The Role of Gender, Birth Order, and Ability in Intra-household Educational Inequality: Evidence from Benin

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Introduction and Motivation

- Intra-household variation explains $\approx 40\%$ of child human capital variation in the developing world (Giannola 2023).

  Distribution (Benin, 2013) Distribution (USA, 2015)

- Possible reasons
  - Parents: # of children, average human capital investment in children, education, wealth.
  - Children: Gender, birth order, and different initial talent.

How effective are different education policies in reducing intra-households inequality?

This Paper ...

Model parents' decision on human capital investments as they relate to:

1. Gender of children,
2. Birth order of children,
3. Innate ability of children.

Decompose absolute average difference in children's education into gender bias, birth order and ability difference effects.

and ...

Design education policy to remove the inequality due to gender and birth order effects.

Preview of Findings

In Benin:

From the reduced form analysis

1. Inverted U-shaped relationship between mean and SD of education.
2. Non-educated parents: **gender + birth order effects** $\approx$ **70 %** $\times$ **Total inequality**.
3. College educated parents: **gender+birth order effects** $\approx$ **33 %**$\times$**Total inequality**.

From the structural model

	Reduce gender & birth order effects	Eliminate gender & birth order effects	Reduce overall inequality
Education voucher	✓	✗	✗
Remove extensive margin education barriers	✓	✗	✓
Targeted educ cost reduction	✓	✓	✗

Literature Review and Contributions

This paper contributes to 4 strands of literature

1. Fertility choice model: (De Tray 1970, Becker and Lewis 1973, Becker and Tomes 1976, Vogl 2016, Weng et al. 2019).
2. Within household schooling decision: Gender and birth order disadvantages (Nerlove, Razin, and Sadka 1984, Biswas 2000, Ota and Moffatt 2007, Fergusson, Horwood, and Boden 2006,Lachaud et al. 2014, Moshoeshoe et al. 2016, Weng et al. 2019, Esposito, Kumar, and Villaseñor 2020).
3. Within household disparities in children's education and distribution of material resources (Rosenzweig and Schultz 1982, Akresh et al. 2012 Giannola 2023).
4. Educational Kuznets Theory: Ram 1990, Londoño 1990, Thomas, Wang, and Fan 2003.

First structural modeling and estimation of household's human capital investments as they relate to gender, birth order and children's innate ability.

Table of contents

1. Data and Stylized Facts

2. The Structural Model

3. Estimation

4. Results

5. Counterfactual Analysis

6. Conclusion

Data

Data for empirical application:

- Population and habitation census data (Benin, 2013).
- Siblings and parents characteristics for about 90,000 individuals between 25 and 40 years old from about 33,000 hhs.
- Variables include gender, age, religion,family size, education attainment, education attainment of parents and siblings.

Parents-Children Educ, Parents' educ-N_c

Data

Sample Restrictions

1. **Sample 1:** hhs with at least 2 children btw 25 and 40 years old. ($\approx$ 51,600 hhs)
   Gender composition by hh type
2. **Sample 2:** hhs with at least one educated child btw 25 and 40 years old.($\approx$ 32,800 hhs)

Sample 0: All hhs with children btw 25-40 yrs old (160,000 hhs)

Sample 1: Use for

- Policy counterfactual, and
- Comparative statics.

Sample 2: use for

- Stylized facts
- Estimation
- Policy counterfactual, and
- Comparative statics.

Stylized Facts

Stylized Fact I: Inverted U-shaped structure between Mean and SD of education

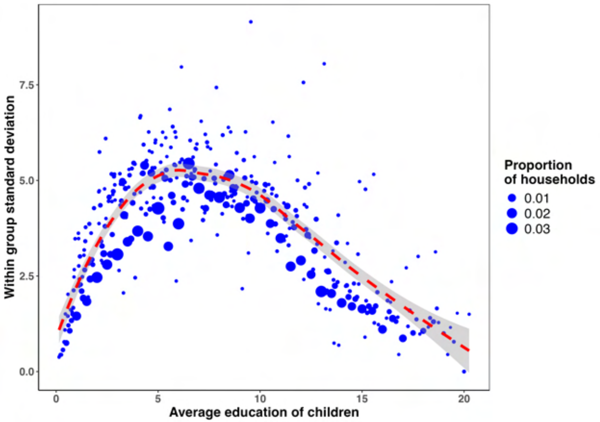


Figure 1: Within group mean and standard deviation of children's education

- Reinforced by the following regression:

$$SD_h = \beta_1 \bar{q}_h + \beta_2 \bar{q}_h^2 + \varepsilon_h, \qquad (1)$$

Estimation results , Map (Benin, 2013), observed vs. min vs. max inequality (Benin, 2013)

This educational Kuznets curve theory was empirically shown using cross countries data (see Ram 1990, Londoño 1990, Thomas, Wang, and Fan 2003)

Stylized Fact II: Inequality Decomposition

$$\Delta_{daughter-son} Educ_h = \beta_0 + \beta_1 Firstborn\_daughter_h + \varepsilon_h, \tag{2}$$

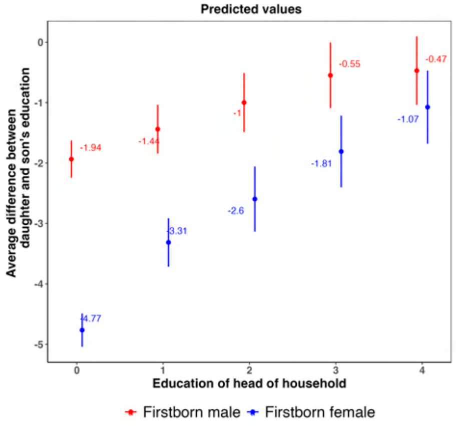


Figure 2: Effect of gender and birth order on within household inequality ($N_c = 2$)

- In blue: the average gender effect + the average birth order effect $(\beta_0 + \beta_1)$,
- In red: the average effect of gender - the average effect of birth order (β_0),

Let $q_h = (q_{1,h}, q_{2,h})$, and

$$Range_h = max(q_h) - min(q_h) = |q_{1,h} - q_{2,h}|$$

$$E[\text{Range}|\text{household has a firstborn daughter}]$$

$$\geq |\beta_0 + \beta_1|$$ Proof

Stylized Fact II: The shares of gender and birth order effects decline as parents' education increases

