Share the Love: Parental Bias, Women Empowerment and Intergenerational Mobility

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Abstract

This paper introduces a collective household decision-making process into a gender-based overlapping generations model with heterogeneous agents. Gender bias is modeled as part of parents' psychic cost – a reflection of their pessimism, which leads to different mobility thresholds for daughters and sons. In this setting, the degree of women's bargaining power is found to be crucial in defining the psychic cost and hence their children's mobility. The framework is applied to the Nigerian General Household Survey panel data. We estimate a multinomial logit model with unobserved heterogeneity, using simulated maximum likelihood, to determine intergenerational mobility across primary, secondary and tertiary sectors. We find that children whose parents work in the secondary and tertiary sectors are more likely to work in the same sector. Greater intra-household female bargaining power leads to greater upward mobility for boys more than girls. Parental gender bias could thus be one of the driving force behind gender-based intergenerational persistence.

Key words: Occupation mobility, gender bias, women bargaining power, sub-Saharan Africa
JEL classification: J16; J62, C35; D10, O55

1 Introduction

Many parents rightly claim the same degree of love for their children, regardless of their sex. However, it is also evident that there exists some form of gender bias and sex preferences in families. Barcellos et al. (2014) find for example that boys fare better than girls in India. They receive more child care, are breastfed longer and even get more dietary supplements. Such differential treatments of sons and daughters in intra-household resource allocation, in the form of disproportional parental time spending and investment in children education, could be important to intergenerational occupational mobility (hereafter IG mobility) of men and women. Given that women attach a relatively higher weight to the welfare of their children, the degree of their empowerment in

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household decision-making process could even be more important. However, in spite of a growing literature on gender and social mobility, the role of women empowerment on IG mobility has received a scant attention.[1] The present paper endeavours to fill this gap.

The paper in particular develops a model and then provides empirical evidences on the role of gender and women bargaining power in IG mobility, using panel data from Nigeria, while accounting for unobserved heterogeneity. Intergenerational mobility studies have been fraught with econometric challenges that arise due to unobservable heterogeneity – heredity of genetic endowments such as ability and preference across generations.[2] When social mobility varies by class, gender or race, it may be an indication of the existence of a differential access to opportunities, which is determined based on these characteristics. Intergenerational persistence becomes more of a policy concern if it is an outcome of such inequality of opportunity rather than differences in ability that are often transmitted from parent to child (Corak 2013). The unobservability of the latter, however, makes the task of understanding the underlying causes of the intergenerational correlation quite challenging. The standard approach to tackle unobserved heterogeneity is to either use panel data or instrumental variables despite finding the appropriate instruments being a daunting task often.

The framework for our theoretical analysis is a gender based overlapping generations model in which married/partnered couples face a trade off between investment in their children education, their consumption and labour force participation. The theory builds on models of altruistic parents that face a warm glow utility and human capital investment threshold (e.g. Banerjee & Newman 1993; Galor & Zeira 1993; Moav 2002; Galor & Moav 2004; Galor & Mountford 2008), which defines individual intergenerational occupational mobility.[3] We follow Chiappori (1988) and Chiappori (1992) in introducing a collective household decision-making process that considers intra-household bargaining power between couples, which is determined according to the human capital of the couples (as in de la Croix & Donckt 2010).[4] Another important motivation comes from the work of Ben-Porath & Welch (1976) and Davies & Zhang (1995) who treated gender inequality a result of parental sex preference, which is a feature of parental utility function.

The paper also complements, but differs, to the debate over gender inequality in human capital investment. Prominent examples include the work of Galor & Weil (1996), Echevarria & Merlo (1999), Lagerlof (2003), Iyigun & Walsh (2007) and de la Croix & Donckt (2010). Motivated by Becker (1981), Echevarria & Merlo (1999), Iyigun & Walsh (2007) and de la Croix & Donckt (2010),

[1] Works by Behrman & Rosenzweig 2005, Currie & Moretti 2003, Emran & Shilpi 2011 and Emran & Shilpi 2015 are among few empirical studies that emphasize the gender effects of intergenerational occupational mobility in developing countries, particularly in Asia.

[2] Previous studies attribute the partial, but high correlations between parents' and children's outcomes to *nature* and *nurture inter alia* (Becker & Tomes 1986; Haveman & Wolfe 1995; Black & Devereux 2011; Checchi et al. 2013). Nature refers to a genetic transmission of the ability of a parent to a child: able parents have a higher chance to have more able children that can attain higher levels of education and hence higher income. Nurture pertains to a parent's time and investment on her child's human capital.

[3] Aiyagari et al. (2000) also apply a gender based overlapping generations model with warm glow utility functions.

[4] Early work in modelling of intra-household decision making process as a bargaining problem goes back to Manser & Brown (1980) and McElroy & Horney (1981).

for instance, put biological differences between women and men at the centre of gender inequality in human capital accumulation. A restricted time allocation by women, in this literature, due to their biological time commitment to childcare during pregnancy, childbirth and breast-feeding, leads to a systematic gender differences in human capital investment. When women devote lower amount of their time to labor market activities, it negatively impacts their returns to education relative to men. This in turn leads to lower parental investment in daughters education.[5]

A novel feature of our models comes with our specification of parental attitude towards different gendered children that determines their children's human capital development and hence IG mobility. In particular, we treat parental gender bias as part of parental psychic cost – a reflection of their pessimism, which negatively impacts their marginal benefit of investing in their children's human capital. This may be a reflection of their pessimistic view of the world as a result of intrinsic values placed by the society in gender roles (or gender stereotypes). Parental bias against a certain gender group is associated to a relatively larger psychic cost attached to the specific gender.[6] Differences in psychic cost (parental gender bias) leads to differences in between human capital investment threshold of girls and boys. This in turn determines the IG mobility threshold for women and men in the economy. Given that women attach a relatively high weight to the welfare of their children (Doepke & Tertilt 2009), then the degree of their intra-household bargaining power is important in defining the psychic costs and hence the mobility of their children.

We show that parental gender bias could be a basis of gender-based intergenerational persistence. Individuals benefit from their opposite sex sibling misfortunes. When parents are biased against a particular gender, then they tend to compensate it by investing more in the opposite sex. However, the total household saving tends to be lower than what it would have been without gender bias, implying that parental gender bias could be a basis for aggregate inefficiency. We also find that IG mobility depends on intra-household bargaining power, parents' occupational background, parental gender bias and sex preferences. Increased women's bargaining power leads to higher IG mobility, given that they attach a higher weight to their children's education.

We apply the framework to a representative panel data survey from Nigeria, over 5,000 households and about 14,000 individuals in the years 2011 and 2013, each. In both waves, we observe the main industry of occupation and the highest level of education for two generations. For children, we observe their most recent job; for parents, the industry of occupation they got engaged into throughout most of their life. We study three economic sectors: primary, secondary and tertiary, in contrast to the (limited) literature in developing countries that merely focuses on two sectors – agriculture and non-agriculture. Using both restricted (sub-sample of adult children who live

[5] In Lagerlof (2003), gender inequality in human capital rather arises through a coordination process. Families play a coordination game against one another, not only caring about the income of their daughters but also the income of their future spouses. In this case, it may be optimal for an atomistic parent to discriminate when all other families discriminate against their daughters. In contrast, in Galor & Weil (1996), gender heterogeneity is rather a result of technological differences related to men's and women's types of labor.

[6] In a society where child marriage is commonly practiced, for instance, parents may fear that their investment in their daughters is little rewarding, and hence may attach a relatively larger psychic cost to their daughter human capital investment.

with their parents) and un-restricted samples of all children, we estimate a multinomial logit model with unobserved heterogeneity using simulated maximum likelihood. Our main empirical findings are twofold: First, children with parents working in the secondary and tertiary sectors are more likely to work in the same sector. Second, a greater intra-household female bargaining power leads to greater upward mobility while it benefits boys more than proportionally. Therefore, parental gender bias could be a driving force behind gender-based intergenerational persistence.

The rest of the paper is organized as follows: Section 2 develops the theoretical model and provides the analytical results. Section 3 and 4 deals with the application of the model to a Sub-Saharan African case. Section 5 concludes.

2 The Model

Suppose an overlapping generation of many individuals identified as male and female. Each person lives for two periods as a child and an adult. Children either go to school and accumulate human capital, if their parents invest in their education, or do nothing. Their consumption in both cases is set to nil.[7] Adulthood begins by women and men joining in a partnership. That is, when reaching adulthood, the son and the daughter of a given family simply draw spouses at random from other families and form their own family.[8] Each couple will have a daughter and a son.[9] Couples collectively decide in working or spending time with their children, in their consumption, and for the level of their children education, subject to the household constraints. The weight of their decision on such household matters depend on their relative bargaining power, which in turn depends on their relative human capital.

2.1 Preferences

The utility function of the ith household is given by

$$u_{it}\left(c_{it}, h_{it+1}\right) = \theta_{it} u^f\left(c_{it}, h_{it+1}\right) + \left(1-\theta_{it}\right) u^m\left(c_{it}, h_{it+1}\right) \tag{1}$$

where u^f and u^m represent the utility of the female and male adults, respectively; c_{it} and h_{it+1} denote the respective total household consumption and children human capital; θ_{it} represents the bargaining power of the female adult. Following de la Croix & Donckt (2010), we model θ_{it} as a function of the couple's relative human capital:

$$\theta_{it} = (1-\epsilon)\left(1-\overline{\theta}\right) + \epsilon h_{it}^f / \left(h_{it}^f + h_{it}^m\right) \tag{2}$$

[7] Alternatively, it could be assumed that their consumption to be included in the consumption of their parents.

[8] For the sake of simplicity, we abstract from the possibility of remaining single, being divorced or being in a same-sex marriage.

[9] We also assume a constant population size, as we abstract from fertility issues.

where parameters ϵ and $\overline{\theta}$ capture the exogenous institutional and social factors. $\overline{\theta} > 0.5$, for e.g., implies that the bargaining power of women is less than that of men even if $h_{it}^{f} = h_{it}^{m}$. Let

$$u^{j}\left(c_{it}, h_{it+1}\right) = \ln\left(c_{it}^{j} - \bar{c}\right) + \frac{1}{2}\beta^{j} \ln\left\{\left(h_{it+1}^{f} + \gamma^{f}\right)^{\sigma}\left(h_{it+1}^{m} + \gamma^{m}\right)^{1-\sigma}\right\} \tag{3}$$

$j \equiv \{f, m\}$ where f and m stand for female and male, respectively; $-j$, the opposite sex; σ denotes the parental sex preference; $\bar{c} \geq 0$ stands for subsistence consumption. According to (3), individuals have 'warm glow' preferences.[10] We assume $\beta^{f} > \beta^{m}$, which implies that women attach a relatively higher weight to the human capital of their children. $\gamma > 0$ is a non-pecuniary (psychic) cost, which negatively impacts the marginal benefit of investing in children's education. Parental bias towards a certain gender is captured by $\gamma^{j} \neq \gamma^{-j}$. Such a bias could be a result of some gender stereotypes.[11]

2.2 Technologies and Constraints

The human capital of the jth gender of the ith household is given:

$$h_{it+1}^{j} = \left(e_{it}^{j}\right)^{\upsilon}\left(h_{t} l_{it}^{j}\right)^{\eta} \tag{4}$$

where e_{it} and l_{it} denote parental education investment in goods and time, respectively and h_t is the average human capital of the parents' generation. We suppose in every period, that the economy has access to both traditional (farm) and modern technologies (nonfarm). Only individuals who received an education during their childhood would have access to modern technologies.[12] The budget constraint of the ith household is

$$c_{it}^{f} + c_{it}^{m} + \left(e_{it}^{f} + e_{it}^{m}\right)/2 = y_{it} \tag{5}$$

y_{it} is the total income of the household, given by $y_{it} = \omega_{t}\left(1 - l_{it}\right) + b_{it}$, where $\omega_{t}\left(h_{t}\right)$ is the wage rate in the farm and b_{it} represents the non-farm wage premium as below.

