Estimating the Returns to Parental Time Investment in Children using a Life-Cycle Dynastic Model

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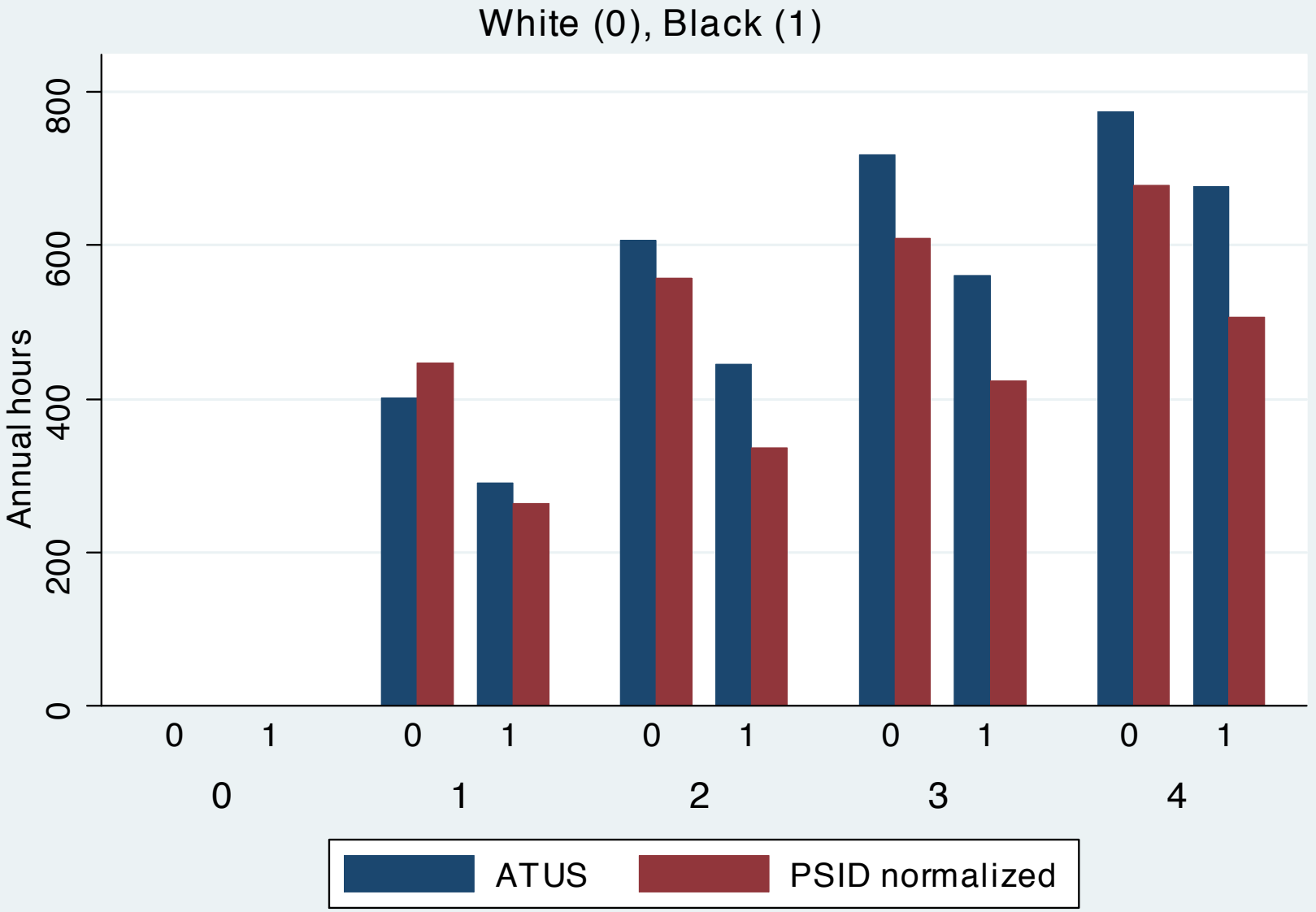
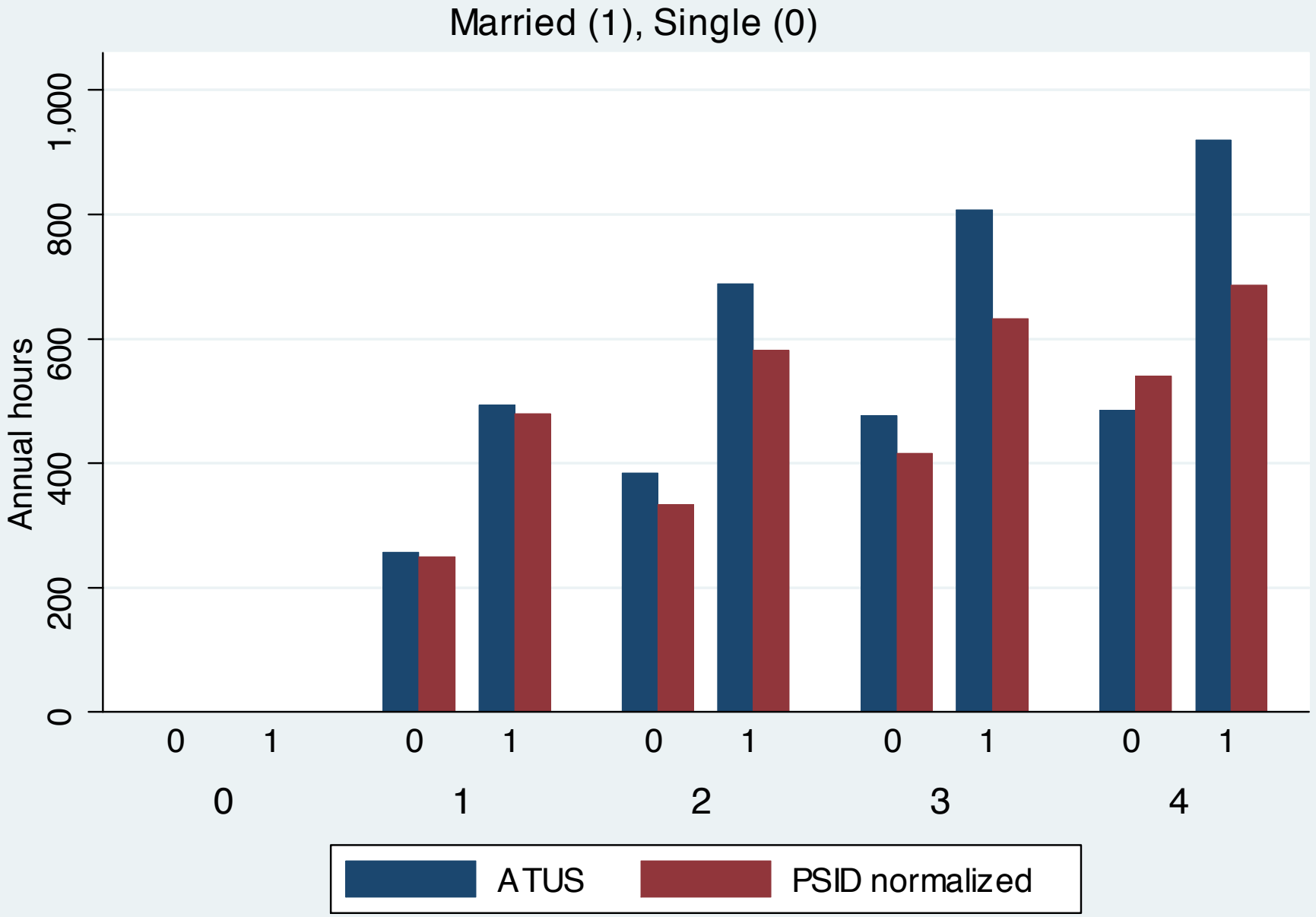
Introduction

