Twofold gendered preferences in the quantity-quality trade-off impact the demographic transition in Ethiopia

by Eva Boonaert, Kaat Van Hoyweghen, Ashenafi Duguma Feyisa,
Peter Goos, and Miet Maertens

Twofold gendered preferences in the quantity-quality trade-off impact the demographic transition in Ethiopia

Version: 30/06/2021

Authors

Eva Boonaert[1*], Kaat Van Hoyweghen[1], Ashenafi Duguma Feyisa[1,2], Peter Goos[3,4], Miet Maertens[1]

Keywords: Family planning, Education, Choice experiment, Demographic transition, Unified growth theory, Sex preferences

JEL: J13, J16, C11

Declarations of interest: None.

Acknowledgements: This work is supported by the VLIR-UOS financed Interuniversity Cooperation Program with Arba Minch University [grant number REI-2019-01-01-19106].

Highlights

- Choice experiment on fertility preferences and the QQ trade-off in Ethiopia
- A QQ trade-off exists until the utility-maximizing number of children is reached
- Gendered preferences for boys in both quantity and quality of childrearing
- Men's fertility preferences entail a larger gender bias than women's preferences

---

[1] *Division of Bioeconomics, Department of Earth and Environmental Sciences, KU Leuven, Belgium*
[2] *Economics Department, Arba Minch University, Arba Minch, Ethiopia*
[3] *Division of Mechatronics, Biostatistics and Sensors, Department of Biostatistics, KU Leuven, Belgium*
[4] *Department of Engineering Management, University of Antwerp, Belgium*
[*] *Corresponding author. E-mail address: eva.boonaert@kuleuven.be. Telephone number: +3216194986. Correspondence to: Celestijnenlaan 200E – B- 3001 Leuven, Belgium.*

Abstract

This is the first study to analyze gendered fertility preferences, rather than actual fertility outcomes, to investigate the existence of a quantity-quality (QQ) trade-off in childrearing. The study is based on the unified growth theory and an empirical application through a discrete choice experiment in southern Ethiopia. The results document that a QQ trade-off exists but only below the utility-maximizing number of children, and is rooted in fertility preferences. Fertility preferences are gendered in two ways: (i) respondents are found to have a preference for boys over girls, both in terms of the quantity and quality of childrearing, and (ii) men generally have a higher preference for more sons than women while both men and women prefer a higher education for boys over a higher education for girls. Results imply that education, especially girls' education, and norms about family size are important to accelerate the demographic transition.

1 Introduction

The world population is predicted to approach 11 billion by 2100 (The World Bank 2019). This is more than a 50% increase of today's population. The largest growth is expected in sub-Saharan Africa (SSA) with a quadrupling of the population by 2100. Understanding SSA's population dynamics is crucial to slowing down global population growth. The latter is important from the perspective of reducing environmental pressures and respecting planetary boundaries (Crist, Mora and Engelman 2017), and in the light of the link between high population growth on the one hand and economic stagnation, maternal mortality and political unrest on the other hand (Bongaarts 2016). The demographic transition model, first proposed by Thompson (1929), is one of the most influential theories explaining global population dynamics. This model introduces four stages in the transition from high fertility and mortality rates (the first or pre-transitional stage) to steadily lower fertility and mortality rates (the fourth or post-transitional stage) while the population expands between these stages as mortality rates drop faster (in the second or early transitional stage) than fertility rates (in the third or late transitional stage). Reducing fertility rates is crucial in accelerating the demographic transition and slowing-down population growth. This holds especially for low- and middle-income countries that are currently in the second and third stages of the demographic transition. SSA currently has the highest total fertility rate (TFR) in the world: 4.8 births per woman, compared to the world average of 2.4 births per woman. An accelerated reduction of this fertility rate can have an important effect on global population growth. Fertility rates are determined by complex interactions between social, economic and cultural factors, in which fertility preferences and access to birth control play crucial roles (Bongaarts 1978).