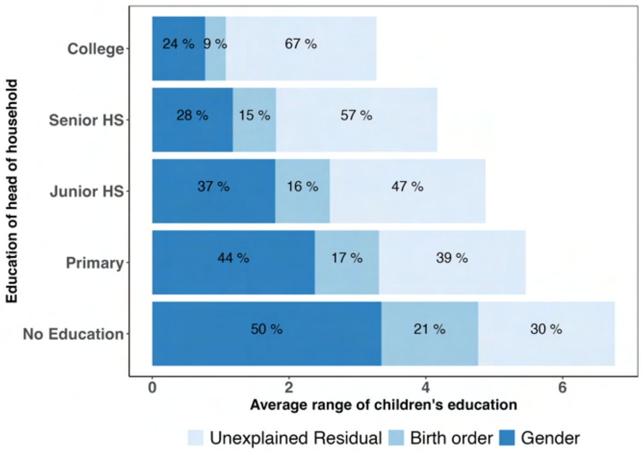
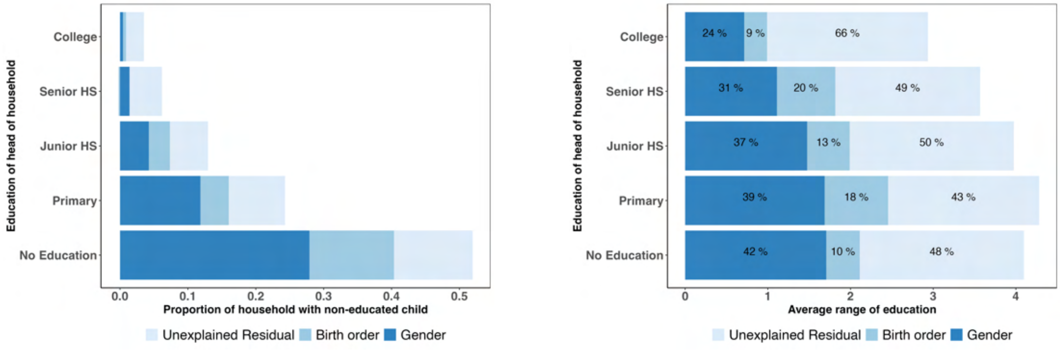


Figure 3: Inequality decomposition ($N_c = 2$)

- Overall inequality reduces as parents' education increases

Inequality Decomposition: Extensive v.s Intensive margin



(a) Extensive margin (b) Intensive margin

Figure 4: Inequality decomposition ($N_c = 2$)

- Compared to the extensive margin, ability have higher share in the total inequality for the intensive margin.
- The decrease in inequality by parents' education is mostly present in the extensive margin.

Facts to Model ...

Stylized Facts

- Increase in average education is associated with an increase in average inequality first, then with a decrease.
- Parents' education matter for average education, inequality, and its decomposition.
- Intra-household educational inequality is present both at extensive & intensive margin.

...

Model Features

- Gender and birth order are the 2 main observed sources of inequality.
- The key unobserved source is children's innate ability.

...

Education policy to remove inequality due to gender and birth order effects ? ...

The Structural Model

The Structural Model: Set up

Each household is characterized by an unobserved type, which determined the observed proportion of educated children.

The parents' decision involves 2 stages:

1. In the first stage Parents decides the number of children (N_c) and the aggregate education (q_T).

2. In the second stage, they distribute the education resources between children solving the following maximization problem.

$$\max_{q_i} U(q, \theta) \tag{3}$$

$$\sum q_i \leq q_T, \; q_i \geq 0, \; q_i \leq q_{\max}$$

$q_{\max}$ is the maximum years of education a child can get.

We model the second stage taking decisions in the first stage as given.

The Structural Model: Set up

I use a generalized utilitarian social welfare function with concave utility function for each child. For $N_c = 2$, Let

$$U(q_h) = \nu_h\Big[\sum_{i=1}^{2} a_{i,h}.(q_{i,h})^{\delta_{i,h}^{low}} - \alpha_i^{low} q_{i,h}\Big] + (1-\nu_h)\Big\{\sum_{i=1}^{2}\Big[e_{i,h}.\big(a_{i,h}.(q_{i,h})^{\delta_{i,h}^{high}} - \alpha_i^{high} q_{i,h}\big)\Big]\Big\},$$

Utility function for any $N_c > 1$ In blue: Simulated, In red: Parameters, In orange: Choice variables.

- ν_h, is parents' constraint for having a non-educated child.
- $a_{i,h} = \frac{\omega_{i,h}}{\sum_{j=1}^{N_{c_h}} \omega_{j,h}} \sim Beta(\beta_1, \beta_2)$, where $a_{i,h}$ is relative ability-based preference for child i.
- $e_{i,h} = 1\{a_{i,h}.(q_T)^{\delta_{i,h}^{high}} - \alpha_i^{high} q_T > a_{j,h}.(q_T)^{\delta_{j,h}^{high}} - \alpha_j^{high} q_T\}$, $e_{j,h} = 1 - e_{i,h}$.
- $\delta_{i,h}^{type} = \gamma - \theta_1^{type} Female_i(1 - Female_j)$, $type \in \{low, high\}$. [γ is normalized to 0.5]
- α_i^{low}, and α_i^{high} are the marginal education costs (financial and opportunity costs) of child i.

ν_h, $Female_{1,h}$, $Female_{2,h}$, and q_{T_h} are drawn from the empirical joint distribution of those variables

The Structural Model: Set up

- We allow θ_1^{high} to be function of daughter's birth order,
- $\theta_1^{high} = \theta_1^{ds,high} 1\{gender\_comp = b^{d,s}\} + \theta_1^{sd,high} 1\{gender\_comp = b^{s,d}\}$
- $b_h^{d,s} = Female_{1,h}.(1 - Female_{2,h}),\ b_h^{s,d} = (1 - Female_{1,h}).Female_{2,h}.$

$$\theta = \left(\theta_1^{low}, \theta_1^{ds,high}, \theta_1^{sd,high}, (\alpha_1^{high} - \alpha_2^{high}), (\alpha_1^{low} - \alpha_2^{low})\right)$$

- α_2^{high}, and α_2^{low} are normalized to 0.