- Human capital transmission across generations is important part of intergenerational persistence in wealth
- Early time input and income are important. Carneiro and Heckman (2003), Cunha and Heckman (2007), Cunha, Heckman, Schennach (2009), Almond and Currie (2011)
- Large black-white achievement gaps. Neal and Johnson (1996)
- Black and white achievement gaps open early. Carneiro, Heckman, Masterov (2003), Todd and Wolpin (2007)
- Lower income and time investment of black mothers
- What explains the differences?

Time with kids, females, by race and no. of kids



Time with kids, females, by marital status and no. of kids



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- The probability of being a single parent of a child under 6 is 65% for black individuals and 14% for white individuals (PSID 1968-1997)
- Lower investment in single parent households
- Family size and spacing of children
  - Families with 2 or more children: age difference is 0.5 year smaller in black families
- Opportunity costs of time: affects fertility and time allocation

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  - Probability of being single for college graduate black female is more than twice the probability of white female with college degree
- Fertility, labor supply, time with children are determined jointly

What This Paper Does? Framework

- Model of dynastic altruistic households: Loury 1981, Becker and Barro 1988, Alvarez 1999. We add
  - Life-cycle: labor supply, endogenous fertility and spacing of children
  - Marriage and assortative mating
  - Household decisions
- Partial Equilibrium model, no borrowing and savings
- Preferences and constrains affect choices parents make over the life-cycle in each generation
  - Parents allocate time between labor market activities and time with children
  - Fertility: limited time and monetary resources allocated between more children
- Role of households: married households can transfer resources
- Dynastic model framework: Different outcomes, labor market, marriage, are aggregated and measured in terms of expected life-time utility of children

What This Paper Does? Estimation

- Develop framework for estimation of the model
- Using data on two generations from the PSID we estimate the model
- Estimate Quantity-Quality tradeoff
- Estimate returns to time investment (and costs), how they vary by race, gender and education
- The source of the gaps has policy implications
- Estimates of "level of altruism" provide insight to parental choices