It has been argued that the demographic transition is not only associated with a decrease in quantity (i.e. number of children), but also with an increase in the quality of childrearing (Galor 2012), e.g. in terms of child education, nutrition and health. This concept of a QQ trade-off in fertility decisions originates from economics and evolutionary ecology (Lawson and Borgerhoff Mulder 2016). The existence of a QQ trade-off would imply that reducing fertility rates and achieving slower population growth is for example more difficult in regions where schooling and educational attainment is low. A wide range of microeconomic models have been proposed to model the QQ trade-off, first introduced by Becker (1960). These models maximize individuals' or parents' utility - defined by the quantity and quality of childrearing - subject to a budget constraint. Empirical studies analyzing the QQ trade-off, often focusing on education as indicator of quality of childrearing, are inconclusive and suggest that the trade-off is small or non-existent and can be non-linear (Clarke 2018). In addition, focusing on SSA, empirical evidence is scarce. Some recent studies find evidence for the QQ trade-off (Temel 2013; Bougma, LeGrand and J.-F. Kobiané 2015; Vogl 2016; Ito and Tanaka 2017) whereas others point to a lack of evidence (Eloundou-Enyegue and Giroux 2012; Kravdal, Kodzi and Sigle-Rushton 2013; Alidou and Verpoorten 2019).

This paper examines the existence of a quantity-quality (QQ) trade-off in childrearing through a focus on fertility preferences and gender bias in fertility preferences. We rely on Galor's (2012) modified theoretical collective household model to understand the QQ trade-off conceptually, and on a discrete choice experiment (DCE) to analyze fertility preferences empirically. The DCE was conducted among 426 respondents in the age category 18 to 25 years in six rural districts in the Southern Nations, Nationalities, and People's Region (SNNPR) of Ethiopia, with the aim of studying fertility preferences ex ante (i.e. before completing the reproductive lifetime). The ex-ante focus minimizes bias due to rationalization for already having a certain number of children (Bongaarts 2011), and addresses the fact that fertility preferences vary considerably over an individual's lifetime due to high existential uncertainty in SSA (Trinitapoli and Yeatman 2018). This paper brings some particular innovations and contributions in the literature on fertility in low- and middle-income countries.

First, different methods have been used in the literature to study the QQ trade-off in childrearing, with most studies focusing on actual fertility outcomes. A first group of studies uses external instruments to study the effect of fertility on quality of childrearing. Studies have used the occurrence of twins as an exogenous source of variation in the number of children (Angrist, Lavy and Schlosser 2010; Black, Devereux and Salvanes 2010; Marteleto and de Souza 2012; Ponczek and Souza 2012; Fitzsimons and Malde 2014). Some studies have used the gender composition of children as an instrument for fertility, arguing that gender preference affects the continuation of child raising (Angrist, Lavy and Schlosser 2010; Becker, Cinnirella and Woessmann 2010; Black, Devereux and Salvanes 2010; Kugler and Kumar 2011; Millimet and Wang 2011; Fitzsimons and Malde 2014). Other studies have focused on fertility shocks (i.e. instruments related to the ability to control conception) such as infertility (Bougma, LeGrand and J. F. Kobiané 2015) or miscarriage (Miller 2009). A second group of studies use the effect of policy reforms on fertility to quantity the effect of fertility on quality of childrearing (Ananat *et al.* 2009; Ananat and Hungerman 2012). This is the first study to use a DCE to analyze the QQ trade-off from a preference perspective. We focus on education as indicator for the quality of childrearing because other quality indicators are often considered as a precondition for children's school performance. Moreover, we estimate the QQ preferences jointly instead of examining the causal effect in one of the two directions, which is mostly done in the literature. Our approach is in line with the notion that decisions towards quantity and quality of childrearing are made simultaneously (Cinnirella 2019).