Estimation

The Structural Model: Summary

Parameters are estimated using simulated method of moments.

List of moment matched

- Ave diff in the educ of daughters and sons [both gender=1 and int margin=1] (θ_1^{low}).
- Ave diff in the educ of 1st born and second [both gender=0 and int margin=1] ($\alpha_{(1)}^{low}$).
- Prop of educated 1st born [both gender=0, and ext margin = 1] ($\alpha_{(1)}^{high}$) .
- Prop of educated firstborn daughters [both genders=1, and ext margin=1] ($\theta_1^{ds,high}$).
- Prop of educated second born daughters [both genders = 1, ext margin =1] ($\theta_1^{sd,high}$).

Def: Ext margin: Households with one non-educated child,

Int margin: households with no non-educated child,

Both gender: Households with one son, and one daughter.

The Structural Model: Estimation

The corresponding sample objective function is the following expression:

$$\hat{Q}(\theta) = (\bar{Y}^d_{d,z} - \bar{Y}^d_{b,z} - (\hat{\mu}^d_{d,z} - \hat{\mu}^d_{b,z}))^2 + (\hat{m}_2 - \hat{\pi}_1)^2 + (\hat{m}_3 - \hat{\pi}_{fb,d})^2 + (\hat{m}_4 - \hat{\pi}_{sb,d})^2 + \sum_{l \in \{d,s\}} (\bar{Y}^l_{2,z} - \bar{Y}^l_{1,z} - (\hat{\mu}^l_{2,z} - \hat{\mu}^l_{1,z}))^2 \quad (4)$$

$$\hat{\theta} = \ \text{argmin}_{\theta \in \Theta} \hat{Q}(\theta).$$

Red: Model prediction, Blue: Data.

Estimation of G(.)

$$a_{i,h} \sim^{i.i.d} Beta(\beta_1, \beta_2) \text{ with } \sum_{i=1}^{N_{c_h}} a_{i,h} = 1$$

β_1 and β_2 are estimated using auxiliary data on GPA.

Model Performance

Results

The Structural Model: Results (**Extensive Margin**)

- For households with both gender and firstborn daughter,

$$\hat{\theta}_1^{b^{d,s},high} = 0.119 \tag{5}$$

- For households with both gender and second born daughter, we have:

$$\hat{\theta}_1^{b^{s,d},high} = 0.13 \tag{6}$$

- For households with only daughters or only sons, we have:

$$\hat{\alpha}_1^{high} - \hat{\alpha}_2^{high} = 0.02 \tag{7}$$

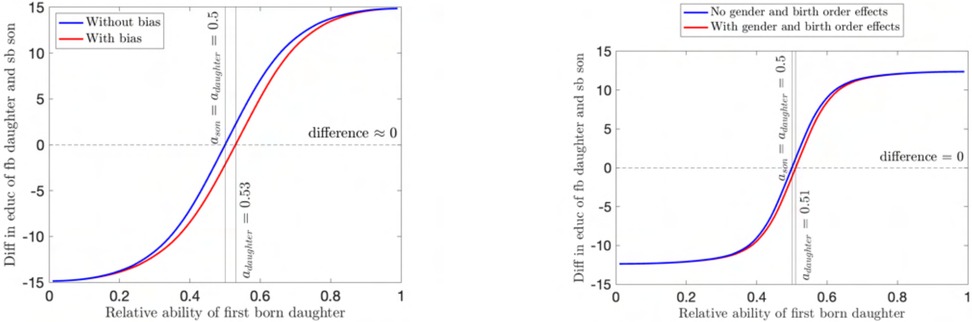
- The average cost difference at the extensive margin is 0.02.
- perceive average utility to graduating high school is 31% higher for 2nd born son compared the 1st born daughter.
- that is 34% higher for 1st born son compared to 2nd born daughter

The Structural Model: Results (**Intensive Margin**)

- $\hat{\theta}_1^{low} = 0.0239$, and $\hat{\alpha}_1^{low} - \hat{\alpha}_2^{low} = 0.0013$ for non-educated parents.
- For college educated parents, $\hat{\theta}_1^{low} = 0.00759$, and $\hat{\alpha}_1^{low} - \hat{\alpha}_2^{low} = 0.00045$.
- parents without formal education perceive a 6.3% higher utility on graduating high school for sons compared to daughters,
- for college-educated parents, the difference is approximately 2%.

Counterfactual Analysis

Counterfactual Analysis: Heterogeneity in the effect of disadvantages by level of ability



(a) Non-educated head of hhs (b) College educated head of hhs

Figure 5: Effect of gender and birth order effects on inequality ($N_c = 2$)

- First-born daughters in non-educated households receive more education than younger brothers if their ability is 13% higher compared to their brothers.
- That number is 4% among college educated parents.

Counterfactual Analysis: Remove constraints for having a non-educated child

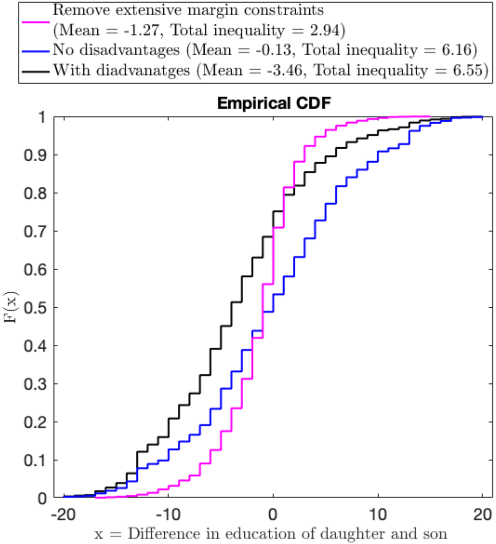


Figure 6: Distribution of the difference in children's education ($N_c = 2$)

The distribution in pink second order stochastically dominates both the one in blue and the on in **black**.