Related Literature

- Household choices:
  - Bernal (2008), Kang (2010): effect of mother's labor supply choice
  - Del Boca, Flinn and Wiswall (2010): quantify the returns to parental time investment accounting for endogenous labor supply and opportunity costs of time
- Empirical literature estimation of production function of outcomes of children: Todd and Wolpin (2003, 2005), Cunha and Heckman (2008), Cunha et al (2009) .
- Time investment: Murnane, Maynard, and Ohis (1981), Guryan, Hurst and Kearney (2008), Datcher-Loury (1988), Houtenville and Smith Conway, Leibowitz 1974, 1977, Hill and Stafford 1980
- Dynastic models with household: Echevarria and Merlo (1999), Regalia and Rios-Rull (2001), Rios-Rull and Sanchez-Marcos (2002), Greenwood, Guner and Knowles (2003)
  - We account for life-cycle, endogenous selection, measuring quantity quality tradeoffs.
- Our contribution: Measure long-run outcomes including marriage market. Account for endogenous fertility, labor supply and time with children, and household interactions

Data

Sources

- Family-Individual File of the Michigan Panel Study of Income Dynamics (PSID) from 1968 to 1996.
- The PSID measures annual hours of housework for each individual
- Normalized data for time with children: this approach can be found in Hill and Stafford (1974, 1980), Leibowitz (1974), and Datcher-Loury (1988)
- Time with children is computed as the deviation of housework hours from the average housework hours of individuals with no child.
- Account gender and education and year
- Negative values are set to zero
- Discretize to 3 levels of time investment

Table 1 : Summary Statistics

(Standard Deviation are in parentheses)

	(1) All		(2) G-1		(3)G-2	
Variable	N	Mean	N	Mean	N	Mean
Female	115,280	0.545	86,302	0.552	28,978	0.522
Black	115,280	0.223	86,302	0.202	28,978	0.286
Married	115,280	0.381	86,302	0.465	28,978	0.131
Age	115,280	26.155	86,302	27.968	28,978	20.756
		(7.699)		(7.872)		(3.511)
Education	115,280	13.438	86,302	13.516	28,978	13.209
		(2.103)		(2.138)		(1.981)
Number of children	115,280	0.616	86,302	0.766	28,978	0.167
		(0.961)		(1.028)		(0.507)
Annual labor income	114,871	16,115	86,137	19,552	28,734	5,811
		(24,622)		(26,273)		(14,591)
Annual labor market hours	114,899	915	86,185	1078	28,714	424
		(1041)		(1051)		(841)
Annual housework hours	115,249	714	86,275	724	28,974	641
		(578)		(585)		(524)
Annual time spent on children	66,573	191	58,564	234	8,009	63.584
		(432)		(468)		(259)
Number of individuals	12,318		6,813		5,505	

Model

Environment

- Two types of individuals, female and male denoted by $\sigma = f, m$.
- Adults live for T periods
- An adult from generation $g \in \{0, ...\infty\}$ makes discrete choices:
  1. Labor supply, $h_{\sigma t}$: no work, part time, full time
  2. Time spent with children $d_{\sigma t}$: none, low, high
  3. Birth (females): b_t

Model

Parental Inputs

- Stochastic production function of the child's characteristics
- Inputs:
  1. Parents' total input of time over the life cycle, D_s
  2. We take time investment in the first 5 years
  3. Income in the first 5 years, W_s
  4. Characteristics of father and mother, education, skill, race, sex: x_f, x_m

Model

Children's Outcomes

- $M(x_0'|x_f, x_m, D_s, W_s)$ is the production function mapping parents' characteristics and time investment into the child's and spouse characteristics
- Outcomes: x_0'
  1. Education
  2. Then fixed effects, depend on education
  3. Spouse characteristics (education, skill) depend stochastically on education;
- $w_{\sigma t}(x_\sigma, H_{\sigma t-1}, h_{\sigma t})$ denotes the earnings function; it depends on:
  1. time invariant characteristic, x_σ, as education, skill, race and gender
  2. human capital accumulated with experience, $H_{\sigma t-1}$
  3. current level of labor supply, $h_{\sigma t}$

Model

Preferences: Life-Cycle Dynastic Model

- Life-cycle utility of a person

$$U_{\sigma g T} = \sum_{t=0}^{T} \beta^t \left[u(.) + \varepsilon_{\sigma k t} \right]$$

- Let $\varepsilon_{\sigma t}$ denote iid the per-period choice specific preference shock vector; β, the annual discount factor
- $\overline{U}_{g+1}$ is the total expected utility of all children;
- The discounted expected lifetime utility of an adult σ in generation

$$U_{\sigma g} = E_0 \left[U_{\sigma g T} + \beta^T \lambda N_{\sigma}^{1-\nu} \frac{\overline{U}_{g+1}}{N_{\sigma}} \right]$$

- Altruistic individuals, the discount factor of the valuation of the children's utility is given by $\lambda N_{\sigma}^{1-\nu}$
- $N_{\sigma} = 1$, discount children utility vs. own by $1 < \lambda < 1$
- Diminishing marginal utility from children: $0 < \nu < 1$