Second, fertility preferences may be gendered in two ways, according to the gender of the child and according to the gender of the parent. Regarding the gender of the child, there is mixed evidence on preferences for boys or girls in SSA in general (Basu and De Jong 2010; Fuse 2010; Rossi and Rouanet 2015; Eliason *et al.* 2018; Flato 2018; Norling 2018; Chao *et al.* 2019) and in Ethiopia in particular (Basu and De Jong 2010; Fuse 2010; Mekonnen and Worku 2011;

Rossi and Rouanet 2015; Berlie and Alamerew 2018). Recent empirical evidence indicates a preference for boys' education over girls' education in SSA (Kazeem, Jensen and Stokes 2010; Taş, Reimão and Orlando 2014; Kuépié, Shapiro and Tenikue 2015; Bérenger and Verdier-Chouchane 2016; Vimefall, Andrén and Levin 2017) and in Ethiopia (Mani, Hoddinott and Strauss 2013; Tesfu and Gurmu 2013). To our knowledge, there is only one study on gendered preferences in the QQ trade-off in SSA in particular (Alidou and Verpoorten 2019). This study estimated a causal relation, considered only gender preferences in education and used historical data. Our paper goes beyond previous studies by jointly analyzing preferences for quantity and quality and focusing on twofold gender biases, based on experimental data. Understanding gendered fertility preferences is important, as a gender bias can contribute to high fertility rates and impede the demographic transition. If girls are less educated than boys, female empowerment and women's opportunity cost to raise more children will remain low in future generations (Atake and Gnakou Ali 2019). The gender gap in school enrolment rates in SSA is the largest in the world: the expected number of years of schooling is 9.3 years for girls and 10.3 years for boys (United Nations 2019).

Third, to measure fertility preferences, previous studies have employed direct questions such as the ideal or desired family size, the wanted fertility, the wanted status of recent births and desire for more children (Bongaarts 2011). These measures have several drawbacks: nonresponse, rationalization, unrealistic, problems with comparison and influence by factors other than family size preference. Our DCE method allows to circumvent these disadvantages in analyzing fertility preferences. The strength of the DCE method is that strategic bias and *yeah saying* is less likely and that it allows to analyze trade-offs in preferences. The DCE is designed using a mixture-amount model with a non-linear utility function. This model is highly appropriate to jointly estimate QQ preferences, and is based on pioneering work of some authors (Raghavarao and Wiley 2009; Khademi and Timmermans 2012; Ruseckaite, Goos and Fok 2017; Goos and Hamidouche 2019; Zijlstra, Goos and Verhetsel 2019).

Finally, the focus on Ethiopia to study the existence of the QQ trade-off is particularly relevant. Ethiopia is the 12th most populous country in the world and the 2nd in SSA, coupled with low school completion rates (completion rate of 54% in primary, 29% in secondary and 8% in tertiary education) and a large gender gap in school enrolment rates (expected years of schooling of 8.3 years for girls and 9.1 years for boys) (The World Bank 2020). The majority are confronted with budget constraints and child labour is still common (Alidou and Verpoorten 2019). With a current TFR of 4.1 births per woman, Ethiopia is believed to have reached the end of the second stage of the demographic transition and to enter the third or late transitional stage. Future population projection crucially depend on how fast the TFR drops during this stage.

2 Theoretical considerations

The QQ trade-off originates from classical economic theory, typically ascribed to Malthus, which models the demand for children in a similar way as the demand for other goods, assuming that children are normal goods without close substitutes. The model assumes that parents' utility is defined by the quantity of children as single dimension, and a positive income elasticity for children. The latter is at odds with the observation of high-income countries having passed all stages of the demographic transition, where the TFR declined over time (Fernihough 2017). Becker generalizes this model by proposing that parents' utility is defined by two dimensions: the quantity and quality of childrearing (1960). Becker postulates that an increase in income due to the industrialization process and the associated increase in the opportunity cost of upbringing results in two effects: a positive income effect that is dominated by a negative substitution effect. This theory is later extended by Becker and Lewis (1973), Willis (1973), Becker and Tomes (1976), Becker, Murphy and Tamura (1990) and Moav

(2005). Galor (2012) shows that for countries that passed all stages of the demographic transition, fertility is not directly related to per capita income within and across countries, refuting the income-related driving force that Becker attributes to the trade-off. Moreover, Becker, Cinnirella and Woessmann (2010) state that Becker's models (1960; 1973) imply an unexplained innate bias against child quantity (i.e. by assuming that the negative substitution effect is higher than the positive income effect).