Comparative Statics: Increase Education Resources

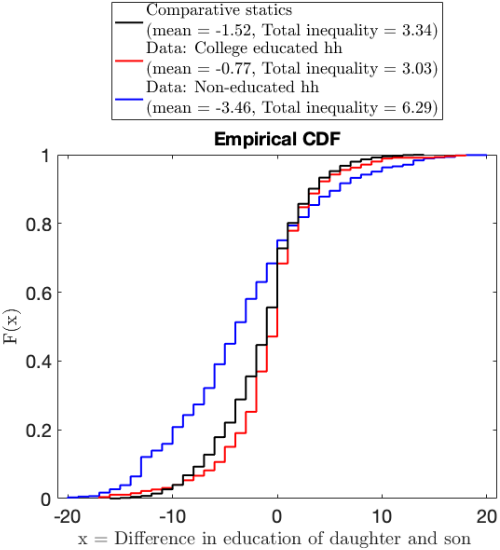


Figure 7: Distribution of the difference in daughter and son's education ($N_c = 2$)

- Remove the high constraint for having an uneducated child among non-educated parents.

  and

- Increase q_T of non-educated parents such that the average is the same as college educated parents.

Counterfactual Analysis: Education cost reduction policy

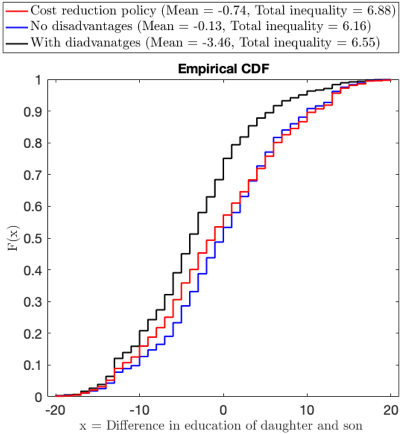


Figure 8: Distribution of the difference in children's education ($N_c = 2$)

1. At the extensive (resp. intensive) margin $\downarrow \approx 2\%$ (resp. $\approx 0.13\%$) in schooling cost for firstborn children.
2. At the extensive (resp. intensive) margin $\downarrow \approx 4\%$ (resp. $\approx 1.8\%$) in schooling cost for daughters.

The cost reduction policy is calibrated such that the distribution with that policy match the one in absence of disadvantages.

Optimal Number of children as function of q_T (When there is a constraint to have an uneducated child)

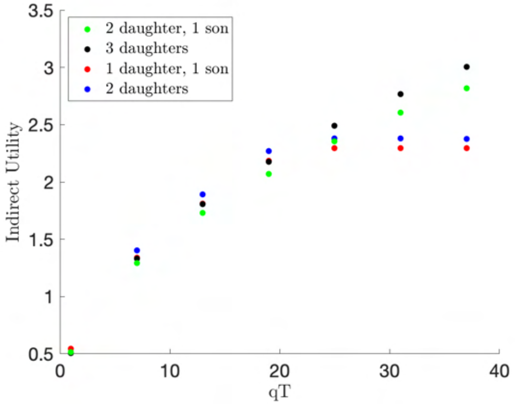


Figure 9: Indirect utility from distribution of education resources

- When education resources are such that $q_T < 20$, $N_c = 2$ is optimal.
- When education resources are such that $20 \leq q_T \leq 40$ $N_c = 3$ is optimal.

Optimal Number of children as function of q_T (When there is a constraint to have an uneducated child)

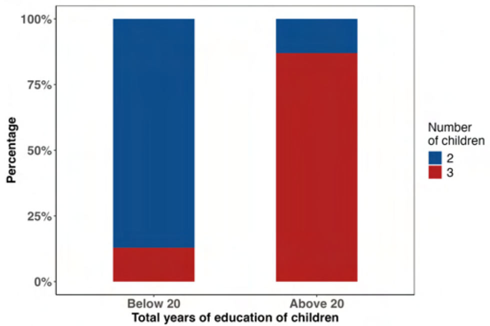


Figure 10: Distribution of number of children by average education of children [for non-educated households with $q_T \leq 40$]

- At least 13% of households with $q_T < 20$ do not have optimal N_c.
- At least 87% of households with $q_T \geq 20$ have optimal N_c.

Optimal Number of children as function of q_T (When there is no constraint to have an uneducated child)

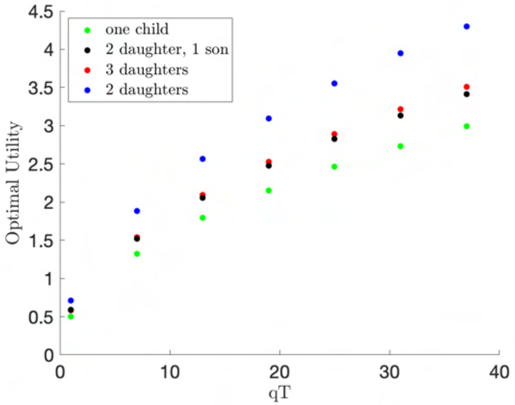


Figure 11: Indirect utility from distribution of education resources

- $N_c = 2$ is always optimal.

Optimal Number of children as function of q_T (When there is no constraint to have an uneducated child)

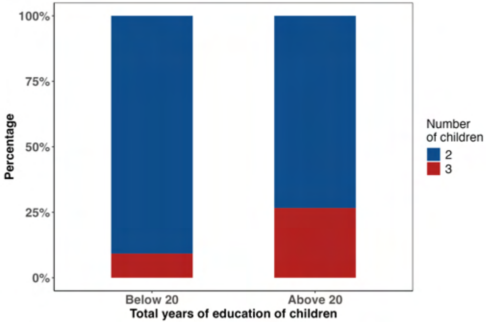


Figure 12: Distribution of number of children by average education of children [for non-educated households with $q_T \leq 40$]

- At least 9% of households with $q_T < 20$ do not have optimal N_c.
- At least 27% of households with $q_T \geq 20$ do not have optimal N_c.

Conclusion

Conclusion

- There is a sharp inverted U shape between the within household average and standard deviation of children's education.
- Among non-educated parents, $\approx 70\%$ of within household inequality is due to gender and birth order effect.
- That number is $\approx 33\%$ among college educated parents.
- Removing extensive margin gender effect on education reduce 3/5 of the gender effect on intra-household inequality.
- An education voucher-type of policy to non-educated parents combined with compulsory education, reduce the gender effect by $\approx 1/2$, and average inequality by $\approx 55\%$.
- A targeted education cost reduction policy ($\approx 4\%$) eliminate the effect of gender and birth order, but does not reduce average intra-household inequality in the sample.