Model

Per-Period Utility

- Additive linear preferences, risk neutrality, no borrowing and savings.
- N_σ number of children
- Married individual

$$u_{1\sigma t} = \alpha_\sigma w_{\sigma t} + \alpha'_\sigma w_{-\sigma t} + \alpha_{\sigma N}(N_t + b_t)$$

- Utility from own and spouse earnings, net costs of children
- Single individual

$$u_{1\sigma t} = \alpha_\sigma w_{\sigma t} + \alpha_{\sigma N}(N_t + b_t)$$

- Disutility from work and time spent with children: for choices indicating labor supply, time spent with children, birth (females), $k_{\sigma jt}$.

$$u_{2\sigma t} = \theta_{k_{\sigma jt}}$$

- Family structure matters for the decision: married individual are affected by the spouse earnings, and we allow costs of children to be different

Complete Information Game Between Spouse

Timing,Information, Strategy

- At the beginning of the period all the household state variables are common knowledge.
- Each period labor supply, investment, transfers to children are chosen by each individual, and birth decisions by the female simultaneously.
- Let $k_{\sigma jt}$ and $k_{-\sigma it}$ denote then choices of an individual and his/her spouse and $k_{jit} = (k_{\sigma jt}, k_{-\sigma it})$
- Markov strategies, specify choices in every state and period

Model

Ex-Ante Valuation Function

- Expected valuation at time 0 of adulthood of a person with household characteristics x_t, $t < T$:

$$V_\sigma(x_t) = \sum_{k_t} p(k_t = s|x_t) \left[u_\sigma(k_t, x_t) + \beta \sum_{x_{t+1}} V_\sigma(x_{t+1}) F(x_{t+1}|x_t, k_t) \right] +$$

$$\sum_{s=1}^{K_t} E_\varepsilon[\varepsilon_{\sigma_t}|k_t = s] p(k_t = s|x_t)$$

- The probability of equilibrium choices of spouse $p(k_t = s|x_t)$ are derived from best response functions
- $F(x_{t+1}|x_t, k_t)$ transitions of divorce and marriage, depend on choices

Model

Best Response Function

- $v_\sigma(k_{jit}; x_t)$ denote σ's best response continuation value (net of shocks)

$$v_\sigma(k_{jit}; x_t) = u(k_{jit}, x_{\sigma t}) + \beta \sum_{x_{t+1}} V_\sigma(x_{t+1}) F(x_{t+1} | x_t, k_{jit})$$

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- Best response probabilities $p_{\sigma jt}(k_{\sigma jt} | k_{-\sigma it}, x_t)$

$$\int \left[\prod_{k_{\sigma jt} \neq k_{j'it}} 1\{v_\sigma(k_{jit}; x_t) - v_\sigma(k_{j'it}; x_t) \geq \varepsilon_{\sigma jt} - \varepsilon_{\sigma j't}\} \right] dF_\varepsilon$$

- For $t = T$: if there is no birth decision

$$v_\sigma(k_{jiT}; x_T) = u(k_{jiT}, x_{\sigma T}) + \beta\lambda {N_{\sigma T}}^{1-v} \frac{\overline{V}_{N\sigma}(k_{jiT}; x_T)}{N_{\sigma T}}$$

- $\overline{V}_N(x_T)$ is sum of the expected valuation over all children.

$$\overline{V}_N(k_{jiT}; x_T) \equiv \sum_{s=0}^{T-1} \left[b_s \sum_{\sigma'} I_{\sigma s}^{\sigma'} \sum_{x_0'} V_\sigma^{(s)}(x_0') M(x_0' | x_f, x_m, D_s(k_{jiT})) \right]$$

Model

- Costs of time: current income and experience, non-pecuniary costs
  - depend on education, gender, race, age
- Time with children: lower cost of time when young, higher income per hour when older
- Quantity-Quality tradeoff: Allocation of time across children, reduces average quality
- Substitution and income effects on timing and spacing of children
- Persistence in human capital across generations

Equilibrium-pure strategies MPE

- In equilibrium, tradeoffs depend on spouse's strategy
- For example, increase in time with kids and decrease labor supply may not imply decline in consumption
- Women make birth decisions, but labor supply and time with kids of men may affect probability of decisions
- Equilibrium in pure strategies exists (Watanabe and Yamashita, 2010) given the functional forms we assumed and estimated (super modular game with increasing differences)
- The equilibria can be Pareto ranked (Milgrom and Roberts,1990, Vives, 2005, Watanabe and Yamashita, 2010)

Estimation Overview

- Estimation with nested fixed point algorithm becomes computationally intensive quickly
- The intergenerational problem is non-standard
- In addition, there is multiple equilibria problem
- Multi-step estimators for dynamic single agent models (Hotz-Miller) allow to estimate the model without solving it
- Using necessary conditions that hold in all equilibria, but one is played
- Games: conditional on the other players strategies the problem is similar to estimation of single agent dynamic problem
- We developed alternative representation allows us to apply Hotz-Miller estimation technique for dynamic single agent and accommodate the multiple equilibria problem

Estimation Strategy

- **Step 1**
- Estimate *earning equations* and *fixed effects* for both generations
  - They are controlled for in the rest of the first stage estimation
- Estimate *conditional choice probabilities*-and *best response probabilities*, using fixed effects as inputs
- Estimate transition functions: marriage, divorce, etc.
- The children's education production function parameters are estimated using a 3SLS $\Rightarrow$obtain *intregenerational transition functions*.