2.3 Couples' Income and Occupation

We assume income pooling and denote the ith couple income by y_{it}. In the second period of their life, each couple is endowed with a unit of labor. Couple allocates their time between child rearing, l_{it}, and work, $1 - l_{it}$. Individuals either work in a farm or in non-farm sectors. Only individuals whose parents invest in their human capital have access to non-farm jobs. If an individual receives

[10] The use of such utility function is ubiquitous in the literature (see for instance, Glomm & Ravikumar 1992, Galor & Zeira 1993, Banerjee & Newman 1993, Galor & Weil 2000 and Benabou 2000). Its main advantage (*vis á vis* other dynastic altruistic models that assume parents derive utility from the utility of their children) is its greater analytical tractability while the qualitative results of the model remains unaffected.

[11] For example, if child marriage is widely common, parents may fear that investing in their daughters is little rewarding, and hence, $\gamma^{f} > \gamma^{m}$.

[12] The outcome will not change if raw labor is assumed to have been upgraded, say, as a result of a universal compulsory primary or secondary education. Then, h_{it} could be interpreted as the special skill required to work in the modern sector.

education during childhood, she/he will have an additional h_{it} unit of efficient labor, which immediately qualifies her/him to work in the non-farm sectors.[13] While the wage rate in the farm is ω_t per unit of labor, the non-farm sectors pay an additional α per unit of human capital. The pooled income of a couple, born at date $t-1$, where only one of them works in the non-farm sectors, for instance, is given by $\omega_t + \alpha h_{it}^j$. One may consider a linear production technology at the aggregate level, without loss of generality, such as $\omega_t = (1-\alpha) A h_t$ where A is a deterministic total factor productivity (TFP).[14] Therefore, aggregate income in the economy, from the traditional and modern sectors, becomes Ah_t. This also implies that the same type of goods are produced in both sectors.[15]

Suppose there are four types of couples at date t. We refer to group 1 couple, denoted by $i=1$, when both members of the household work in the non-farm sectors. Group 2, $i=2$, is when the female works in farm while the male works in the non-farm sectors. Group 3, $i=3$, is the opposite of the that. In group 4 couple, $i=4$, both work in farm. We also assume couples are ex ante homogeneous within groups. In this case, the pooled income of the ith couple is given by

$$y_{it} = (1 - l_{it})\,\omega_t + b_{it} \tag{6}$$

where b_{it} is income premium defined as follows:

$$b_{it} \equiv \begin{cases} \alpha\left(h_{it}^f + h_{it}^m\right) \text{ if } i=1 \\ \alpha h_{it}^f \text{ if } i=2 \\ \alpha h_{it}^m \text{ if } i=3 \\ 0 \text{ if } i=4 \end{cases} \tag{7}$$

The first line of Eq. (7) shows the pooled income premium as both couples work in the non-farm sectors. The second (third) line is the wage premium earned by the female (male) adult member of the household. The wage premium is nil in the last line since there is no one in this household who works in the non-farm sectors.

[13] One may rather interpret h_{it} as the special skill required to work in the modern sector.

[14] Such an assumption, particularly, could be useful for a future extension of the model to aggregate issues. We focus here in mobility, which is mainly an individual matter.

[15] Explicit differentiation of the final goods as an agriculture and manufacture goods (as in Galor & Mountford 2008) may lead to a further complication of the model (as it might add another heterogeneity) but with little benefit to our purpose.

2.4 Households Optimal Decisions

2.4.1 Optimal Investment in Education

Households maximize (1) and (3) subject to (4), (5) and their income constraints. The solutions consist of optimal investment in sons' and daughters' educations, in terms of goods and time:

$$e_{it}^{m*} = \left(y_{it} - \overline{c} + z\gamma^f/2\right) a_{it}\left(1-\sigma\right) - \gamma^m\left(1 - a_{it}\left(1-\sigma\right)/2\right) z \tag{8a}$$

$$e_{it}^{f*} = \left(y_{it} - \overline{c} + z\gamma^m/2\right) a_{it}\sigma - \gamma^f\left[\left(1 - a_{it}\sigma/2\right)\right] z \tag{8b}$$

$$l_{it}^{j*}/e_{it}^{j*} = \eta/\left(\omega_t \upsilon\right) \tag{8c}$$

Eq. (8) shows that parental investment in children's education depends on their income, some basic needs ($\overline{c}$), their sex preference (σ), education technologies (υ and η), TFP and productivity parameters (A and α), and their psychic cost, γ. Given that $\beta^f > \beta^m$ that women attach relatively more weight to the welfare of their children, the higher their bargaining power in the household decision-making process (higher ψ_{it}) the higher becomes parental investment in children's human capital (Proposition 1). Eq. (8c) captures the trade off between parental time spending and material investment in child education. The ratio l_{it}^j/e_{it}^j decreases in the farm wage rate ω_t and depends on schooling technologies, υ and η. If wages are higher, parents may prefer to allocate more time to work and compensate their children with more of material investment. According to (8a) and (8b), individuals with income below the subsistence level $\overline{c}$ will not invest in the human capital of their children. Furthermore, since the last terms in (8a) and (8b) are positive, the presence of psychic costs creates additional pressure on parental investment in children's human capital.

Effective investments in children's education are given by, with respect to parental goods and time spending, respectively

$$e_{it}^j = \max\left(0, e_{it}^{j*}\right) \tag{9a}$$

$$l_{it}^j = \max\left(0, l_{it}^{j*}\right) \tag{9b}$$

There are thus three types of couples in the economy. The first are those couples whose consumption decision entail consuming the full amount of their income, and do not invest in their children's human capital due to their failure to meet the minimum consumption requirement ($\overline{c} > 0$) and overcome their psychic cost ($\gamma > 0$). The second are those who invest in only one of their children due to the presence of parental gender bias, $\gamma^j \neq \gamma^{-j}$. The third are those couples who invest in the human capital of both of their children.

Eq. (8) shows that individuals benefit from their opposite sex misfortunes (higher γ^{-j}). Not only the non-pecuniary cost related to the ones gender but also the psychic cost associated to the opposite sex is important to a person's human capital accumulation. When parents are biased towards a particular gender of their child they tend to compensate that by investing more in the opposite sex. However, total saving (in a household), e_{it}^*, is lower than the case where there is no

psychic cost, $\gamma = 0$. This is easily seen by adding (8a) and (8b):

$$e_{it}^{*} = (y_{it} - \overline{c})\, a_{it} - \left(\gamma^{m} + \gamma^{f}\right)(1 - a/2) \tag{10}$$

Total saving (e_{it}^{*}) in the case $\gamma_i^{j} = 0$ and $\gamma_i^{-j} \neq 0$ is smaller than total saving in the case where $\gamma^{j} = \gamma^{-j} = 0$. Combining $l_{it} \equiv \left(l_{it}^{m} + l_{it}^{f}\right)/2$ and (8) gives total time spending in children education for the ith household,

$$l_{it}^{*} = \left[y_{it}a_{it} - 2\overline{c}a_{it} - (1 - a_{it}/2)\, z\left(\gamma^{m} + \gamma^{f}\right)\right] \eta / \left(2\omega_t \upsilon\right) \tag{11}$$

which is also lower than the case where there is no psychic cost, $\gamma^{j} = \gamma^{-j} = 0$. Therefore, parental gender bias can be a basis for inefficiency in the economy, which lead to the following proposition:

Proposition 1 *(i) The greater γ^{-j} or the lesser γ^{j}, the higher e_{it}^{j} becomes. (ii) An increase in women's bargaining power increases couples' investment in children's education. (iii) Parental gender bias ($\gamma^{j} \neq 0$) reduces the total household investment in education.*

From Proposition 1, it appears that individuals benefit from their opposite sex sibling misfortunes (higher γ^{-j}). Not only the non-pecuniary cost related to one's gender but also to the opposite sex is important to the person's human capital accumulation. When parents are biased against a particular gender, then they tend to compensate by investing more in the opposite sex. However, households' savings are lower than the case where there is no psychic cost at all, $\gamma = 0$. Therefore, parental gender bias could be a basis for aggregate inefficiency.

Using, (7) and (11), we can rewrite (6) as follows:

$$y_{it}^{*} = \begin{cases} \xi_{it} + x_{it}\alpha\left(h_{it}^{f} + h_{it}^{m}\right) \text{ if } i = 1 \\ \xi_{it} + \alpha x_{it} h_{it}^{f} \text{ if } i = 2 \\ \xi_{it} + \alpha x_{it} h_{it}^{m} \text{ if } i = 3 \\ \xi_{it} \text{ if } i = 4 \end{cases} \tag{12}$$

where

$$\begin{aligned} \xi_{it} &\equiv x\omega_t + 2\overline{c}\eta\frac{\psi_{it}}{2 + \psi_{it}} + \frac{\eta/\upsilon}{2 + \psi_{it}} z_t \left(\gamma^{m} + \gamma^{f}\right) \\ x_{it} &\equiv \frac{2 + \upsilon\psi_{it}}{2 + \psi_{it}} \end{aligned}$$

(12) are couples' pooled incomes that consider optimal allocation of time spending in child rearing and work, given that couples choose to invest in their children's education. Apparently, factors that are important to l_{it}^{j*} are also important to y_{it}^{*}.

2.5 Optimal Human Capital

From Eqs. (4) and (8), we derive the jth offspring optimal human capital accumulation function, which also determines its mobility:

$$h_{it+1}^{*j} = \begin{cases} \left(y_{it}^{*} - \overline{c} + z\gamma_i^f/2\right) a_{it}\left(1-\sigma\right) z^{-1} - \gamma_i^m\left(1 - a_{it}\left(1-\sigma\right)/2\right) \text{ if } j = m \\ \left(y_{it}^{*} - \overline{c} + z\gamma_i^m/2\right) \sigma a z^{-1} - \gamma_i^f\left(1 - a_{it}\sigma/2\right) \text{ if } j = f \end{cases} \tag{13}$$

where y_{it}^{*} is defined in eq. (12).

It is straightforward to see that Proposition 1 and the preceding discussion also apply to individual optimal human capital. It follows that from (9) and (13), an individual's human capital who is born at time t is given by

$$h_{it+1}^{j} = \max\left(0, h_{it+1}^{j*}\right) \tag{14}$$

Couples' optimal decisions thus have a corner solution where some do not invest in the human capital of their children. Individuals with $h_{it+1}^{j} = 0$ are destined to work in farm at $t+1$ and earn the farm wage rate ω_{t+1} per unit of their labor supply. However, individuals with $h_{it+1}^{j} = h_{it+1}^{j*} \neq 0$ will work in the non-farm sectors and earn the premium wage rate.

2.6 Intergenerational Linkage

Note that given that there are four groups of households at time t, at time $t+1$ there could be a maximum of eight groups of heterogenous individuals, categorized based on their gender and family background, who will work in the non-farm sectors. These are four female and four male offsprings. One group of females and males are from farmer parents while the other are from non-farmer parents. There is one more group of male and female offsprings with farmer fathers but non-farmer mothers; and another one, with farmer mothers but non-farmer fathers.