Appendix

Appendix A1: Average level of education of children as function of parents' education

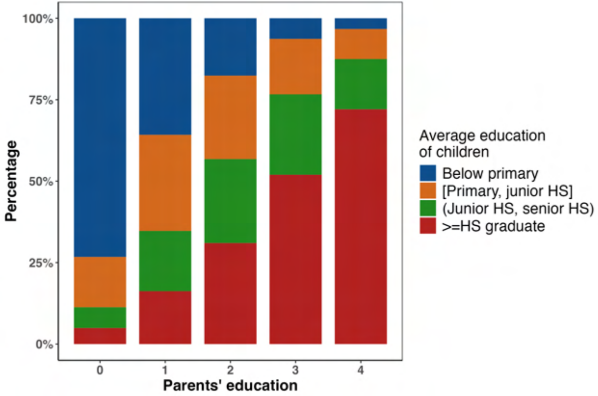


Figure 13: Average children's education as function of parents' education (Benin, 2013). return

Appendix A2: Number of children as function of parents' education

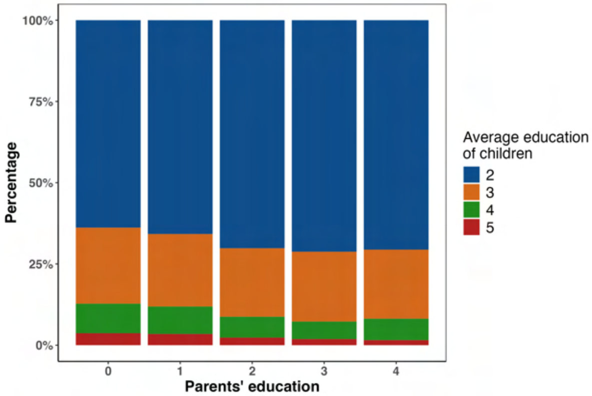


Figure 14: Distribution of number of children as function of parents' education (Benin, 2013). return

Appendix A3: Gender composition by type of households (households with 2 children)

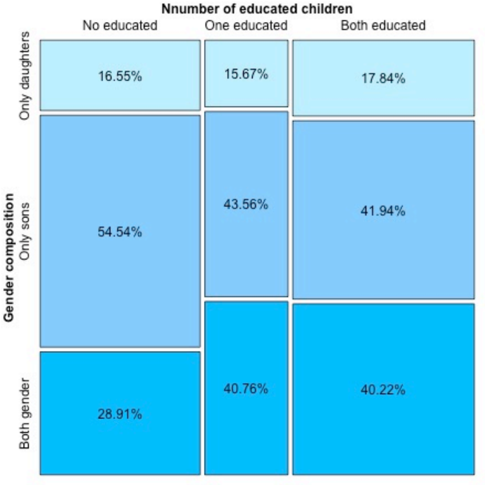
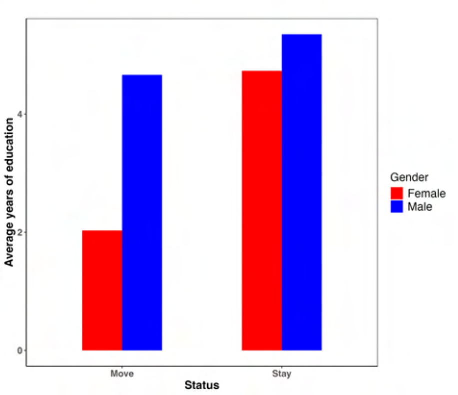
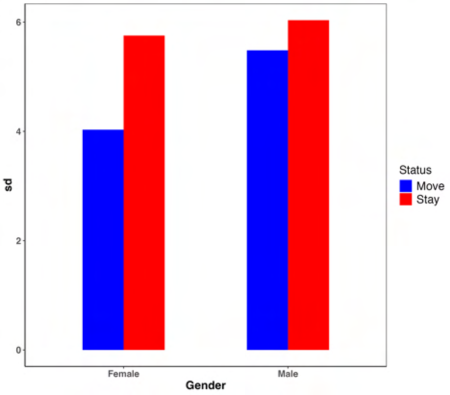


Figure 15: Gender composition by number of educated children (Benin, 2013). return

Appendix A: Move and Stay back adult children



(a) Mean



(b) Standard Deviation

Figure 16: Mean and standard deviation of adult children

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Appendix A4: Average level of education and educational inequality

Table 1: Educational inequality on average education

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Non-educated hh		College educated hh	
Average education ($\bar{q}$)	1.25*	1.04*	1.44*	1.26*	0.87*	0.64*
	[1.24; 1.27]	[1.02; 1.07]	[1.42; 1.46]	[1.23; 1.29]	[0.81; 0.94]	[0.54; 0.75]
$\bar{q}^2$	−0.08*	−0.06*	−0.09*	−0.08*	−0.05*	−0.04*
	[−0.08; −0.08]	[−0.06; −0.06]	[−0.09; −0.09]	[−0.08; −0.08]	[−0.05; −0.04]	[−0.04; −0.03]
R^2	0.69	0.71	0.73	0.74	0.61	0.62
Covariates		✓		✓		✓
Num. obs.	32729	32729	19558	19558	1438	1438

* Null hypothesis value outside the confidence interval. Covariates include parents' education, area of residence, religion, number of children, and gender composition of the household.

return

Appendix A5: Average level of education and educational inequality

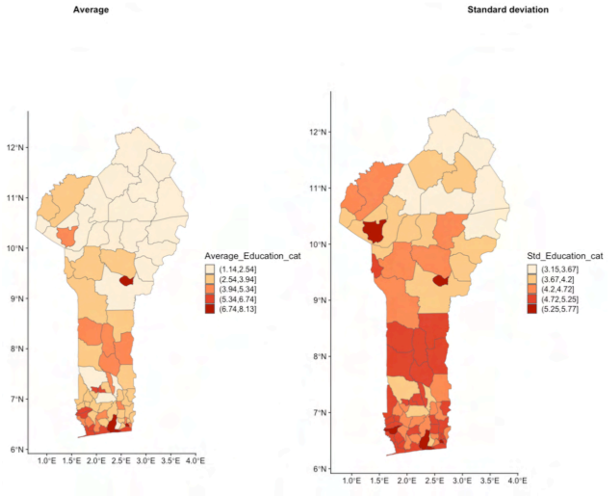


Figure 17: Across region mean and standard deviation of education for people btw 18-40yrs (Benin, 2013). return