The unified growth theory models the transition from Malthusian stagnation to modern economic growth in a single framework. The theory states that technical progress increases the demand for human capital, which results in an increase in income (Cinnirella and Streb 2017). This results in reduced budget constraints and makes more resources available for the quantity and quality of children. Furthermore, the increased demand for human capital results in a reallocation of these resources from the quantity to the quality component of childrearing. Our study is based on the most recent theoretical framework of Galor (2012) that considers the possible existence of the QQ trade-off. We extent the model to study gendered preferences, including a gender gap in human capital. Consider a two-parents collective household model where both parents have their own preferences. Both parents get utility[5] from their own consumption (c), the number of surviving children (n) and the gender-specific human capital (h_i where i refers to boys *(b)* or girls *(g)*) (via increased returns on investment) (Eq. 1):

$$\mathrm{U}_{parent} = (1 - \gamma) * \ln(\mathrm{c}) + \gamma * [\ln(n) + + \ln\left(h_b^{\alpha} + h_g^{\beta}\right)] \tag{1}$$

where $\gamma \in [0,1]$ and $\alpha, \beta \in [0,1]$ represent the household's preferences for childrearing quantity and quality respectively. Assume that the household has one unit of time. Parents choose the number of children and associated quality of upbringing based on the constraint of the total

---

[5] The utility is assumed to be log-linear towards n, h and c in order to have a strictly monotonically increasing and quasi-concave function over [0, +∞[.

amount of time that can be allocated to upbringing and labor. The fraction of the time unit available for the household for raising children is τ. This cost can be decomposed into the fraction of fixed time cost that is independent of the child quality (τ^q) and the time cost (τ_i^e) per unit of education (e_i) where i refers to boys (b) or girls (g) (Eq. 2):

$$\tau = \tau^q + \tau_b^e * e_b + \tau_g^e * e_g \tag{2}$$

The household's budget constraint is then defined by the potential household income (y) if the whole time unit is devoted to the labor market. This income can be divided between the opportunity cost of raising n children ($\tau * n * y$) or towards consumption (c) (Eq. 3):

$$\tau * n * y + c \leq y \tag{3}$$

Assume that an individual with gender i's level of human capital (h_i) is defined by the level of education of gender i (e_i) and the rate of technological progress (t) (Eq. 4):

$$h_i(e_i, t) \tag{4}$$

On the one hand, technological progress results in a lower level of adaptation of existing human capital to the new environment. Therefore, h_i is supposed to be a decreasing strictly convex function of g. On the other hand, education reduces this effect by increasing the adaptability of human capital to the new environment. Therefore, h_i is assumed to be an increasing concave function of e_i with $\lim_{e \to 0} h_{e,i}(e_i, t) = \infty$, $\lim_{e \to \infty} h_{e,i}(e_i, t) = 0$ and $h_i(0, t) > 0$ (i.e. individuals have a certain level of human capital without investment in the level of education). The optimal solution to this problem implies that (Eq. 5, 6 and 7):

$$n = \frac{\gamma}{\tau^q + \tau_b^e * e_b + \tau_g^e * e_g} \tag{5}$$

$$\tau_b^e * (h_b^\alpha + h_g^\beta) = \alpha * \frac{\partial h_b^{\alpha-1}}{\partial e_b} * (\tau^q + \tau_b^e * e_b + \tau_g^e * e_g) \tag{6}$$

$$\tau_g^e * (h_b^\alpha + h_g^\beta) = \beta * \frac{\partial h_g^{\beta-1}}{\partial e_g} * (\tau^q + \tau_b^e * e_b + \tau_g^e * e_g) \tag{7}$$