- **Step 2**

- **Step 3**
- Using techniques from Hotz, Miller, Sanders, and Smith (1994), we form moment conditions from the BR functions and estimate structural parameters, *discount factors and per-period utility parameters*, using GMM.

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- **Step 2**
- We derive representation of the ex-ante valuation function $V(x_0)$ in terms of CCP's, BR, transition functions, per-period utility function parameters.

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Estimation-Representation Step 2

- $U_\sigma(k_{jit}, x_t)$ is the ex-ante conditional lifetime utility as period t, *excluding* the dynastic component. It is only a function of CCP's, transition functions, per-period utility function parameters. $H(x_0|x_t, k_{jit})$ is the intra-generational transition function

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- Assuming stationarity, we can write $V(x_0)$ the ex-ante value function at $t = 0$ as a function of the expected life cycle utility and the expected $V(x_0)$ of the next generation

$$V(x_0) = \sum_{k_{-\sigma i0}} \left\{ p(k_{-\sigma i0}|x_0) \sum_{k_{\sigma j0}} \left[U_\sigma(k_{ji0}, x_0) + E_\varepsilon(\varepsilon_{\sigma j0}|k_{ji0}, x_0) \right] p_0(k_{\sigma ji0}|x_0) \right\}$$
$$+ \sum_{k_{-\sigma i0}} \left\{ p(k_{-\sigma i0}|x_0) \sum_{k_{\sigma j0}} \left[\lambda \beta^T \sum_{x_0} V(x_0) H(x_0|x_t, k_{jit}) \right] p_0(k_{\sigma ji0}|x_0) \right\}$$

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- Inverting the above equation, we write $V(x_0)$ as a function of choice probabilities, transition functions expected shocks and per-period utility parameters.

Education outcomes-3SLS System

(Standard Errors in parenthesis; Exclude class is Less than High School)

Variable	High School	Some College	College
High School Father	0.008	0.023	0.155
	(0.068)	(0.104)	(0.128)
Some College Father	-0.012	0.057	0.162**
	(0.047)	(0.074)	(0.086)
College Father	-0.014	0.021	0.229*
	(0.071)	(0.110)	(0.135)
High School Mother	0.004	0.093	0.083
	(0.057)	(0.089)	(0.107)
Some College Mother	-0.016	0.036	-0.089
	(0.054)	(0.085)	(0.098)
College Mother	-0.122	0.03	0.222
	(0.076)	(0.116)	(0.140)
Mother's Time	-0.091	-0.048	0.299**
	(0.075)	(0.114)	(0.130)
Father's Time	0.153**	0.273**	-0.108
	(0.069)	(0.103)	(0.131)
Mother's Labor Income	0.021	-0.014	-0.004
	(0.025)	(0.039)	(0.048)
Father's Labor Income	0.015	0.018	-0.023
	(0.010)	(0.016)	(0.020)
Female	0.034	0.158**	0.110**
	(0.030)	(0.045)	(0.056)
Black	-0.227**	-0.236	0.324**
	(0.093)	(0.141)	(0.162)
Constant	0.606	-0.416	-0.889
	(0.255)	(0.396)	(0.450)
Observations	4,980	4,980	4,980

Education Outcomes Estimates

- Parental education increases education outcomes, males have higher impact (Rios-Rull and Sanchez-Marcus, 2002)
- Both maternal and paternal time investment increase the likelihood of higher educational outcome of their children.
  1. Fathers' time investment increases the probability of graduating from high school and getting some college education
  2. Mothers' time increases the probability of achieving a college degree.
- Girls have a higher likelihood than boys of achieving higher education levels.
- Blacks have higher variance than white in their educational outcomes
  1. blacks have a higher probability of not completing high school
  2. Conditional on completing high school; higher probability of graduating from college.

Labor Market Earnings-Results

- Parental input affect earnings through education
- Regress log earnings on age*education, part time and full time work, previous 4 years experience (by gender)
- Slope of age-log(earnings) profile of college graduate is 3 times larger than that of less than high school, almost double that of some college
- Labor market "tax" for female and black (in the fixed effect estimates)
  1. Small relative to the education-age compensation
  2. Black "tax" is smaller than the female "tax"

Table 11: GMM Estimates of Utility Function and Discount Factors

Discount Factors				
Intertemporal	β	0.85		
		(8.5E-4)		
Intergenerational	λ	0.90		
		(1.0E-5)		
Number Children	ν	0.10		
		(1.3E-7)		
Utility of Earnings and Net Cost of Children				
Female			Male	
Married own earnings		0.31	Married own earnings	0.22
		(1.0e-3)		(2.0e-3)
Married Spouse earnings		-0.03	Married Spouse earnings	-0.14
		(7.0e-4)		(1.0e-3)
Married number of children		-0.18	Married number of children	-0.29
		(2.0e-3)		(2.0e-3)
Single earnings		0.29	Single earnings	0.03
		(1.0e-3)		(8.0e-4)
Single number of children		-0.22	Single number of children	0.12
		(2.0e-3)		(2.0e-3)
N		50,514		