Formally, this is shown by combining (12) and (13), which gives the optimal human capital, for each group, associated to female,

$$h_{it+1}^{f} = \begin{cases} \chi_{it}^{f}\sigma z^{-1} - q_{it}\gamma^f + \sigma\vartheta_{it}\left(h_{it}^{m} + h_{it}^{f}\right) \text{ if } i = 1 \\ \chi_{it}^{f}\sigma z^{-1} - q_{it}\gamma^f + \sigma\vartheta_{it}h_{it}^{f} \text{ if } i = 2 \\ \chi_{it}^{f}\sigma z^{-1} - q_{it}\gamma^f + \sigma\vartheta_{it}h_{it}^{m} \text{ if } i = 3 \\ \chi_{it}^{f}\sigma z^{-1} - q_{it}\gamma^f \text{ if } i = 4 \end{cases} \tag{15}$$

and male offsprings,

$$h_{it+1}^{m} = \begin{cases} \chi_{it}^{m}(1-\sigma) - p_{it}\gamma^{m} + (1-\sigma)\vartheta_{it}\left(h_{it}^{m} + h_{it}^{f}\right) \text{ if } i = 1 \\ \chi_{it}^{m}(1-\sigma) - p_{it}\gamma^{m} + (1-\sigma)\vartheta_{it}h_{it}^{f} \text{ if } i = 2 \\ \chi_{it}^{m}(1-\sigma) - p_{it}\gamma^{m} + (1-\sigma)\vartheta_{it}h_{it}^{m} \text{ if } i = 3 \\ \chi_{it}^{m}(1-\sigma) - p_{it}\gamma^{m} \text{ if } i = 4 \end{cases} \tag{16}$$

where

$$\begin{aligned} \chi_{it}^{j} &\equiv \left(\omega_t - 2\overline{c} + z_t\gamma^{-j}\frac{1}{2\upsilon}\right) z_t^{-1}\frac{2\upsilon\psi_{it}}{2+\psi_{it}} \\ p_{it} &\equiv 1 - (1-\sigma)\frac{\psi_{it}}{2+\psi_{it}} \\ q_{it} &\equiv 1 - \sigma\frac{\psi_{it}}{2+\psi_{it}} \\ \vartheta_{it} &= \alpha a_{it} x z_t^{-1} = z_t^{-1}\alpha\frac{2\upsilon\psi_{it}}{2+\psi_{it}} \end{aligned}$$

Eqs. (15) and (16) capture the intergenerational linkages between the occupations (and human capital) of children and their parents, for daughters and sons, respectively.[16] In the first lines, offsprings who are working in the modern sector are linked with parents who worked in the same sector. In the second (third) lines, only the mothers (fathers) worked in the modern sector while the fathers (mothers) worked in the agriculture sector. The last lines show the upward mobility of sons and daughters of farmer parents.

The difference between the human capital of daughters and sons, in (15) and (16), respectively, arise due to differences in gender preferences ($\sigma \neq \frac{1}{2}$) and gender bias, $\gamma^{m} \neq \gamma^{f}$.[17] Differences between individuals of the same gender comes from heterogeneity in family occupational background.

2.7 Mobility Threshold

Let's define

$$h_{it+1}^{j} \geq 0 \equiv \Omega_i^{j} \text{ and } h_{it+1}^{j} = 0 \equiv \overline{\Omega}_i^{j} \tag{17}$$

Then an individual works in the non-farm sectors iff $\Omega_i^{j} > \overline{\Omega}_i^{j}$. The individual works in farm, however, iff $\Omega_i^{j} = \overline{\Omega}_i^{j}$. The implicit function $\overline{\Omega}_i^{j}$ thus defines critical points at which parents do not

[16] We dropped the stars (*) for simplicity.

[17] An important distinction between the two types of parental gender bias ($\gamma^{m} \neq \gamma^{f}$ and $\sigma \neq \frac{1}{2}$) is made based on their short- and long-run impacts, respectively. For instance, $\gamma^{m} < \gamma^{f}$ implies the marginal benefit of investing in sons is higher than that of daughters in the short run. In this case, when resources are meager, parents may prefer to allocate little resources to their daughters. However, such bias may decline, and eventually disappear, at the later stage of the development process. Particularly, for similar parental preferences towards sons and daughters, $\sigma = \frac{1}{2}$:

$$\lim_{h_{it+1}^{m}\to\infty} u'_{h_{it+1}} = \lim_{h_{it+1}^{f}\to\infty} u'_{h_{it+1}} = 0$$

invest in their children human capital.[18] The higher Ω_i^j becomes the more likely the individual becomes mobile. The mobility of two individuals can thus be compared and contrasted using the associated Ω_i^j. For instance, if $\Omega_2^m > \Omega_3^f$, then sons whose mothers work in the non-farm sectors are more likely to show (upward) mobility than daughters whose fathers work in the same sectors.

Considering (15) and (16), $\overline{\Omega}_i^j$ are given for females and males, respectively, as follows:

$$\overline{\Omega}_i^f = \begin{cases} \omega + \alpha\left(h_i^f + h_i^m\right) - \left(\frac{z}{2v}\varrho_i^f + 2\overline{c}\right) & \text{if } i = 1 \\ \omega + \alpha h_i^f - \left(\frac{z}{2v}\varrho_i^f + 2\overline{c}\right) & \text{if } i = 2 \\ \omega + \alpha h_i^m - \left(\frac{z}{2v}\varrho_i^f + 2\overline{c}\right) & \text{if } i = 3 \\ \omega - \left(\frac{z}{2v}\varrho_i^f + 2\overline{c}\right) & \text{if } i = 4 \end{cases} \tag{18}$$

and

$$\overline{\Omega}_i^m = \begin{cases} \omega + \alpha\left(h_{it}^f + h_{it}^m\right) - \left(\frac{z}{2v}\varrho_i^m + 2\overline{c}\right) & \text{if } i = 1 \\ \omega + \alpha h_i^f - \left(\frac{z}{2v}\varrho_i^m + 2\overline{c}\right) & \text{if } i = 2 \\ \omega + \alpha h_i^m - \left(\frac{z}{2v}\varrho_i^m + 2\overline{c}\right) & \text{if } i = 3 \\ \omega - \left(\frac{z}{2v}\varrho_i^m + 2\overline{c}\right) & \text{if } i = 4 \end{cases} \tag{19}$$

where[19]

$$\begin{aligned} \varrho_i^f &\equiv \gamma^f\left(\frac{1}{\sigma}\frac{2+\psi_i}{\psi_i} - 1\right) - \gamma^m \\ \varrho_i^m &\equiv \gamma^m\left(\frac{1}{1-\sigma}\frac{2+\psi_i}{\psi_i} - 1\right) - \gamma^f \end{aligned}$$

The first and fourth lines in (18) and (19) define critical points for individuals whose both parents work in nonfarm and farm, respectively. The second (third) lines are related to mobility threshold for individuals only whose mothers (fathers) work in nonfarm.

According to (18) and (19), mobility threshold is the difference between the pooled income of a family and its basic needs plus the non-pecuniary costs. Once families are able to meet their basic needs, their children's mobility is determined by the parents attitude towards different gendered children. Therefore, the presence of mobility threshold largely depends on the presence of parental psychic cost. Given that $\overline{c} > 0$ and $\varrho_i^j > 0$, there will be some parents that fall short of investing in their children education, condemning them to work in the low-paying farm work.[20]

ϱ_i^j captures *effective* parental gender bias. The higher it is, the less mobile the particular child becomes. It is the psychic cost related to the jth person weighted by relative bargaining power of the couples and parental sex preference, net of the psychic cost associated to the opposite sex. For instance, the higher ϱ_i^f becomes the more parents are biased towards their sons (the lower γ^m),

[18] We drop the time subscripts as all variables are in contemporary terms.

[19] Time subscripts are dropped as all variables are in contemporaneous terms.

[20] On the contrary, if $\overline{c} = \varrho_i^j = 0$, then *all* parents invest in their children human capital, regardless of their initial endowment or family occupation composition, leading to a complete IG mobility.

making their daughters less mobile. However, the more an individual is favored by his/her parents (as reflected on σ) or the higher the bargaining power of the women (the higher ψ_i), the lesser ϱ_i^j becomes. This is quite intuitive given that women are assumed to put relatively more weight in the welfare of their children, showing more willingness to allocate household resources to their children's education.

The IG mobility are thus a function of many aggregate and individual factors. It depends, for instance, on aggregate productivity parameters (A, α and h); it also depends on a parent's education level or occupation type (whether $h_i^j \neq 0$ or not), relative bargaining power of couples (as captured in ψ_i), the psychic cost specific to ones child gender (γ^j), parental sex preference (σ), the level of subsistence consumption ($\overline{c}$) and education technologies (η and υ):

$$\Omega_i^j = \digamma\left(A, \overline{c}, \alpha, \eta, \upsilon, \sigma, h, \psi_i, h_i^j, h_i^{-j}, \gamma^j, \gamma^{-j}\right) \tag{20}$$

2.8 Intergenerational Occupational Mobility

An individual who is born at time t works in the nonfarm iff $h_{it+1}^j > 0$ and in farm iff $h_{it+1}^j = 0 \equiv \overline{\Omega}_i^j$. The implicit functions $\overline{\Omega}_i^j$ define the thresholds at which parents do not invest in children's education. While they determine the offsprings' mobility, their relevance largely depends on the presence of parental psychic cost, $\gamma^j > 0$.[21]

Proposition 2 *Women's bargaining power is positively associated to IG mobility.*

When comparing the mobility of males and females, and between individuals with different family backgrounds, we consider two cases: i) when parents show no particular sex preference and gender bias, and ii) when parents are gender-biased and favor boys. In the first case, $\gamma^m = \gamma^f$ and $\sigma = 1/2$, there would be no intrinsic differences between the human capital of men and women, i.e. $h^f = h^m$.

Proposition 3 *(i) Children whose parents work in non-farm sectors are more likely to work in nonfarm than those whose two parents work in farm or than those whose fathers work in nonfarm. (ii) Children whose mothers work in non-farm sectors are more likely to work in nonfarm than those whose fathers work in nonfarm or than those whose two parents work in farm.*

However, the relations between children from group 1 and 2 households, and between children from group 3 and 4 households are ambiguous. For instance, the bargaining power of the mothers for households in group 2 is higher than that of the mothers in group 1 households ($\psi_2 > \psi_1$), implying a higher IG mobility in the former. But, the fact that both parents of households in group 1 work in the modern sector makes mobility relatively more likely in this group of households. The same analysis applies when comparing individuals in group 3 and 4 households. Although the bargaining

[21] For example, if $\gamma^j = 0$, then mobility is inevitable ($h_{it+1}^j > 0$), as long as the household minimum consumption is satisfied.

power of the mothers is relatively higher in the group 4 households, this would be compromised by the fact that both parents in this group work in the farm.

In the second case where $\gamma^m < \gamma^f$ and $\sigma < 1/2$, boys are favored while parents invest more than proportional in their sons' education. Thus, not only there are mobility differences among individuals with different family backgrounds but also within families themselves (between opposite sex siblings):

Proposition 4 *(i) Between siblings, sons are relatively more mobile than their sisters. (ii) Sons (daughters) whose mothers work in non-farm sectors are more likely to work in nonfarm than sons (daughters) whose two parents work in farm. (iii) Sons (daughters) whose two parents work in non-farm sectors are more likely to work in nonfarm than sons (daughters) whose fathers work in nonfarm.*

With respect to the relative mobility between the opposite sex, it follows from Proposition 4: (i) Sons whose mothers work in nonfarm are more likely to work in nonfarm than daughters whose both parents work in farm. (ii) Sons whose both parents work in nonfarm are more likely to work in nonfarm than daughters whose fathers work in nonfarm.

The relative mobility of sons (daughters) between group 1 and 2, between group 2 and 3 and between group 1 and 4 households are ambiguous. Although the intra-household bargaining power of the mothers is relatively larger in group 2 households than group 1 and 3 households, the human capital of group 2 of households is relatively smaller compared to the human capital of the households in group 1 and group 3. Similarly, mobility in group 1 households (where both parents work in the non-farm sectors) is not necessarily higher than mobility in group 4 households (where both parents work in farm). Because, even though there is relatively larger human capital in group 1 households, the bargaining power of the mothers is relatively better in group 4 households.

In summary, IG mobility depends on couples' preferences and biases towards certain sex of their children, their relative bargaining powers and their occupational backgrounds.

3 Data and variables

We use the Nigerian General Household Survey (NGHS) data, a two waves (2011 and 2013) panel of 5,000 households with about 14,000 individuals in each wave.[22] NGHS is a nationwide survey that collects detailed information on demographic characteristics, education, health, employment, time use and migration of household head and household members. It is one of the very few national representative panel survey available in developing countries that collects information on adult's parental background.[23]

[22]The data is collected by the National Bureau of Statistics of Nigeria in collaboration with the Bill and Melinda Gates Foundation and the World Bank.

[23]More statistical addendum of NGHS is available on Living Standards Measurement Study (LSMS) website of the World Bank. See http://go.worldbank.org/IFS9WG7EO0.