The derivation can be found in Appendix B. The optimal solution reveals two main elements. First, Eq. 5 illustrates the inverse relationship (i.e. trade-off) between quantity (n) and quality

(e). Eq. 5 shows that if preferences are homothetic (i.e. no preference for quantity or quality of childrearing), an increase in parents' income (y) will have no effect on the number of children, since a rise in income would result in an income effect towards quantity and a substitution effect towards the quality of upbringing, which will cancel each other out. Eq. 6 and 7 show that the optimal level of investment in child quality increases if the demand for human capital for boys (α) or girls (β) increases (i.e. $\partial e(t, \alpha, \beta, \tau^q, \tau_i^e)/\partial \alpha > 0$ and $\partial e(t, \alpha, \beta, \tau^q, \tau_i^e)/\partial \beta > 0$), the time cost to raise a child (independent of child quality) increases (i.e. $\partial e(t, \alpha, \beta, \tau^q, \tau_i^e)/\partial \tau^q > 0$) or the cost to educate a child decreases (i.e. $\partial e(t, \alpha, \beta, \tau^q, \tau_i^e)/\partial \tau_i^e > 0$). Second, regarding the effect of gender preference, Eq. 5 shows that fertility (n) will decrease when the gender education gap (e_g/e_b) improves towards more schooling for boys and/or girls and vice versa. In addition, Eq. 6 and 7 show that if the preference for human capital of boys (α) is higher than the preference for human capital of girls (β), either the ratio of the time cost per unit of education for boys over girls (τ_b^e/τ_g^e), or the ratio of investment in education of boys over girls (e_b/e_g) will increase.

3 Materials and methods

3.1 Research area and sampling

We used primary survey and DCE data from the SNNPR in Ethiopia. We collected data in six districts in the Gamo Gofa and Segen People's Zones in SNNPR (Figure 1). This is a predominantly rural area with high ethnic diversity (85 ethnic groups) (Central Statistical Agency 2012). The TFR is 4.9 in the Gamo Gofa Zone and 5.6 in the Segen People's Zone (Central Statistical Agency 2012; Teklu, Sebhatu and Gebreselassie 2013). Net school attendance in the region is 73.8% for primary school and 16.4% for secondary school. The educational system in Ethiopia is visualized in Figure C1 in Appendix C.

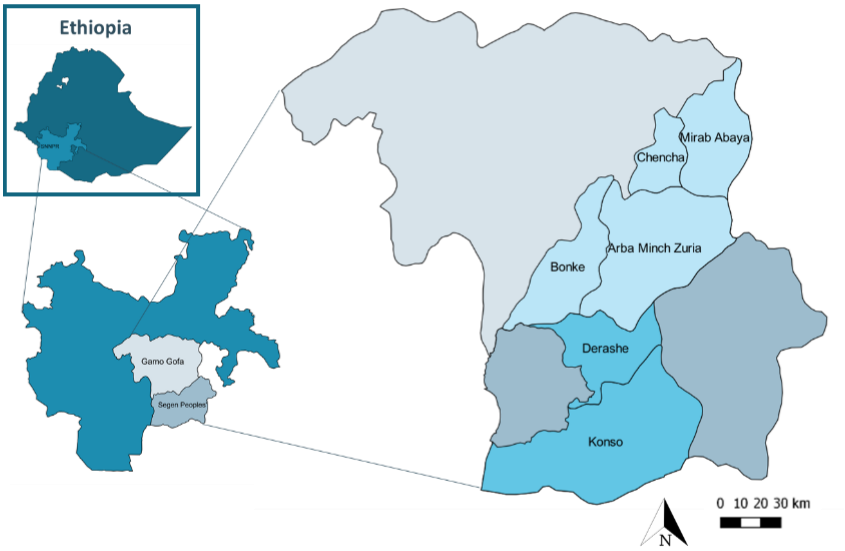

Figure 1: Map of the study area in the Gamo Gofa Zone and Segen People's Zone within the Southern Nations, Nationalities, and People's Region in Ethiopia