Results-utility parameters and households behavior

$$u_{1\sigma t} = \alpha_\sigma w_{\sigma t}(x_\sigma, H_{\sigma t-1}, h_{\sigma t}) + \alpha'_\sigma w_{-\sigma t}(x_{-\sigma}, H_{-\sigma t-1}, h_{-\sigma t}) + \alpha_{\sigma N}(N_t + b_t)$$

- Marriage reduces costs of children for females -0.18 for married, -0.22 for single
- but increases them for males: -0.29 for married, 0.03 for single,
- Male's utility from wife's earnings is negative, married women have high utility from own income (relative to single women)

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- $\nu = 0.1$,the marginal increase in the utility from 2nd child is 0.87, and 0.82 for the 3rd child

Aggregate Measure of Returns

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- Rate of return to parental time investment $\Lambda_{D\sigma}(x_t)$:

$$\Lambda_{D\sigma}(x_t) \equiv \frac{\partial \log\left(N_T^{1-\nu}\,\frac{\overline{V}_{N\sigma}(x_T)}{N_T}\right)}{\partial D_T}$$

Aggregate Measure of Returns

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- The marginal costs are measured as

$$\frac{\partial \log\left(U_\sigma(k_{ji0}, x_0)\right)}{\partial D_T}$$

Dependent Variable: Log of Valuation of Children

(Standard Errors in Parenthesis)

Variables	Black	White	Variables	Black	White
Number Children	0.458	0.645	Mother's Time per child	**0.082**	**0.073**
	(0.020)	(0.012)		(0.003)	(0.002)
Number Children Squared	-0.054	-0.071	x Number Children	**0.002**	**0.002**
	(0.003)	(0.002)		(0.001)	(0.001)
Number of Female Children	1.081	0.515	x Number Female Children	**-0.005**	**-0.005**
	(0.007)	(0.004)		(0.001)	(0.000)
Number of Female Children Squared	-0.160	-0.066	Father's Time per child	**0.053**	**0.049**
	(0.002)	(0.001)		(0.003)	(0.002)
Mother: High School	0.053	0.046	x Number of Children	-0.000	0.000
	(0.007)	(0.004)		(0.001)	(0.001)
Mother: Some College	0.025	0.025	x Number Female Children	0.001	-0.000
	(0.007)	(0.004)		(0.001)	(0.000)
Mother: College	0.074	0.072	Constant	6.683	7.807
	(0.007)	(0.004)		(0.033)	(0.020)
Father: High School	0.064	0.061	N	6,720	6,720
	(0.007)	(0.004)	R-squared	0.948	0.96
Father : Some College	0.125	0.116			
	(0.007)	(0.004)			
Father : College	0.193	0.177			
	(0.007)	(0.004)			

Aggregate Measure of Returns

- Returns to maternal time investment is higher for blacks, no difference in returns to paternal time investment
- Black individuals have higher probability of college (and less than high school), also lower returns in the labor market and marriage market
- As the utility function estimates indicate, the costs of children is higher in single parent family
- The higher proportion of single black mothers is an important factor the differences in investment patterns of black and white individuals
- The returns to maternal time investment are significantly higher for boys.

Measuring the Quantity Quality Tradeoffs

- We construct a measure of the rate of change in valuation from children in the number of children