Appendix A6: Average level of education and educational inequality

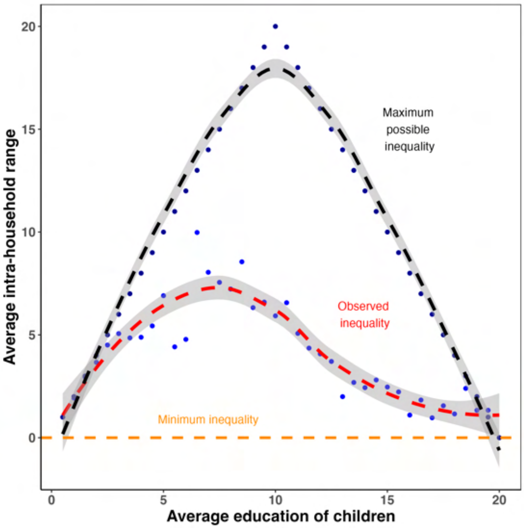


Figure 18: Average inequality (observed, min, and max) as function of average years of education for households with 2 children(Benin, 2013). return

Appendix A7: Proof

$$\Delta_{daughter-son}Educ_h = \beta_0 + \beta_1 Firstborn\_daughter_h + \varepsilon_h$$

$$E\Big[|\Delta_{daughter-son}Educ|\Big] = E\Big[|\beta_0 + \beta_1 Firstborn\_daughter + \varepsilon|\Big]$$

$$E\Big[|\beta_0 + \beta_1 Firstborn\_daughter + \varepsilon|\Big] \geq \Big|E\Big[\beta_0 + \beta_1 Firstborn\_daughter + \varepsilon\Big]\Big|$$

By Jensen's inequality.

$$E\Big[\Big|\beta_0 + \beta_1 Firstborn\_daughter + \varepsilon\Big|\Big] \geq \Big|\beta_0 + \beta_1 E[Firstborn\_daughter] + \underbrace{E[\varepsilon]}_{\text{Assumed to be 0}}\Big|$$

Therefore,

$$E[Range] \geq |\beta_0 + \beta_1 E[Firstborn\_daughter]|$$

Hence,

$$E[Range| \text{ household has firstborn daughter}] \geq |\beta_0 + \beta_1|$$

return

Appendix B: Histogram of within household difference in average education of daughters and sons (Benin, 2013)

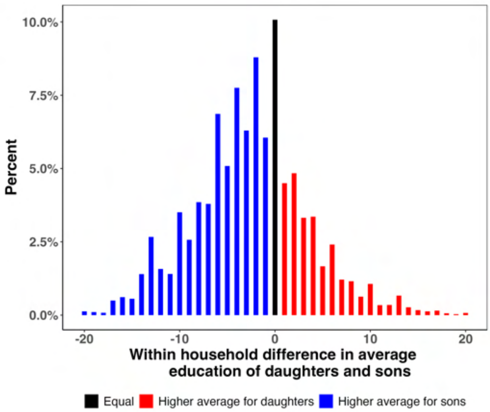


Figure 19: Histogram of within household difference in average education of daughters and sons (Benin, 2013)

Gender disadvantage in education attainment $\Longrightarrow$ Higher mass on the negative side.

return

Appendix B: Histogram of within household difference in average education of daughters and sons (USA, 2015)

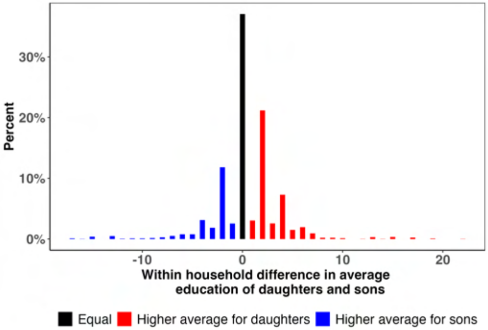
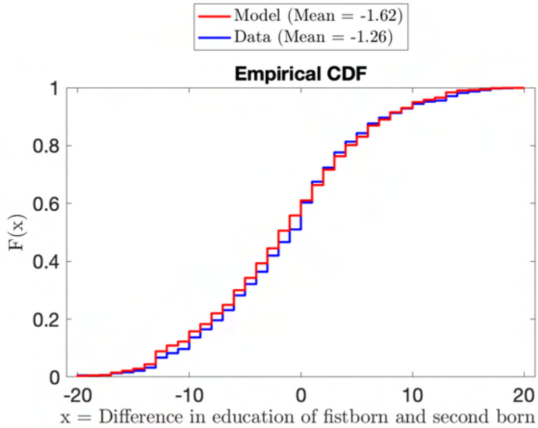


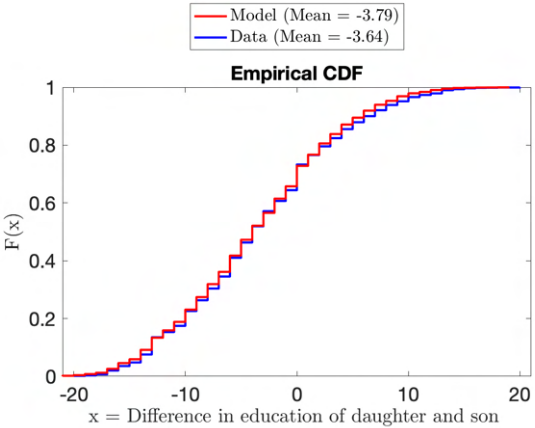
Figure 20: Histogram of within household difference in average education of daughters and sons (USA, 2015)

return

Appendix C1: Model vs. Data



(a) Firstborn vs. second born

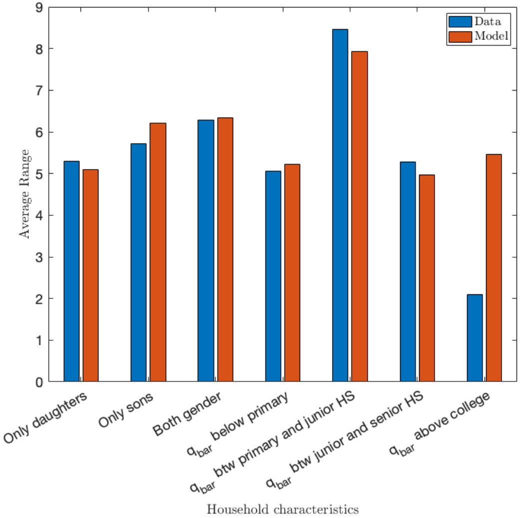


(b) Daughter vs. son

Figure 21: Distribution of the difference in education (Data vs. Model)