3.1 Sample

We consider individuals between the ages of 15 and 65 years who have been active in the labor market in the last 12 months at the time of data collection. We use both *restricted* (sub-sample of adult children who live with their parents) and *un-restricted* samples, each one having its own advantages and disadvantages.[24] The un-restricted sample includes all adult individuals for whom we observe the parents' education and occupation status regardless of whether they are alive or reside in the same household while the restricted sample includes only young adults who still live with their parents. There are two major concerns in using the restricted sample.[25] First, co-residence may lead to a sample selection problem that biases the intergenerational persistence coefficient downward. For instance, Francesconi & Nicoletti (2006) and Azam & Bhatt (2012) document a substantial bias in intergenerational educational persistence coefficient when constructing father-son pairs in the UK and India, respectively. Second, coresidence over represents younger adults who are still living with their parents, which in turn restricts the analysis to unrepresentative young population (Hnatkovska et al. 2013; Jalan & Murgai 2007). While the un-restricted sample tackles these issues, the restricted sample provides the opportunity to assess the effect of life course variation of parental characteristics on intergenerational occupational mobility. In our case, using the restricted sample enables us to compare the contribution of maternal and paternal occupation observed at different ages to children's occupational choice.

3.2 Descriptive statistics

Our response variable is the occupation sector of children. Economic sectors has been defined under three categories: primary (agriculture, forestry, fishing), secondary (manufacturing, construction) and tertiary (service).[26] Our main control variables include parental background information of parents (education and occupation) and women bargaining power. NGHS collects parental background information (education and occupation) of all household members, regardless of whether the parent is alive or, resides in the same household. In both waves, we observe the main industry of occupation and the highest level of education for both generations. For children, it is their most recent job; for parents, it is the industry of occupation they got engaged into throughout most of their life. Our women bargaining power variables are based on individual human capital endowments. The literature has used various bargaining power measures such as relative education, employment type, asset ownership depending on data availability (see Doss (2013) for a survey of the literature). However, it is generally found that education better explains distribution of bargaining power in a household decision making, especially for women (Lührmann & Maurer 2008; Friedberg & Webb 2006). Accordingly, for the un-restricted sample, we use a dummy indicator for women empowerment – whether or not the mother's educational attainment is higher than

[24] See Table 6 in the appendix for summary statistics of the restricted sample

[25] Most of existing intergenerational studies in developing countries rely solely on cohabitation in identifying parent-child pairs.

[26] In the theoretical framework, secondary and service sectors are identified as a modern sector.

that of the father. Women are expected to have more bargaining power when they attain more education than their partners. With the objective of assessing *intensity of women empowerment* in the restricted sample, we interact education with age differences between the couples. Women are expected to be more empowered when they are younger and have higher educational attainment than their husbands.

Table 1 gives the summary statistics of the unrestricted sample.[27] NGHS covers a panel sample of 5,000 households and 14,000 individuals in each wave that spread over six zones in rural and urban areas. The majority of children (about 50%) engaged in agriculture and about 47% of the are male and have 6 years of schooling on average. Nigerian households on average are large, with slightly more than seven members in a household. The families are multi-generational and they are extended both horizontally and vertically; about 6% of household members in the unrestricted sample are neither the household head nor a spouse or a child. Polygamous unions are also common. About 16% of married individuals are engaged in this type of relationship. On average, children have more years of schooling (7 years) than their fathers (3 years) and their mother (2 years)regardless of whether parents are alive or, if alive, reside in the same household. About 21% of mothers have more years of schooling than fathers. About 70% and 47% of fathers and mothers are mainly engaged in the primary sector, respectively. More mothers (about 38%) are engaged in the service sector than fathers (about 24%).

Table 1 – Descriptive statistics for the unrestricted sample

Group(Variable)	Mean	Std. Dev.[c]	Min.[a]	Max.[b]
Dependent: Children's sector				
1=primary (base), 2=Secondary, 3=Tertiary				
Controls:				
Consumption (10,000)	70.395	95.930	1.516	6,789.529
Age	33.300	14.064	15	65
Household size	7.297	3.484	1	31
Years of schooling	6.589	5.385	0	18
Father schooling	3.20	4.936	0	18
Mother schooling	2.196	4.036	0	18
Mother more schooling	0.206			
Sex	0.527			
Father primary sector	0.696			
Father secondary sector	0.066			
Father tertiary sector	0.238			
Mother primary sector	0.473			

Continued on next page...

[27] see Table 10 in the appendix for the definition of variables.

Table 1 – continued

Group(Variable)	Mean	Std. Dev.[c]	Min.[a]	Max.[b]
Mother secondary sector	0.147			
Mother tertiary sector	0.380			
Married	0.558			
North-Central Zone	0.169			
North-East Zone	0.186			
North-West Zone	0.197			
South-East Zone	0.147			
South-South Zone	0.163			
South-West Zone	0.138			
Year 2011	0.504			
Year 2013	0.496			

Note. Number of observations: 28,402 over all waves.

[a,b] Min. and Max. are not reported for binary variables as per 0 and 1, respectively.

[c] Standard Deviation for binary variables can be retrieved using $\sqrt{p(1-p)}$, where p is the probability of event.

3.3 Sectoral shift and occupation mobility

Most, but not all, of the African economies witness a sharp increase in the share of service sector in their economies and entry to non-farm employment is often an avenue to escape from extreme poverty (IFAD 2011; Bank 2005; Lanjouw & Lanjouw 2001).[28] In Nigeria, farm jobs as a share of total jobs has also declined recently, suggesting a major structural shift within the economy. Figure 1 plots the proportion of individuals working in each sector across 10 years birth cohorts for both genders. Despite nearly 20 years of growth in Nigeria, agriculture still represents a large share of employment. But still, there has been a significant shift of labor force participation from agriculture to the manufacturing and service sectors.

In the youngest cohort, there is an increase in the proportion of individuals who are engaged in the agriculture sector. This doesn't not necessarily correspond to the slowdown of structural change;[29] rather, it corresponds to the age of individuals in the last cohort. Individuals in this cohort are still young (aged between 15 and 27) at the time of the survey; and, entry to non-agriculture sector mostly happens in the later life cycle due to queuing effects (unemployment) in the labor market (Bossuroy & Cogneau 2013). Comparing the first (the oldest) and the fourth (the second youngest) cohorts, the rate of structural change (a decline in the share of primary sector jobs) is about 26%. The declining rate varies across gender: comparing the youngest and the oldest

[28] Throughout the developing economies, incomes in the non-farm sector have raised rapidly and it accounts for a larger share of household income than agricultural incomes. For instance, in Africa income from non-farm employment accounts 34% in the 1990s and 2000s (Haggblade et al. 2010).

[29] Structural change is loosely defined as a decline in the share of primary sector jobs.

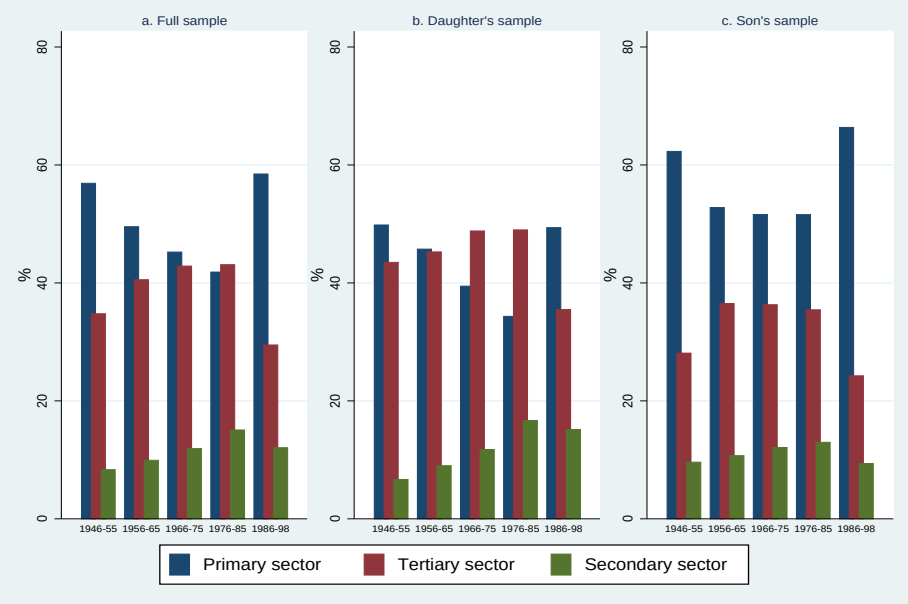

Figure 1 – Proportion of jobs across 10 years birth cohort

cohort, we document about 31% and 17% decline in the proportion of female and male workers in the agriculture sector, respectively (see panel B and C of figure 1).

Given that sectoral shift (structural change) is one of the determinants of IG mobility, it is important to account for its contribution. If there are more jobs created in the non-agricultural sector than it used to be, the number of individuals working in the modern sectors (secondary and tertiary) whose parents worked or are still working in agriculture sector raises. Following Bossuroy & Cogneau (2013), we call this gross mobility across generations. Table 2 presents the probability of children participation in the service sector conditional on parents sector, for son and daughters. Participation in the tertiary sector is persistent across generations. We find that more than half of daughters in the tertiary sector had a mother working in the same sector, while less than 25% of individual in the service sector declare that either their mother or father were in the agriculture sector. Overall, the probability of being employed in the service and manufacturing sector is much higher for children if their parents were employed in the same sector. There is a relatively higher intergenerational persistence between mothers' and daughters' employment status in the tertiary sector. Sons that have a farmer mothers are relatively more mobile; they have a higher chance (about 22%) of joining the service sector than daughters whose mother was a farmer (about 12%).

By comparing gross and net mobility, we identify the effects of structural change on IG mobility. Gross mobility captures the likelihood of children to have a different occupation than that of their parents. Net mobility is gross mobility minus the minimum movement across sectors due to structural change. We call *minimum movement* the situation where children whose parents are engaged in modern sectors remain in the same sector. Gross mobility for daughters and sons are 54% and 65% while net mobility are 29% and 39%, respectively. Table 2 suggest that more than half of IG mobility is left unexplained by structural change in Nigeria and there is a significant

Table 2 – Children's service sector participation conditional on parents' sector

	Mother		Father	
	Daughters	Sons	Daughters	Sons
Primary sector	0.12	0.22	0.09	0.09
Secondary sector	0.40	0.49	0.18	0.27
Tertiary sector	0.57	0.53	0.33	0.42
	Gross mobility	Minimum share of movers	Net mobility	# Obs.
Daughters	0.54	0.26	0.28	14,976
Sons	0.65	0.26	0.29	13,427

Note: The table reads as follows. 12% of daughters whose mothers were engaged in primary sector are engaged in the service sector, against 57% of children whose mother is in the service sector. 54% of daughters have a different sector than their parent's. If all modern sector daughters would have stayed in the same sector (no downward mobility to primary sector for individuals whose parents are engaged in secondary or tertiary sectors) and only farmers daughters transit to other secondary or tertiary sectors due to economic structural change in a daughter's generation, the movement rate would be 26%, pointing out 28% sector mobility unexplained by structural change.

difference on intergenerational occupation mobility between men and women. One of our hypothesis is that women's bargaining power, partly, explains the net IG mobility. In the next section, this is further investigated using an econometric model that overcomes the challenges that arise due to unobservable heterogeneity.