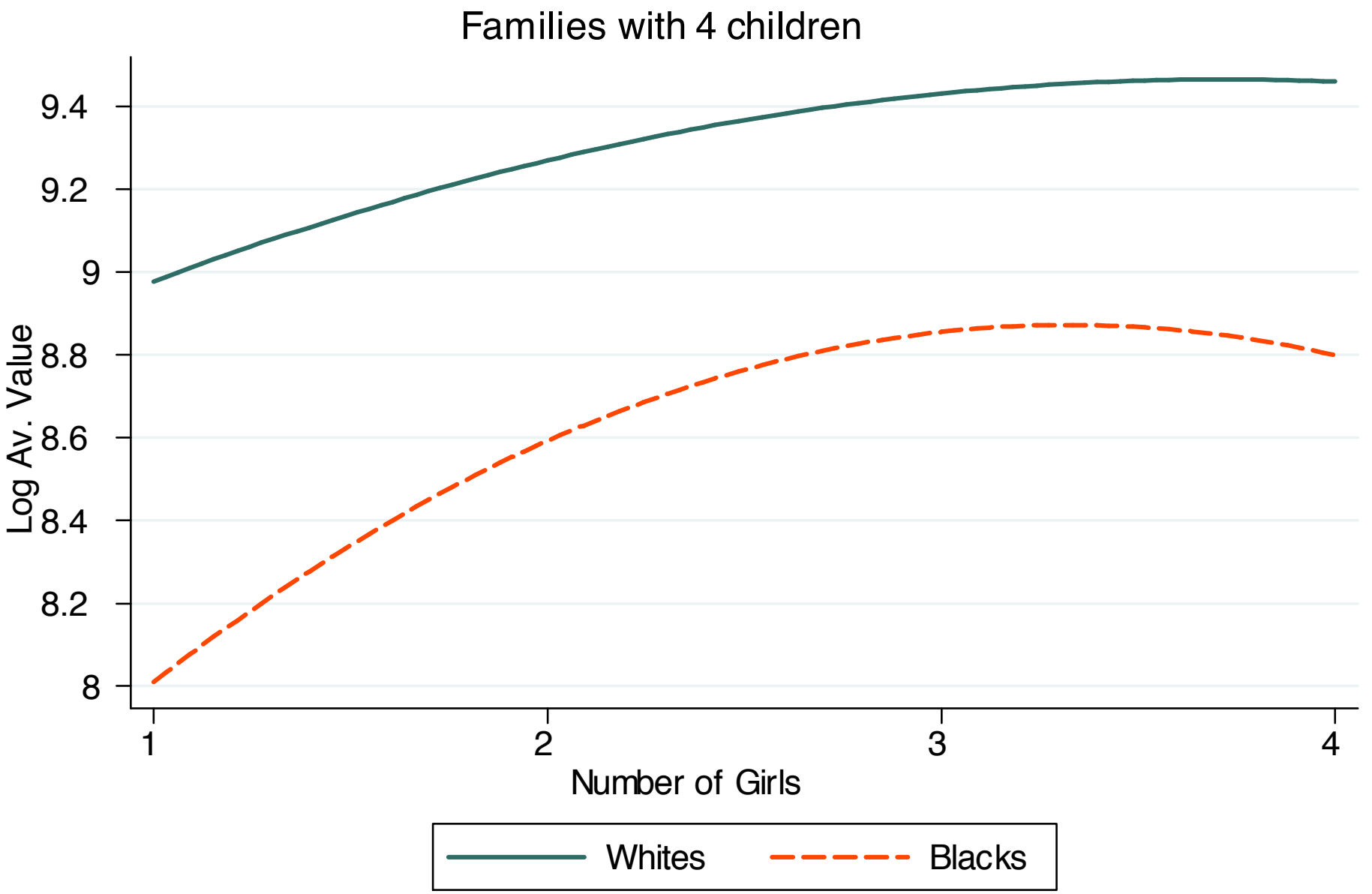
$$\Lambda_{N\sigma}(x_t) \equiv \frac{\partial \log\left(\frac{N_T^{1-\nu}\overline{V}_{N\sigma}(x_T)}{N_T}\right)}{\partial N_T}$$

- If $\frac{\partial \log\left(\frac{\overline{V}_{N\sigma}(x_T))}{N_T}\right)}{\partial N_T} < 0$ there is quantity-quality tradeoff
- We regress $Log(\frac{(\overline{V}_{N\sigma}(x_T)}{N_{\sigma T}})$ on education of parents, number of children, number of children squared, number of female children and number of female children squared
- Captures the change in valuation per child for black and white individuals given the optimal adjustment of time investment