return

Appendix C2: Model vs. Data



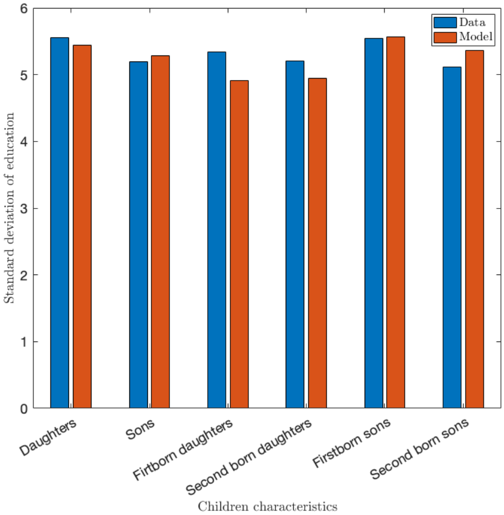


Figure 22: Moments (Data vs. Model)

return

Model for $N_c = 3$

Appendix D1: The Structural Model

For $N_c = 3$, Let

$$U(q_h, \theta) = \nu_h^l \Big[\sum_{i=1}^{N_c} a_i.(q_i)^{\delta_{i,h}^l} - \alpha_i^l q_i \Big] + \nu_h^m \Big\{ \sum_{i=1}^{N_c} \Big[e_i^m.\big(a_i.(q_i)^{\delta_{i,h}^m} - \alpha_i^m q_i\big) \Big] \Big\} \tag{8}$$

$$+\nu_h^h \Big\{ \sum_{i=1}^{N_c} \Big[e_i^h.\Big[\big(a_i.(q_i)^{\delta_{i,h}^h} - \alpha_i^h q_i\big) \Big] \Big\}$$

where,

- $\nu^{type} \sim Bernoulli(p_{type})$,
- $\delta_{i,h}^{type} = \gamma - \theta_1^{type} Female_i \frac{1}{N_c - 1} \sum_{\{i,j \in h\}, j \neq i} (1 - Female_j)$, with

  $type \in \{low(l), medium(m), high(h)\}$

The Structural Model

$$e_i^m = 1\{\exists j : \left(a_i.(q_i)^{\delta_{i,h}^m} - \alpha_i^m q_i\right) > \left(a_j.(q_i)^{\delta_{j,h}^m} - \alpha_j^m q_j\right)\},$$

$$e_i^h = 1\{\left(a_i.(q_i)^{\delta_{i,h}^h} - \alpha_i^h q_i\right) > \left(a_j.(q_i)^{\delta_{j,h}^h} - \alpha_j^h q_j\right), \forall j \neq i\},$$

They are derived from the following constraints:

$$\sum_{i=1}^{3} e_i^m = 2 \text{ and } \sum_{i=1}^{3} e_i^h = 1$$

The vector of parameters of interest is

$$\theta = \left(\theta_1^l, \theta_1^m, \theta_1^h, \alpha_{(1)}^l - \alpha_{(2)}^l, \alpha_{(1)}^m - \alpha_{(2)}^m, \alpha_{(1)}^h - \alpha_{(2)}^h\right)$$

The dimension of θ is 1×6. return

To allow for heterogeneous effect of gender disadvantage we can assume that

$$\theta_1^{type} = \theta_1^{type}(birth\_order)$$

Model generalization for $N_c \geq 2$

The Structural Model ($N_c > 1$): Set up

Let $type \in \{0, 1, \ldots N_c - 1\}$, where

- 0 corresponds to the least constrained/no constraints to have a non-educated child,
- and $N_c - 1$ corresponds to constrained to have $N_c - 1$ non-educated children.

$$U(q_h, \theta) = \sum_{c=2}^{N_{c_h}} \left\{ 1\{N_{c_h} = c\}. \sum_{type} \left\{ \nu_h^{c,type}. \sum_{i=1}^{c} e_i^{c,type}. \left[a_i.(q_i)^{\delta_{i,h}^{type}} - \alpha_i^{type} q_i \right] \right\} \right\} \text{ where,} \quad (9)$$

- $\nu_h^{c,\cdot} \sim Multinomial(p_{c,.})$, with $p_{c,.} = (p_{c,0}, p_{c,1}, \ldots, p_{c,N_c-1})$, and $\sum_{type=0}^{N_c-1} p_{c,type} = 1$
- $\delta_{i,h}^{type} = \gamma - \theta_1^{type} Female_i \frac{1}{N_{c_h}-1} \sum_{\{i,j \in h\}, j \neq i} (1 - Female_j)$,
- $\sum_{i=1}^{c} e_i^{c,type} = N_{c_h} - type$,
- $q_h = (q_{1,h}, \ldots, q_{N_c,h})$

The Structural Model: Set up

Let, $M = C(N_{c_h}, N_{c_h} - type)$ be the total number of possible combination of $\left\{1, 2, \ldots, N_{c_h}\right\}$ s.t $e_k^{c,type} = 1$,

and, $S = \{S_1, S_2, S_M\}$ denotes the set of possible combinations.