3.4 Estimation Strategy

Given that the measure of sectoral mobility is ordinal, panel multinomial logit model with unobserved heterogeneity suits our purpose. Let $\mathscr{S}_{it} = s$ denotes the sector in which individual i $(i = 1, \ldots, N)$ is at time t $(t = 1, \ldots, T_i)$. The probability of making choice s in period t conditional on observed characteristics $\mathbf{x}_{it}$ and unobserved heterogeneity η_i has the structure

$$\mathbb{P}(\mathscr{S}_{it} = s|\mathbf{x}_{it}, \eta_i) = \frac{\exp\left(\mathbf{x}_{it}\boldsymbol{\beta}_s + \eta_{is}\right)}{\sum_{l=1}^{S}\exp\left(\mathbf{x}_{it}\boldsymbol{\beta}_{sl} + \eta_{il}\right)} \tag{21}$$

For identification, we impose the usual restriction by normalizing $\boldsymbol{\beta}_1 = 0$ and $\eta_1 = 0$ meaning that the primary sector is our base outcome. We assume that the unobserved heterogeneity varies between the two other sectors $(\eta_{i2} \neq \eta_{i3})$ and we allow for correlation between them. Then, their distribution follows a bivariate standard normal distribution with mean $\bar{\boldsymbol{\eta}} = [0, 0]'$ and covariance matrix $\boldsymbol{\Sigma}$ with variances $\sigma^2_{\eta_{i2}}$ and $\sigma^2_{\eta_{i3}}$, and covariance $\sigma_{\eta_{i2}\eta_{i2}}$. Let define $\kappa_{ist} = 1$ if individual i is in sector s at time t and zero otherwise. The likelihood function associated with Eq.(21) is

$$\mathscr{L} = \prod_{i=1}^{N}\left(\int_{-\infty}^{+\infty}\prod_{t=1}^{T_i}\prod_{s=1}^{S}\left[\mathscr{S}_{it} = s|\mathbf{x}_{it}, \eta_i)\right]^{\kappa_{ist}}\varphi(\eta_i)\,\mathrm{d}(\eta_i)\right), \quad s = 1, 2, 3 \tag{22}$$

where $\varphi(\eta)$ denotes the distribution of η. We maximize Eq.(22) using simulated maximum likelihood.

To maximize the associated likelihood function, we must integrate over the distribution $\varphi(\eta)$. We use the simulated maximum likelihood method, which is given by:

$$\mathscr{L}_{\text{sim}} = \prod_{i=1}^{N} \frac{1}{R} \sum_{r=1}^{R} \prod_{t=2}^{T_i} \prod_{s=1}^{S} \left(\frac{\exp(\mathbf{x}_{it}\boldsymbol{\beta}_s + \eta_s^r)}{\sum_{l=1}^{S} \exp(\mathbf{x}_{it}\boldsymbol{\beta}_{sl} + \eta_l^r)} \right)^{\kappa_{ist}} \tag{23}$$

where R is the number of draws values from the distribution of the unobserved heterogeneity distribution.[30]

The coefficients reported are the average marginal effects of the explanatory variables on the log odds ratios $[\mathbb{P}_{is}(t)/\mathbb{P}_{i1}(t)]$ for $s = 1, 2, 3$. For continuous control variables $\mathbf{x}^k$, the marginal effect computed as:

$$\tilde{\beta}_s = \frac{\partial \mathbb{P}_s}{\partial x_s^k} = \mathbb{P}_s \left(\beta_s^k - \sum_{l=1}^{S} \beta_l^k \mathbb{P}_l \right) \tag{24}$$

Parameters (24) are affected by unobserved heterogeneity. In the case of discrete variables, Eq. (24) does not apply and the marginal effects are computed as the difference in the predicted probabilities evaluated at alternative values of discrete variables. In the sequel, the marginal effects are computed at means and at zero unobserved heterogeneity. The later choice is consistent with our specification, as expected value of the random heterogeneity effect is null.

In all estimations, we include a number of main and other control variables including parental years of schooling, age, household consumption, household size, sex, marital status, regional and time dummies. Parents' years of schooling is used as a proxy for their human capital. Children education and age are proxies to their human capital, representing the level of their education and work experience, respectively. Household consumption, marital status, and household size are used to control taste, preference and income related heterogeneity between children.

The coefficients for intergenerational persistence may become spurious if parents and children have different labor market opportunities in their respective generation and geographical locations. For instance, the coefficient for IG mobility can be overestimated if there are more jobs available in the modern sector now than it used to be. Similarly, if both parents and children live in an area with limited job opportunities in the manufacturing and service sectors, then occupational persistence in the primary sector may be an artifact of not adequately controlling for heterogeneity in the availability of non-farm jobs. To account for unobserved location and generation specific heterogeneity, we control for region and time dummies. These may also capture peer effects, agglomeration forces and cohort effects.

[30] The simulation is based on Halton sequences draws. For each draw, the likelihood is evaluated and averaged over the R draws. We use 50 draws.

4 Empirical Results

With a clear indication of positive intergenerational persistence on the sector of economic activity between parents' and children's that run along gender lines (father-son and mother-daughter) in Table 2, we turn to a more formal econometric analysis. Table 3 summarize the marginal effects from panel multinomial logit model with unobserved heterogeneity for children sector of economic activity using unrestricted sample. Specification tests (likelihood ratio and significance of $\sigma^2_{\eta_i}$) show that the model with unobserved heterogeneity is preferred. Thus, in what follows we interpret the results of the model that accounts individual heterogeneity for brevity.[31] The marginal effect of sex is positive and strongly significant, implying a strong gender effect on IG mobility. This supports our theoretical framework and further provides a rationale to split the data into sub-samples of sons and daughters.

4.1 Intergenerational Occupational Persistence

Do children of farmers have a chance to join the modern sector? Is the chance similar to sons and daughters? Is there a link with mothers characteristics most importantly their education and occupation? Table 3 presents our results to these questions in column 2 and 3 for daughters and sons, respectively; recall that our model control for unobservable heterogeneity and the results reported here are not driven by the unobserved genetic correlations between parents and children. The overall result show that parental characteristics matter, though in some unexpected way. Having a father in primary sector have a significant negative effect to join tertiary sector to sons but not daughters. On the other hand, having a mother who was a farmer make it less likely one will be engaged in tertiary sector, for men and women. Overall, children whose parents work in the primary sector are less likely to work in the modern sector (in secondary and tertiary sector). This is so for both sons and daughters, but the effect is larger for women than men. This finding is inline with the results of Lambert et al. (2014) in Senegal and Emran & Shilpi (2011) in Nepal. There is also a strong and positive IG sector persistence in tertiary sector. Children whose mothers have worked in the tertiary sector are more likely to work in the same sector. The marginal effect is slightly larger for daughters, which is 0.08 compared to 0.07 for sons. The marginal effects of fathers' participation in the service sector on children's choice economic sector are 0.09 and 0.20 for daughters and sons, respectively. Having had either parents (and more so father) in the service sector make it less likely that one will be in secondary sector, with a far more pronounced effect for sons.

Parental education effects on the probability of being engaged in the modern sector is weak, thought for sons there is a strong positive effect of father years of schooling for sons in service sector. We find that having more household resource (proxied by consumption) makes joining the modern sector likely but the effect is pronounced in service sector for daughters. Having larger

[31] Results of the model without unobserved heterogeneity using unrestricted sample are available in the appendix, Table 7.

household size reduce the probability of joining the service sector and the effect is stronger again for women. Own education plays an important role to join the service sector for both men and women. Geographic location of residence effects on the probability of joining the tertiary sector is strong, for women there is a significant negative effect of residing in states in which agriculture dominates. For instance, daughters in the north-eastern part, a region mostly known for the production of crops and livestock, have much lesser chance to join the tertiary sector than their sons counterparts. On the other hand, sons living in the South-South Zone where the main economic activity involves production of oil have much higher chance to join the service sector.

Table 3 – Estimation results (average marginal effects) for the model with unobserved heterogeneity

	Full sample		Daughters		Sons	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Sector: Secondary						
Consumption (in log)	0.008**	0.003	-0.010	0.006	0.010**	0.005
Age	0.0003	0.001	0.001	0.002	2.81e-06	0.001
Age squared	-0.00001	0.000	-0.00003	0.00002	-2.95e-06	0.00002
Household size	-0.003***	0.001	0.0009	0.001	-0.005***	0.001
Years of schooling	-0.0009*	0.000	-0.003***	0.001	0.0001	0.0006
Father schooling	-0.0005	0.0007	0.0005	0.001	-0.001	0.0008
Mother schooling	0.001*	0.0008	0.003	0.001	0.0003	0.001
Mother more schooling	0.014**	0.006	0.010**	0.010	0.018***	0.008
Sex	0.013**	0.005	—	—	—	—
Father in primary sector	-0.217***	0.021	-0.142***	0.022	-0.253***	0.030
Father in tertiary sector	-0.104***	0.008	-0.111***	0.013	-0.126***	0.013
Mother in primary sector	-0.107***	0.010	-0.220***	0.016	-0.022**	0.011
Mother in tertiary sector	-0.050***	0.008	-0.105***	0.013	0.001	0.011
Married	0.027***	0.006	-0.008	0.011	0.007	0.009
North-Central Zone	-0.024***	0.007	-0.086***	0.010	0.048***	0.017
North-East Zone	0.013	0.009	0.012	0.013	0.022	0.015
South-East Zone	-0.008	0.009	-0.091***	0.011	0.088***	0.024
South-South Zone	0.005	0.009	-0.104***	0.010	0.128***	0.027
South-West Zone	-0.011	0.009	-0.105***	0.010	0.089***	0.024
Year 2013	-0.016***	0.004	-0.009	0.007	-0.016***	0.005
Sector: Tertiary						
Consumption (in log)	0.102***	0.007	0.102***	0.009	0.075***	0.008
Age	0.018***	0.002	0.015***	0.003	0.019***	0.002
Age squared	-0.0002***	0.00002	-0.0001***	0.00004	-0.0002***	0.00003
Household size	-0.016***	0.002	-0.015***	0.002	-0.013***	0.002

Continued on next page...

Table 3 – continued

Variable	Full sample Coef.	Full sample Std. Err.	Daughters Coef.	Daughters Std. Err.	Sons Coef.	Sons Std. Err.
Years of schooling	0.016***	0.001	0.013***	0.002	0.016***	0.001
Father schooling	0.003**	0.001	-0.0003	0.002	0.005***	0.001
Mother schooling	-0.002	0.002	-0.003	0.002	-0.002	0.001
Mother more schooling	0.026**	0.012	0.002	0.016	0.042***	0.014
Sex	0.202***	0.009	—	—	—	—
Father in primary sector	-0.125***	0.025	-0.038	0.031	-0.158***	0.034
Father in tertiary sector	0.078***	0.023	0.086***	0.029	0.107***	0.026
Mother in primary sector	-0.215***	0.018	-0.346***	0.028	-0.072***	0.019
Mother in tertiary sector	0.105***	0.017	0.083***	0.022	0.072***	0.019
Married	0.090***	0.011	0.095***	0.015	0.024	0.016
North-Central Zone	0.021	0.016	-0.024	0.021	0.012	0.021
North-East Zone	-0.079***	0.015	-0.182***	0.021	-0.001	0.019
South-East Zone	-0.007	0.018	-0.123***	0.026	0.067**	0.027
South-South Zone	0.063***	0.018	-0.014	0.024	0.068**	0.027
South-West Zone	0.155***	0.020	0.107***	0.026	0.093***	0.027
Year 2013	-0.064***	0.007	-0.072***	0.010	-0.035***	0.009
$\sigma^2_{\eta_{i2}}$	14.949***	1.228	10.623***	1.427	9.712***	1.244
$\sigma^2_{\eta_{i3}}$	13.162***	0.941	11.801***	1.226	9.086***	0.989
$\sigma_{\eta_{i2}\eta_{i3}}$	0.825***	0.019	0.850***	0.027	0.692***	0.047
Log likelihood	-13413.355		-6655.1016		-6125.258	
Wald χ_2(d.o.f)[a]	862.38		465.64		480	
d.o.f[a]	20		19		19	
Prob > χ_2	0.000		0.000		0.000	
# Observations	19001		9654		9347	

Notes: [a] dof=degree of freedom of the Wald statistic.