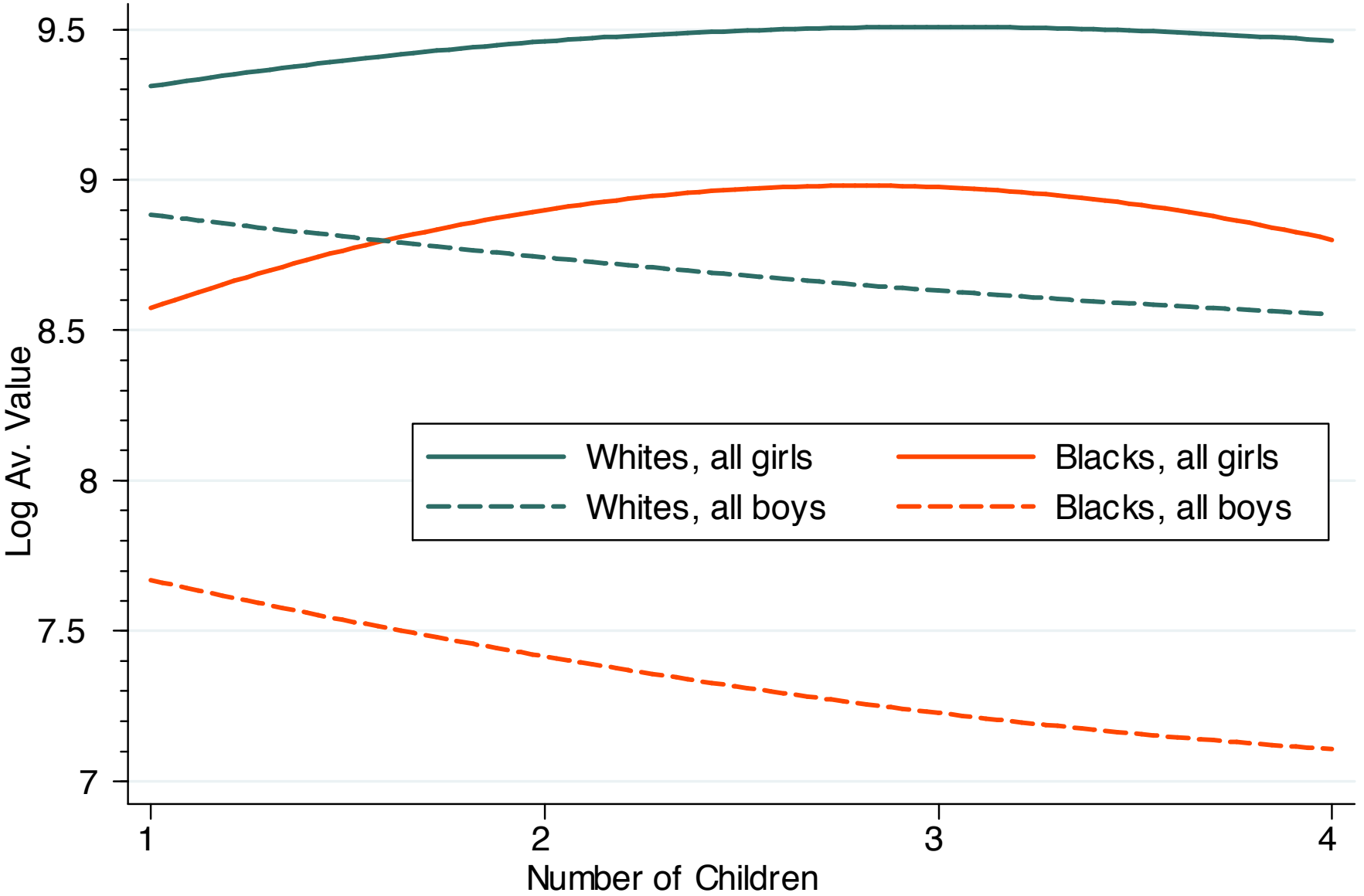
Dependent Variable: Dependent Variable: Log($\frac{(\overline{V}_{N\sigma}(x_T)}{N_{\sigma T}}$), excluded class less than high school

Variables	Black	White
Number Children	-0.3572	-0.1934
	(0.029)	(0.029)
Number Children Squared	0.0165	0.0339
	(0.004)	(0.005)
Number of Female Children	1.0621	0.4908
	(0.011)	(0.01)
Number of Female Children Squared	-0.1598	-0.066
	(0.003)	(0.003)
Mother: High School	0.053	0.0462
	(0.013)	(0.011)
Mother: Some College	0.0253	0.0251
	(0.011)	(0.013)
Mother: College	0.0739	0.0719
	(0.013)	(0.011)
Father: High School	0.0615	0.0636
	(0.0011)	(0.013)
Father : Some College	0.1247	0.1162
	(0.013)	(0.011)
Father : College	0.1929	0.1768
	(0.013)	(0.011)

Quantity-Quality Tradeoff, by number of female children



uantity-Quality Tradeoff by number of children, same gender



Measuring the Quality-Quantity Trade-offs

- The level of investment per child is smaller the larger the number of children
  - Driven by the time constraint and the opportunity costs of time and not by the properties of the production function technology of children.
- The negative relationship between mother's education and fertility is explained by higher opportunity cost of time of educated mothers in terms of forgone earnings.
- Quality-quantity trade-off for black individuals is significantly larger than that of white individuals.
- Mainly due to the higher fertility of single black female and the resulting greater time constraint they face.

Measuring the Quality-Quantity Trade-offs

- The tradeoff is smaller for girls (negative after the third child)
- Females have higher valuation functions
  1. Females earn less than men with the same productive characteristics
  2. But, more likely to obtain a higher education level than males, given equal amount of parental inputs
  3. Education is highly compensated in the labor market.
  4. Females receive larger transfers when married, work less.
  5. They are endowed (in our model) with birth decisions and males value children, but cannot make decisions to have them (Echevarria and Merlo (99)).

Results Summary

- We develop a framework to evaluate returns of parental time investment, accounting for the role of household structure labor market and marriage market outcomes
- Parental time investment increases outcomes, but mothers invest more time in children
  - The returns to maternal time is 60% larger than paternal return
- The valuation functions of black individuals are lower than that of white
- Nevertheless, blacks have a higher return to maternal time investment than whites.
  - There is a significantly higher proportion of black single mothers than whites
  - Costs of children are higher for single mothers than the costs of married mothers
- Mothers act in a compensatory manner, investment more time in boys than in girls as the number of children increases
  - The returns to maternal time investment are significantly higher for boys.
  - Girls already have a higher likelihood of achieving a high level of education than boys
  - Girls have higher expected valuation conditional on education, despite labor market "tax" due to household transfers

Extensions and Robustness

- Capture differential spending on children by income groups, interaction of income and number of children in the utility function
- Siblings effect in the production function
- Measure costs differences: change in expected life-time utility of a parent when increasing time with children, and number of children
- Measure intergeneration mobility in terms of $V(x_0)$, by race, education