Compute

$$q_h^{c,\star}(S_m) = argmax\Big\{ \sum_{k \in S_m} a_i.(q_k)^{\delta_{k,h}^{type}} - \alpha_k^{type} q_k \text{ subject to } \sum_k q_k = q_T \text{ and } 0 \leq q_k \leq q_{max} \Big\} \tag{10}$$

Compute $U(q_h^\star(S_m), \theta)$, for $m \in \{1, 2, \ldots M\}$,

The optimal educational distribution is

$$q_h^\star(S_m) \mid U(q_h^\star(S_m) > U(q_h^\star(S_{m'}), \ \forall m' \neq m, \ \text{with } q_i^\star = 0 \text{ if } i \notin S_m$$

The vector of parameter is

$$\theta = (\theta_1^{type}, \alpha_1^{type}, \ldots, \alpha_{N_c - 1}^{type})$$

Illustrative Example

- Let $N_{c_h} = 3$, and $type = 1$,
- $C(N_{c_h}, N_{c_h} - type) = C(3, 2) = 3$, the possible combinations are $\{1, 2\}, \{1, 3\}$, and $\{2, 3\}$.
- We compute $q_h^\star(\{1, 2\})$, $q_h^\star(\{1, 3\})$, and $q_h^\star(\{2, 3\})$, and
- $U(q_h^\star(\{1, 2\}), \theta)$, $U(q_h^\star(\{1, 3\}), \theta)$, and $U(q_h^\star(\{2, 3\}), \theta)$
- Suppose that $U(q_h^\star(\{1, 2\}), \theta) > U(q_h^\star(\{1, 3\}), \theta) > U(q_h^\star(\{2, 3\}), \theta)$
- The optimal educational distribution is $(q_h^\star(\{1, 2\}), 0)$.

Appendix E: GMM Standard Errors

1. Variance covariance matrix for parameter estimates is given by:

$$\Omega = \Big[\frac{\partial m(\theta)'}{\partial \theta}\Big|_{\hat{\theta}} V^{-1} \frac{\partial m(\theta)}{\partial \theta}\Big|_{\hat{\theta}}\Big]^{-1}$$

2. $\frac{\partial m(\theta)}{\partial \theta}$ is obtained numerically,

$$\frac{\partial m(\theta)}{\partial \theta}\Big|_{\hat{\theta}} = \frac{m(\hat{\theta} + h) - m(\hat{\theta})}{h}$$

3. V, the variance-covariance matrix of the data moments is calculated by bootstrapping the data - calculate the moments N times, then use these N obs of the moments and calculate the covariance between them.
4. The std errors will be the square roots of the diagonal elements of Ω.

Appendix F: Return to schooling

$$log(Y) = \eta_0 + \sum_{k=0}^{4} \eta_{1,k} E_k + \eta_2 Female + \sum_{k=0}^{4} \eta_{3,k} E_k \times Female + Age + \varepsilon$$

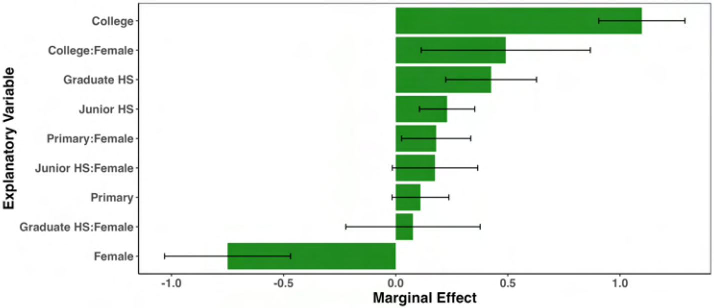


Figure 23: Return to schooling (Benin, 2010)

- Total return to college compared to no educ is 22% $\uparrow$ for men compared to female.
- It is 36% higher for HS graduation

References I

Akresh, Richard et al. (2012). "Child ability and household human capital investment decisions in Burkina Faso". In: *Economic Development and Cultural Change* 61.1, pp. 157–186.

Becker, Gary S and H Gregg Lewis (1973). "On the Interaction between the Quantity and Quality of Children". In: *Journal of political Economy* 81.2, Part 2, S279–S288.

Becker, Gary S and Nigel Tomes (1976). "Child endowments and the quantity and quality of children". In: *Journal of political Economy* 84.4, Part 2, S143–S162.

Biswas, Debashis (2000). "Gender Disparities in Education in the Developing World". In.

De Tray, Dennis N (1970). *An Economic Analysis of Quantity-Quality Substitution in Household Fertility Decisions*. Tech. rep. RAND CORP SANTA MONICA CALIF.

Esposito, Lucio, Sunil Mitra Kumar, and Adrián Villaseñor (2020). "The importance of being earliest: birth order and educational outcomes along the socioeconomic ladder in Mexico". In: *Journal of Population Economics* 33, pp. 1069–1099.

Fergusson, David M, L John Horwood, and Joseph M Boden (2006). "Birth order and educational achievement in adolescence and young adulthood". In: *Australian Journal of Education* 50.2, pp. 122–139.

References II

Giannola, Michele (2023). "Parental investments and intra-household inequality in child human capital: evidence from a survey experiment". In: *The Economic Journal*, uead086.

Lachaud, James et al. (2014). "Family size and intra-family inequalities in education in Ouagadougou". In: *Demographic Research* 31, pp. 1455–1476.

Londoño, Juan Luis (1990). "Kuznetsian tales with attention to human capital". In: *Third Inter-American Seminar in Economics, Rio de Janeiro, Brazil.*

Moshoeshoe, Ramaele et al. (2016). "Birth order effects on educational attainment and child labour: Evidence from lesotho". In: *Economic Research Southern Africa (ERSA).*

Nerlove, Marc, Assaf Razin, and Efraim Sadka (1984). "Investment in human and nonhuman capital, transfers among siblings, and the role of government". In: *Econometrica: Journal of the Econometric Society*, pp. 1191–1198.

Ota, Masako and Peter G Moffatt (2007). "The within-household schooling decision: a study of children in rural Andhra Pradesh". In: *Journal of Population Economics* 20.1, pp. 223–239.

Ram, Rati (1990). "Educational expansion and schooling inequality: International evidence and some implications". In: *The Review of Economics and Statistics*, pp. 266–274.

References III

- Rosenzweig, Mark R and T Paul Schultz (1982). "Market opportunities, genetic endowments, and intrafamily resource distribution: Child survival in rural India". In: *The American Economic Review* 72.4, pp. 803–815.
- Thomas, Vinod, Yan Wang, and Xibo Fan (2003). "Measuring education inequality: Gini coefficients of education for 140 countries, 1960-2000". In: *Journal of Education Planning and Administration* 17.1, pp. 5–33.
- Vogl, Tom S (2016). "Differential fertility, human capital, and development". In: *The Review of Economic Studies* 83.1, pp. 365–401.
- Weng, Qian et al. (2019). "Family size, birth order and educational attainment: Evidence from China". In: *China Economic Review* 57, p. 101346.