Significance levels: ∗: 10% ∗∗: 5% ∗ ∗ ∗: 1%

4.2 The Role of Women Bargaining Power in IG mobility

Women's human capital accumulation and labor market participation is linked to their empowerment. Women human capital is found to be one of the pathways to improve women bargaining power in a household (Lührmann & Maurer 2008; Friedberg & Webb 2006). Accordingly, we construct measures of women empowerment based on two concepts. First, we use mothers' education relative to to her husband (fathers). Women empowerment is positively related to IG mobility (from the primary to the modern sectors). Mothers bargaining power increases the likelihood of being employed in the secondary and tertiary sector by 1.4% and 3%, respectively. However, the effect is much stronger for boys than for girls, particularly in the service sector. Increasing women

empowerment may barely benefit the mobility of daughters but sons, to the service sector. This may imply that either the decisions regarding daughters' service sector participation are made by both parents or that mothers attach a greater psychic cost to their daughters' human capital investment (the latter being more likely).[32]

Second, relying on a sub-sample of children who are still living with their parents, we define women empowerment intensity by interacting age and education differences within couples. This leads to four variables: mothers who are older and have more years of schooling than fathers, younger mothers with more years of schooling, older mothers with less years of schooling, and younger mothers with less years of schooling (base). Empirical evidence from developed countries suggests that economic conditions of parents are particularly important during early childhood (Heckman 2008). Parental characteristics also matters more during adolescence and parental social status including their occupation are especially important in early adulthood, at the time of entering labor market (Härkönen & Bihagen 2011). To check this possibility and test the effect of women empowerment intensity on children occupation mobility, we repeat our analysis using a sample of childrens who are still living with their parents (the restricted sample). Table 4 present the results of this exercise. Mothers' empowerment intensity is positively related to children's upward mobility. Having a younger mother with higher years of schooling increases the likelihood of working in the secondary and tertiary sector by 3.1% and 3.6%, respectively. In line with our finding using the unrestricted sample the strength of this effect disappears in the daughters sample in the service sector. Parent's participation in tertiary sector has a significant positive influence on children's (both sons and daughters) probability of participating in the same sector. Daughters with parents in primary sector have the lowest probability to enter in to the service sector. Consumption increase the probability joining the service sector of daughters but not sons. Having larger household size reduce the probability of joining the modern sector of both men and women, the effect is larger for women.

Table 4 – Estimation results (average marginal effects) for the sub-sample (kids living with their parents). Women empowerment: intensity (interaction between age and education of mother)

	Full sample		Daughters		Sons	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Sector: Secondary						
Consumption (in log)	0.006	0.008	-0.007	0.015	0.02	0.013
Age	-0.003	0.003	0.02	0.019	-0.007	0.006
Age squared	0.00006	0.00007	-0.0005	0.0004	0.0001	0.0001
Household size	-0.0006	0.001	0.002	0.003	-0.002	0.002

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[32]The Chibok schoolgirls kidnapping by Boko Haram Militia best exemplifies the challenges that parents in Nigeria face in sending their daughters to schools.

Table 4 – continued

Variable	Full sample		Daughters		Sons	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Years of schooling	0.001	0.001	0.001	0.002	0.0007	0.002
Father schooling	-0.002	0.001	0.001	0.002	-0.005***	0.001
Mother schooling	0.0008	0.001	-0.001	0.002	0.003*	0.002
Mother older educated	-0.016	0.027	-0.053	0.048	-0.017	0.039
Mother younger educated	0.024*	0.012	0.076***	0.026	0.001	0.017
Mother older less educated	-0.015	0.014	-0.031	0.028	-0.014	0.021
Sex	0.022***	0.01	—	—	—	—
Father in primary sector	-0.368***	0.032	-0.341***	0.043	-0.367***	0.034
Father in tertiary sector	-0.240***	0.02	-0.239***	0.027	-0.230***	0.021
Mother in primary sector	-0.079***	0.017	-0.158***	0.033	-0.045*	0.025
Mother in tertiary sector	-0.048***	0.016	-0.086***	0.031	-0.031	0.023
Married	0.046	0.039	0.024	0.073	0.031	0.049
North-Central Zone	0.015	0.019	-0.007	0.035	0.023	0.028
North-East Zone	0.01	0.018	-0.002	0.034	0.005	0.025
South-East Zone	0.019	0.023	-0.016	0.037	0.052	0.037
South-South Zone	0.044*	0.024	0.01	0.039	0.076	0.037
South-West Zone	0.026	0.023	-0.011	0.039	0.06	0.037
Year 2013	-0.060***	0.012	-0.061***	0.023	-0.081***	0.017
Sector: Tertiary						
Consumption (in log)	0.018	0.011	0.060***	0.019	-0.01	0.015
Age	0.0003	0.004	-0.014	0.012	-0.003	0.008
Age squared	0.00006	0.00008	0.0004	0.0002	0.0001	0.0001
Household size	-0.008***	0.002	-0.012***	0.0041	-0.006**	0.003
Years of schooling	0.003**	0.001	0.0009	0.003	0.005**	0.002
Father schooling	0.006***	0.001	0.004	0.002	0.008***	0.002
Mother schooling	-0.001	0.001	0.0007	0.003	-0.003	0.002
Mother older educated	-0.007	0.038	0.041	0.066	-0.049	0.048
Mother younger educated	0.038**	0.016	-0.002	0.028	0.059***	0.021
Mother older less educated	0.036*	0.02	0.052	0.035	0.025	0.026
Sex	0.028**	0.012	—	—	—	—
Father in primary sector	-0.136***	0.034	-0.073	0.051	-0.126***	0.036
Father in tertiary sector	0.227***	0.03	0.238***	0.05	0.230***	0.035
Mother in primary sector	-0.100***	0.026	-0.134***	0.046	-0.088***	0.032
Mother in tertiary sector	0.104***	0.023	0.102**	0.041	0.107***	0.029
Married	-0.018	0.045	0.012	0.081	-0.01	0.056
North-Central Zone	-0.01	0.023	0.026	0.045	-0.028	0.029
North-East Zone	0.019	0.023	0.048	0.045	0.012	0.028
South-East Zone	0.055*	0.028	0.092*	0.05	0.028	0.037

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Table 4 – continued

Variable	Full sample		Daughters		Sons	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
South-South Zone	0.076***	0.028	0.098*	0.051	0.067*	0.036
South-West Zone	0.044	0.028	0.072	0.054	0.017	0.035
Year 2013	0.019	0.015	-0.063**	0.027	0.071***	0.019
$\sigma^2_{\eta_{i2}}$	2.971**	1.180	1.043	1.080	3.41e-12	5.34e-09
$\sigma^2_{\eta_{i3}}$	1.128**	0.533	0.305	0.485	1.739***	0.740
$\sigma_{\eta_{i2}\eta_{i3}}$	0.619**	0.248	0.619	0.718	0.744**	0.308
Log likelihood	-2045.503		-831.789		-1175.946	
Wald χ_2(d.o.f)^a	143.39		83.14		340.61	
d.o.f^a	22		21		21	
Prob $> \chi_2$	0.000		0.000		0.000	
# Observations	3803		1435		2368	

Significance levels: $*$: 10% $**$: 5% $***$: 1%

4.3 Robustness Check

The regression results presented in the previous section demonstrate that women empowerment does not lead to a substantial improvement of intergenerational occupational mobility of daughters but sons. It is very likely that strength of intergenerational occupation persistence depends on the age at which her different characteristics are observed. To compare the contribution of maternal empowerment at different ages to childrens occupational choice, we repeated our analysis using a sample of childrens who are still living with their parents. Our result holds up reasonably well, mothers bargaining power significantly increases the likelihood of childrens being employed in the secondary and tertiary sector (see Table 9). However, the effect of mother barraging power on probability to engage in the service sector is not significant for daughters but for sons.

Table 5 – Estimation results (average marginal effects) for the sub-sample (kids living with their parents). Women empowerment: Mother has more years of schooling than father

	Full sample		Daughters		Sons	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Sector: Secondary						
Consumption (in log)	0.006	0.008	-0.005	0.016	0.012	0.011
Age	-0.003	0.004	0.022	0.019	-0.005	0.005
Age squared	0.00003	0.00008	-0.0006	0.0005	0.0001	0.0001
Household size	-0.0006	0.002	0.003	0.003	-0.002	0.002
Years of schooling	0.001	0.001	0.0009	0.003	0.001	0.001
Father schooling	-0.001	0.001	0.001	0.002	-0.004**	0.001
Mother schooling	0.0007	0.001	-0.001	0.002	0.002	0.001
Mother more schooling	0.024**	0.012	0.067***	0.024	0.003	0.014
Sex	0.024**	0.01	—	—	—	—
Father in primary	-0.349***	0.029	-0.325***	0.041	-0.376***	0.039
Father in tertiary	-0.232***	0.021	-0.237***	0.028	-0.232***	0.025
Mother in primary	-0.072***	0.017	-0.147***	0.033	-0.031	0.022
Mother in tertiary	-0.036**	0.016	-0.071**	0.031	-0.014	0.02
Married	0.059	0.042	0.041	0.078	0.049	0.049
North-Central Zone	0.007	0.019	-0.022	0.034	0.014	0.024
North-East Zone	0.007	0.018	-0.008	0.033	0.007	0.023
South-East Zone	0.019	0.023	-0.011	0.038	0.039	0.032
South-South Zone	0.041*	0.024	0.011	0.04	0.054*	0.032
South-West Zone	0.023	0.023	-0.018	0.038	0.042	0.032
Year 2013	-0.056***	0.012	-0.056**	0.023	-0.065***	0.015
Sector: Tertiary						
Consumption (in log)	0.022**	0.011	0.061***	0.019	-0.002	0.015

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Table 5 – continued

Variable	Full sample Coef.	Full sample Std. Err.	Daughters Coef.	Daughters Std. Err.	Sons Coef.	Sons Std. Err.
Age	-0.0003	0.004	-0.014	0.012	-0.002	0.007
Age squared	0.00008	0.00009	0.0004	0.0003	0.0001	0.0001
Household size	-0.009***	0.002	-0.013***	0.004	-0.006**	0.003
Years of schooling	0.004**	0.001	0.002	0.003	0.005**	0.002
Father schooling	0.006***	0.001	0.004	0.003	0.008***	0.002
Mother schooling	-0.001	0.001	0.0006	0.003	-0.002	0.002
Mother more schooling	0.025*	0.015	-0.003	0.026	0.038**	0.019
Sex	0.027**	0.012	—	—	—	—
Father in primary	-0.133***	0.035	-0.051	0.047	-0.192***	0.043
Father in tertiary	0.217***	0.034	0.252***	0.054	0.193***	0.034
Mother in primary	-0.109***	0.026	-0.134***	0.044	-0.103***	0.033
Mother in tertiary	0.092***	0.023	0.095***	0.041	0.087***	0.028
Married	-0.026	0.045	0.006	0.081	-0.026	0.057
North-Central Zone	-0.009	0.023	0.025	0.045	-0.022	0.028
North-East Zone	0.015	0.023	0.044	0.044	0.008	0.028
South-East Zone	0.051*	0.028	0.08	0.05	0.033	0.036
South-South Zone	0.078	0.028	0.094*	0.051	0.074	0.035
South-West Zone	0.047*	0.028	0.074	0.054	0.025	0.034
Year 2013	0.016	0.015	-0.064**	0.027	0.060***	0.019
$\sigma^2_{\eta_{i2}}$	2.212**	0.971	0.379	0.875	2.610*	1.372
$\sigma^2_{\eta_{i3}}$	0.546	0.434	0.041	0.180	1.409*	0.770
$\sigma_{\eta_{i2}\eta_{i3}}$	0.619	0.520	-0.171	2.678	0.672**	0.320
Log likelihood	-2074.132		-844.806		-1191.013	
Wald χ_2(d.o.f)[a]	155.35		102.27		91.75	
d.o.f[a]	20		19		19	
Prob $> \chi_2$	0.000		0.000		0.000	
# Observations	3836		1449		2387	

Significance levels: $*$: 10% $**$: 5% $***$: 1%

5 Conclusion

The paper has introduced gender effects into intergenerational occupational mobility. In the model, intergenerational occupational mobility is determined by the education that individuals receive during childhood. Parental investment in children's education is a function of parental characteristics such as their occupation and income, their attitude towards different gender of their children and their bargaining power, given differences between the parents on the weight they attach to the welfare of their children. Gender bias is part of parents' psychic cost – a reflection of their pessimism on children adulthood outcomes. Parental bias against a certain gender group is associated to a relatively larger psychic cost attached to the specific gender. Differences in psychic cost leads to differences in human capital investment threshold of girls and boys, which, in turn, determines the intergenerational occupational mobility threshold for women and men in the economy. Given that women attach a relatively higher weight to the welfare of their children, then the degree of their empowerment is important in defining the psychic costs and hence the mobility of their children.

