - asymmetric response to early vs. late income $\rightarrow$ early constraints bind
  - late investments increasing in early & late income $\rightarrow$ strong complementarity and both constraints binding
- birth order effects?
  - family income tends to increase over time, suggesting later children might do better
  - greater competition for resources with more children suggests first child might do better

Summary

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	Ability Correlation	Cons. Value ($v > 0$)	Uncertainty w/Risk Aversion	Poor have Downward Biased Beliefs	Credit Constraints
Birth Order	N	N	N	N	O
High MR to i_1	N	N	Y	Y	Y
Higher MR for Poor	N	Y	Y	Y	Y
↑ Income → ↑i_1	N	Y	Y	O	Y
Timing of Income	N	N	N	N	Y

Conclusions

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- Many potential explanations/theories for why poor children perform so poorly
- By looking closer at these theories, we can begin to distinguish between them
  - helpful for identifying limits of different theories
  - helps in thinking about identification in more complicated structural models
  - helps identify areas where additional empirical work may be fruitful

"Sufficient Complementarity"

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Complementarity Condition:

$$f_{12} > 0 \quad \text{and} \quad \underbrace{\frac{f_1 f_2}{f_{12} f}}_{\text{Hicks elast. of sub.}} < CIES(c_3(\chi h_3 - RL_2)) \underbrace{\left(1 - \frac{RL_2}{\chi h_3}\right)}_{1 - \frac{max.\ debt}{Life.\ Income}}$$

▸ Back

Factor Score Weights

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Factor Score Weights on Early Investment Measures

	Age Group			
Early Investment Measure	**0-1**	**2-3**	**4-5**	**6-7**
Number of Books Child Has	0.32	0.24	0.20	0.12
Mom Reading	0.32	0.26	0.21	
Eating w/ Mom and Dad	0.09	0.17	0.20	0.03
Child Taken to Outing	0.17	0.13	0.14	
See Father Daily	0.10	0.20	0.24	
Musical Instrument				0.11
Child Taken to a Performance				0.20
Child Taken to a Museum				0.18
Child Takes Lessons/Extracurr. Activities				0.16
Get Daily Newspaper				0.08
Encourage Hobbies				0.10
Get Together with Family Friends				0.02