We found that intergenerational occupational mobility depends on intra-household bargaining power, parents' occupational background, parental gender bias and sex preferences. Increased women's bargaining power leads to higher IG mobility, given that they attach a higher weight to their children's education. When applying the framework to a representative panel data survey from Nigeria, we found that children with parents (especially, with mothers) working in the modern sectors are more likely to work in the same sector. A greater intra-household female bargaining power leads to greater upward mobility while it benefits boys more than proportionally. Therefore, parental gender bias could be one of the driving force behind gender-based intergenerational persistence. Our result indicate that parents psychic costs and social norms against women can make it extremely difficult for women to move out of traditional economic activities like agriculture and join the emerging sectors like service. It also clearly indicate that empowering mothers don't necessarily benefit all children similarly. This is not to suggest that the promotion of womens empowerment is not beneficial. Whether seen as separate or complementary causes, it is important that policies that encourage human capital accumulation of young women should be prompted. This indeed will play a decisive role to promote social mobility in the long run.

Our paper is designed to contrast the effects of women empowerment on gender based intergenerational occupational mobility, using couples' relative education as determinant of their intra-household bargaining power. A future extension of our work would be to use other bargaining power measure, depending on data availability, such as asset ownership. While unlikely to change the key results, a more general utility function (dynastic altruism) and an explicit differentiation of the final goods as agriculture and non-agriculture goods can also be introduced to enrich the model further.

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A Appendix for the Theory

A.1 Household Optimal Decision

A.1.1 Solutions for the Couple's Problem

The couples solve the following problem, from Eqs. (1) and (3) (in the manuscript),

$$\max_{\left\{c_{it}^m, c_{it}^f, e_{it}^f, e_{it}^m, l_{it}^f, l_{it}^m\right\}} \left\{ \begin{array}{c} \theta_{it} \ln\left(c_{it}^f - \overline{c}\right) + (1-\theta_{it}) \ln\left(c_{it}^m - \overline{c}\right) \\ +\psi_{it} \ln\left[\left(h_{it+1}^f + \gamma^f\right)^{\sigma} + \ln\left(h_{it+1}^m + \gamma^m\right)^{1-\sigma}\right] \end{array} \right\} \tag{25}$$

subject to Eqs. (4), (5) (in the manuscript) and (6). ψ_{it} represents the weighted intra-household bargaining power of the female, as given by

$$\psi_{it} \equiv \theta_{it}\beta^f + (1-\theta_{it})\,\beta^m \tag{26}$$

From the first order conditions of the problem, we have:

$$\frac{c_{it}^m - \overline{c}}{c_{it}^f - \overline{c}} = \frac{1-\theta_{it}}{\theta_{it}} \tag{27}$$

$$\frac{\theta_{it}}{c_{it}^f - \overline{c}} = \frac{h_{it+1}^f \sigma \upsilon \psi_{it}}{\left(h_{it+1}^f + \gamma\right) e_{it}^f} = \frac{\psi_{it}(1-\sigma)\,\upsilon}{h_{it+1}^m + \gamma^m} \frac{h_{it+1}^m}{e_{it}^m} \tag{28}$$

$$\frac{\theta_{it}}{c_{it}^f - \overline{c}} \omega_t = \frac{\eta\sigma\psi_{it}}{h_{it+1}^f + \gamma^f} \frac{h_{it+1}^f}{l_{it}^f} = \frac{\psi_{it}(1-\sigma)\,\eta}{h_{it+1}^m + \gamma^m} \frac{h_{it+1}^m}{\omega_t l_{it}^m} \tag{29}$$

From (27), the relative consumption of male and female is determined by their relative intra-household bargaining power. Eqs. (28) and (29) equate the marginal benefits in sons' and daughters' education investment, in terms of goods and time spending, respectively. Combing (28) and (29) will lead to

$$\frac{e_{it}^f}{l_{it}^f} = \frac{e_{it}^m}{l_{it}^m} = \omega_t \frac{\upsilon}{\eta} \tag{30}$$

Thus, the ratio of parental investment in goods and time is the same for both sons and daughters, which is proportional to the wage rate in the agricultural sector.

To derive optimal education investment, first substitute Eq. (4) (in the manuscript) and (30)

into (28) to get[33]

$$e_{it}^{f} = \frac{\sigma}{1-\sigma} e_{it}^{m} - \gamma z_t \tag{31}$$

where

$$\begin{aligned} z_t &\equiv \left(\omega_t \upsilon / \left(h_t \eta\right)\right)^{1-\upsilon} \\ \gamma &\equiv \frac{\left(1-\sigma\right)\gamma^{f} - \sigma\gamma^{m}}{1-\sigma} \end{aligned}$$

Then, from Eqs. (4) (in the manuscript), (28) and (30), one obtains:

$$c_{it}^{f} - \overline{c} = \frac{\theta_{it}}{\left(1-\sigma\right)\upsilon\psi_{it}} \left(e_{it}^{m} + z_t \gamma^{m}\right) \tag{32}$$

But, we can rewrite (27) as

$$c_{it}^{m} = \varkappa c_{it}^{f} + b \tag{33}$$

where $\varkappa \equiv \frac{1-\theta_{it}}{\theta_{it}}$ and $b \equiv \overline{c}\frac{2\theta_{it}-1}{\theta_{it}}$. Then substitute (33) into the budget constraint (5) (see manuscript) to get

$$c_{it}^{f} - \overline{c} + \theta_{it}\left(e_{it}^{f} + e_{it}^{m}\right)/2 = \theta_{it} y_{it} - 2\overline{c}\theta_{it} \tag{34}$$

Combining (32) and (34), and using (31), finally, gives

$$e_{it}^{m} = \left(y_{it} - 2\overline{c} + z_t \gamma^{f}/2\right) a_{it}\left(1-\sigma\right) + \left(a_{it}\left(1-\sigma\right)/2 - 1\right) z_t \gamma^{m} \tag{35}$$

where

$$a_{it} \equiv \frac{\upsilon\psi_{it}}{1 + \frac{1}{2}\upsilon\psi_{it}} \tag{36}$$

Eq. (35) represents the optimal education investment for sons. In order to get the one for daughters, substitute (35) into (31):

$$e_{it}^{f} = \left(y_{it} - 2\overline{c} + z\gamma^{m}/2\right)\sigma a_{it} + z_t \gamma^{f}\left(\sigma a_{it}/2 - 1\right) \tag{37}$$

Combining (30), (35) and (37), one could easily solve for optimal time spending in children education, for daughters and sons.

[33] We consider first degree homogeneity in Eq. (4) (in the manuscript), $\upsilon + \eta = 1$.

A.2 Proofs for the Propositions

A.2.1 Proposition 1

Proof. (i) It is straightforward to see, from (8), e_{it}^{j*} and l_{it}^{j*} increase in γ^{-j}. (ii) Given that $\beta^f > \beta^m$, $\partial e_{it}^{j*}/\partial \psi_{it} > 0$ and $\partial l_{it}^{j*}/\partial \psi_{it} > 0$. (iii) See (10) and (11) and the related discussion. ■

A.2.2 Proposition 2

Proof. Given $\beta^f > \beta^m$, higher θ_i implies higher ψ_i, which in turn implies lower ϱ_i^j and hence higher Ω_i^j. ■

A.2.3 Proposition 3

Proof. Given, $h_i^m = h_i^f$, and considering Eq. (2) (in the manuscript) and (26), we have $\psi_2 > \psi_1 = \psi_4 > \psi_3$. Then , from (18) and (19), $\Omega_2 > \{\Omega_3, \Omega_4\}$ and $\Omega_1 > \{\Omega_3, \Omega_4\}$ ■

A.2.4 Proposition 4

Proof. From (2), (26) and considering $h_i^m > h_i^f$, we know $\psi_2 > \psi_4 > \psi_1 > \psi_3$. Then, from (18) and (19): (i) $\Omega_i^m > \Omega_i^f$, (ii) $\Omega_2^j > \Omega_4^j$ and (iii) $\Omega_1^j > \Omega_3^j$. ■

B Appendix for the empirical part

Table 6 – Descriptive statistics for the restricted/sub-sample

Group(Variable)	Mean	Std. Dev.[c]	Min.[a]	Max.[b]
Dependent: Children's sector				
1=primary (base), 2=Secondary, 3=Tertiary				
Controls:				
Consumption (10,000)	13.353	0.746	9.626	16.481
Age	20.469	5.469	15	65
Household size	7.30	3.48	1	31
Years of schooling	8.697	3.506	3	31
Father schooling	5.567	5.585	0	18
Mother schooling	4.202	4.882	0	18
Mother more schooling	0.256			
Mother older educated	0.040			
Mother younger educated	0.215			
Mother older less educated	0.151			
Mother younger less educated	0.592			
Sex	0.381			
Father primary sector	0.586			
Father secondary sector	0.087			
Father tertiary sector	0.328			
Mother primary sector	0.434			
Mother secondary sector	0.104			
Mother tertiary sector	0.461			
Married	0.026			
North-Central Zone	0.172			
North-East Zone	0.192			
North-West Zone	0.196			
South-East Zone	0.151			
South-South Zone	0.168			
South-West Zone	0.121			
Year 2011	0.477			
Year 2013	0.523			

Note. Number of observations: 7,160 over all waves.

[a,b] Min. and Max. are not reported for binary variables as per 0 and 1 respectively.

[c] Standard Deviation for binary variables can be retrieved using $\sqrt{p(1-p)}$ where p is the probability of event.

Table 7 – Estimation results (average marginal effects) for the pooled model (model without heterogeneity)

Variable	Full sample		Daughters		Sons	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Sector: Primary (base)						
Sector: Secondary						
Consumption (in log)	0.013***	0.004	-0.008	0.009	0.025***	0.009
Age	0.0004	0.001	0.003	0.003	.002	.003
Age squared	-0.00002	0.00003	-0.00005	0.00004	-0.00002	0.000
Household size	-0.003***	0.0009	0.0009	0.002	-0.009***	0.002
Years of schooling	-0.001*	0.0005	-0.003*	0.002	0.001	0.001
Father schooling	-0.0003	0.0008	0.0004	0.002	-0.001	0.001
Mother schooling	0.002*	0.001	0.004	0.002	0.0002	0.002
Mother more schooling	0.017***	0.007	0.011	0.016	0.026*	0.014
Sex	0.022***	0.005	—	—	—	—
Father in primary sector	-0.169***	0.016	-0.126***	0.037	-0.203***	0.032
Father in tertiary sector	-0.104***	0.009	-0.099***	0.023	-0.110***	0.015
Mother in primary sector	-0.119***	0.008	-0.190***	0.018	-0.029	0.025
Mother in tertiary sector	-0.049***	0.007	-0.084***	0.015	0.004	0.024
Married	0.036***	0.007	-0.002	0.018	0.008	0.022
North-Central Zone	-0.026***	0.008	-0.083***	0.014	0.057*	0.031
North-East Zone	0.023***	0.009	0.008	0.017	0.026	0.036
South-East Zone	-0.003	0.011	-0.088***	0.018	0.104***	0.038
South-South South-South	0.015	0.011	-0.100***	0.017	0.147***	0.040
South-West Zone	-0.009	0.009	-0.103***	0.016	0.101***	0.036
Year 2013	-0.026***	0.006	-0.016	0.012	-0.029**	0.013
Sector: Tertiary						
Consumption (in log)	0.105***	0.007	0.113***	0.013	0.085***	0.013
Age	0.014***	0.002	0.013***	0.004	0.016***	0.004
Age squared	-0.0001***	0.000	-0.0001**	0.000	-0.0002***	0.000
Household size	-0.015***	0.001	-0.016***	0.003	-0.012***	0.003
Years of schooling	0.014***	0.001	0.012***	0.002	0.015***	0.001
Father schooling	0.001	0.001	-0.001	0.003	0.003	0.002
Mother schooling	-0.002	0.002	-0.003	0.004	-0.002	0.003
Mother more schooling	0.013	0.009	-0.004	0.021	0.034*	0.019
Sex	0.154***	0.008	—	—	—	—
Father in primary sector	-0.057*	0.022	-0.026	0.052	-0.094**	0.040
Father in tertiary sector	0.077***	0.028	0.055	0.064	0.077*	0.043

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Table 7 – continued

Variable	Full sample		Daughters		Sons	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Mother in primary sector	-0.115***	0.013	-0.207***	0.042	-0.073***	0.024
Mother in tertiary sector	0.079***	0.013	0.058	0.041	0.040*	0.024
Married	0.059***	0.010	0.073***	0.021	0.013	0.033
North-Central Zone	0.025***	0.012	-0.021	0.034	-0.0005	0.028
North-East Zone	-0.068***	0.012	-0.164***	0.032	-0.011	0.028
South-East Zone	-0.012	0.015	-0.111***	0.038	0.042	0.034
South-South Zone	0.043***	0.015	-0.017	0.039	0.040	0.033
South-West Zone	0.106***	0.016	0.081*	0.046	0.053	0.033
Year 2013	-0.064***	0.009	-0.078***	0.018	-0.038**	0.017
Log likelihood	-14501.006		-7078.503		-6555.901	
Wald χ_2(d.o.f)[a]	4593.91		3317.47		2354.96	
d.o.f[a]	40		38		38	
Prob > χ_2	0.000		0.000		0.000	
# Observations	19001		9654		9347	

Notes: [a] d.o.f=degree of freedom of the Wald statistic.

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 8 – Estimation results (average marginal effects) for the sub-sample (kids living with their parents) model without heterogeneity. Women empowerment: intensity (interaction between age and education of mother)

	Full sample		Daughters		Sons	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Sector: Secondary						
Consumption (in log)	0.01	0.012	-0.006	0.033	0.019	0.022
Age	-0.004	0.004	0.023	0.108	-0.007	0.011
Age squared	0.00006	0.00007	-0.0006	0.002	0.0001	0.0002
Household size	-0.0005	0.002	0.003	0.006	-0.002	0.0043
Years of schooling	0.001	0.001	0.0009	0.006	0.001	0.002
Father schooling	-0.002	0.001	0.001	0.004	-0.005*	0.002
Mother schooling	0.0009	0.001	-0.002	0.005	0.003	0.003
Mother older educated	-0.023	0.033	-0.059	0.102	-0.018	0.056
Mother younger educated	0.031*	0.018	0.08	0.056	0.002	0.031
Mother older less educated	-0.017	0.02	-0.029	0.057	-0.014	0.032
Sex	0.030**	0.014	—	—	—	—
Father in primary sector	-0.335***	0.05	-0.331***	0.135	-0.351***	0.085
Father in tertiary sector	-0.212***	0.025	-0.232***	0.071	-0.205***	0.043
Mother in primary sector	-0.096***	0.022	-0.166**	0.066	-0.051	0.041
Mother in tertiary sector	-0.052**	0.021	-0.087	0.064	-0.027	0.036
Married	0.067	0.048	0.042	0.168	0.047	0.078
North-Central Zone	0.018	0.025	-0.006	0.076	0.019	0.042
North-East Zone	0.008	0.022	-0.003	0.07	0.007	0.037
South-East Zone	0.026	0.031	-0.014	0.083	0.051	0.059
South-South Zone	0.059*	0.035	0.016	0.091	0.075	0.062**
South-West Zone	0.034	0.036	-0.012	0.092	0.054	0.065
Year 2013	-0.073***	0.021	0.066	0.062	-0.081**	0.036
Sector: Tertiary						
Consumption (in log)	0.019	0.015	0.06	0.044	-0.006	0.025
Age	0.0009	0.005	-0.015	0.06	-0.003	0.017
Age squared	0.00005	0.00008	0.0004	0.001	0.0001	0.0003
Household size	-0.008***	0.002	-0.012	0.009	-0.006	0.004
Years of schooling	0.003	0.002	0.0009	0.007	0.004	0.003
Father schooling	0.006***	0.002	0.004	0.006	0.007**	0.003
Mother schooling	-0.002	0.002	0.0004	0.007	-0.003	0.003
Mother older educated	-0.001	0.047	0.046	0.144	-0.043	0.081
Mother younger educated	0.036*	0.022	-0.003	0.063	0.058*	0.035
Mother older less educated	0.036	0.027	0.052	0.079	0.024	0.043

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Table 8 – continued

Variable	Full sample		Daughters		Sons	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Sex	0.026	0.017	—	—	—	—
Father in primary sector	-0.115***	0.044	-0.072	0.125	-0.140**	0.069
Father in tertiary sector	0.200***	0.04	0.225*	0.129	0.183***	0.059
Mother in primary sector	-0.097***	0.028	-0.13	0.09	-0.087**	0.045
Mother in tertiary sector	0.102***	0.026	0.101	0.085	0.102**	0.04
Married	-0.03	0.052	0.004	0.172	-0.026	0.089
North-Central Zone	-0.012	0.027	0.027	0.11	-0.028	0.04
North-East Zone	0.022	0.026	0.051	0.103	0.01	0.039
South-East Zone	0.054	0.036	0.093	0.123	0.033	0.059
South-South Zone	0.081**	0.036	0.103	0.13	0.075	0.056
South-West Zone	0.043	0.041	0.073	0.152	0.022	0.058
Year 2013	0.021	0.028	-0.061	0.087	0.069*	0.041
Log likelihood	-2075.492		-833.105		-1181.941	
Wald χ_2(d.o.f)[a]	1429.88		583.28		933.54	
d.o.f[a]	44		42		42	
Prob $> \chi_2$	0.000		0.000		0.000	
# Observations	3803		1435		2368	

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 9 – Estimation results (average marginal effects) for the sub-sample (kids living with their parents) model without heterogeneity. Women empowerment: Mother has more years of schooling than father

	Full sample		Daughters		Sons	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Sector: Secondary						
Consumption (in log)	0.009	0.012	-0.004	0.032	0.016	0.021
Age	-0.005	0.005	0.024	0.112	-0.007	0.011
Age squared	0.00007	0.00008	-0.0006	0.002	0.0001	0.0002
Household size	-0.0004	0.002	0.003	0.005	-0.003	0.004
Years of schooling	0.002	0.002	0.0008	0.005	0.002	0.003
Father schooling	-0.002	0.002	0.001	0.004	-0.005*	0.002
Mother schooling	0.0007	0.002	-0.001	0.005	0.003	0.003
Mother more schooling	0.029*	0.016	0.068	0.05	0.006	0.027
Sex	0.030**	0.014	—	—	—	—
Father in primary	-0.326***	0.046	-0.318**	0.126	-0.344***	0.079
Father in tertiary	-0.212***	0.024	-0.230***	0.068	-0.206***	0.041
Mother in primary	-0.087***	0.022	-0.153**	0.061	-0.04	0.042
Mother in tertiary	-0.042**	0.021	-0.073	0.062	-0.016	0.037
Married	0.072	0.049	0.047	0.176	0.053	0.08
North-Central Zone	0.01	0.024	-0.021	0.07	0.017	0.04
North-East Zone	0.008	0.022	-0.008	0.066	0.008	0.037
South-East Zone	0.026	0.029	-0.008	0.079	0.044	0.055
South-South Zone	0.057*	0.033	0.015	0.088	0.071	0.059
South-West Zone	0.029	0.034	-0.019	0.086	0.051	0.063
Year 2013	-0.066***	0.02	-0.059	0.06	-0.072**	0.034
Sector: Tertiary						
Consumption (in log)	0.022	0.015	0.059	0.044	-0.0007	0.024
Age	0.0006	0.005	-0.015	0.062	-0.002	0.016
Age squared	0.00007	0.00009	0.0004	0.001	0.0001	0.0003
Household size	-0.009***	0.003	-0.013	0.008	-0.006	0.004
Years of schooling	0.004	0.002	0.001	0.007	0.005	0.003
Father schooling	0.006***	0.002	0.004	0.006	0.007**	0.003
Mother schooling	-0.001	0.002	0.0005	0.007	-0.002	0.003
Mother more schooling	0.024	0.02	-0.003	0.06	0.037	0.032
Sex	0.026	0.017	—	—	—	—
Father in primary	-0.117***	0.041	-0.058	0.112	-0.155**	0.066
Father in tertiary	0.198***	0.037	0.239	0.122	0.173***	0.054
Mother in primary	-0.104***	0.028	-0.133	0.089	-0.100**	0.046

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Table 9 – continued

Variable	Full sample		Daughters		Sons	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Mother in tertiary	0.093***	0.026	0.093	0.083	0.088**	0.04
Married	-0.029	0.052	0.004	0.174	-0.027	0.091
North-Central Zone	-0.01	0.027	0.025	0.108	-0.026	0.04
North-East Zone	0.016	0.026	0.045	0.101	0.006	0.039
South-East Zone	0.049	0.035	0.079	0.12	0.034	0.058
South-South Zone	0.079**	0.035***	0.093	0.128	0.077	0.056**
South-West Zone	0.046	0.041	0.074	0.151	0.025	0.059
Year 2013	0.017	0.028	-0.063	0.088	0.061	0.041
Log likelihood	-2080.314		-845.038		-1197.799	
Wald χ_2(d.o.f)[a]	1454.01		591.53		940.19	
d.o.f[a]	40		38		38	
Prob > χ_2	0.000		0.000		0.000	
# Observations	3836		1449		2387	

Significance levels: $*$: 10% $**$: 5% $***$: 1%

Table 10 – List and definitions of variables

Variable name	Definition	Nature
Children's sector, $\mathscr{S}_{i,t} = 1, 2, 3$	1=primary (agriculture:base), 2=secondary (industry), 3=tertiary (service)	discrete
Consumption	Per capita household food and non-food consumption expenditure in regional price	continuous
Age	age of individuals (completed years)	continuous
Age square	Age square	continuous
Household size	Household family size	continuous
Years of schooling	Children number of years of schooling associated with the highest grade completed	continuous
Father schooling	Father's number of years of schooling associated with the highest grade completed	continuous
Mother schooling	Mother's number of years of schooling associated with the highest grade completed	continuous
Mother more schooling	Mother has more years of schooling than father's	binary (yes=1)
Mother older educated	Mother is older and has more years of schooling than father's	binary (yes=1)
Mother younger educated	Mother is younger and has more years of schooling than father's	binary (yes=1)
Mother older less educated	Mother is older and has less years of schooling than father's	binary (yes=1)
Mother younger less educated (base)	Mother is younger and has less years of schooling than father's	binary (yes=1)
Sex	Gender of children	binary (female=1)
Father primary sector	Father engaged in agriculture, forestry, fishing and mining for most of his life	binary (yes=1)
Father secondary sector (base)	Father engaged in manufacturing and construction sector for most of his life	binary (yes=1)
Father tertiary sector	Fathers engaged in the service sector for most of his life	binary (yes=1)
Mother primary sector	Mothers engaged in agriculture, forestry, fishing and mining for most of her life	binary (yes=1)
Mother secondary sector (base)	Mothers engaged in manufacturing and construction sector for most of her life	binary (yes=1)
Mother tertiary sector	Mothers engaged in the service sector for most of his life	binary (yes=1)
Married	Married (Monogamous or polygamous)	binary (yes=1)
North-Central Zone	Includes Benue , Kogi, Kwara, Nasarawa, Niger, Plateau and FCT Abuja states	binary (yes=1)
North-East Zone	Includes Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe states	binary (yes=1)
North-West Zone	Includes Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto and Zamfara states	binary (yes=1)
South-East Zone	Includes Abia, Anambra, Ebonyi, Enugu, and Imo states	binary (yes=1)
South-South Zone	Includes Akwa-Ibom, Bayelsa, Cross River, Delta, Edo and Rivers states	binary (yes=1)
South-West Zone	Includes Ekiti, Lagos, Ogun, Ondo, Osun and Oyo states	binary (yes=1)
Time	Structural change indicator: Years 2011 (base) and 2013	binary (yes=1)

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