The sample comprises 434 respondents in the age category 18 to 25 years. The choice of this age group is motivated by the focus on ex ante preference data at the start of the reproductive lifetime and is based on the legal minimum age for marriage of 18 years and the median age of first childbirth of 19.5 years in Ethiopia (Ethiopian Society of Population Studies 2008). We used a three-stage sampling strategy. In the first stage, we selected 31 villages in the 6 districts in a stratified random way, with stratification based on district and agro-ecology (low-, mid- and highlands). In the second stage, we listed all households with members in the targeted age category in each of these 31 villages, and randomly selected a fixed number of 14 households from this list in each village. In the third stage, we randomly selected one of the household members in the relevant each category within each selected household.

3.2 Choice experiment design

We investigated latent fertility preferences using a DCE method that allows to analyze trade-offs[6], and self-expressed fertility preferences through follow-up questions to respondents on

---

[6] DCE and contingent valuation are both common methods to investigate preferences but the latter does not allow

the preferred number of children after implementation of the DCE. In a DCE, respondents are confronted with several choice cards including two or more mutually exclusive alternatives that are defined by a set of attributes with varying levels, within and across the choice cards. By repeatedly asking respondents to reveal their most preferred option, one can – based on the random utility theory proposed by Thurstone (1927) – determine which attributes and levels contribute most to the respondent's utility and analyze potential trade-offs between attributes.

3.1.1 Attributes and attribute levels

Given the focus on the QQ trade-off in fertility preferences, the attributes include the number of children (as the sum of the number of boys and girls) and eight attributes related to schooling: the number of boys/girls not receiving any schooling and the number of boys/girls attaining a certificate at the end of primary, secondary or tertiary schooling (Table 1). Secondary schooling includes both high school and preparatory school. Tertiary schooling comprises both technical and vocational schooling (TVET) and university because both entail higher costs due to (i) school fees (while primary and secondary school are free of charge) and (ii) transportation to and/or accommodation in larger cities where TVET and university institutions are located. The choice to focus on completing a certain level of education is based on the high drop-out ratio in primary (46%) and secondary school (71%) (The World Bank 2020).

The attributes consist of discrete levels ranging from zero/one to 12 children. The maximum total number of children is set at 12, a choice guided by the observed household size in the study area. Therefore, when designing the DCE, we incorporated a constraint ensuring that the sum of the number of girls and boys distributed over the four education levels should not exceed 12. This resulted in 162,425 possible attribute level combinations or alternatives.

---

to analyze trade-offs.

Table 1: Attributes and their levels in the DCE

Variable	Attributes	Attribute levels
Amount component		
a	Total number of children (*Number of Children*)	1, 2, 3, 4, 5, 6, 8, 9, 10, 12
Mixture component		
x_1	Number of boys who have not received any schooling (*Boys No Schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12
x_2	Number of girls who have not received any schooling (*Girls No Schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12
x_3	Number of boys who have completed primary schooling (*Boys Primary Schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12
x_4	Number of girls who have completed primary schooling (*Girls Primary Schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12
x_5	Number of boys who have completed high school & preparatory schooling (*Boys Secondary*	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12
x_6	Number of girls who have completed high school & preparatory schooling (*Girls Secondary*	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12
x_7	Number of boys who have completed university or TVET (*Boys Tertiary Schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12
x_8	Number of girls who have completed university or TVET (*Girls Tertiary Schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12

3.1.2 Mixture-amount modelling

In our study, any given family with at least one child is interpreted as a mixture of the eight components listed in Table 1. Because we are also interested in the impact of the total number of children on the respondents' preference, we used a mixture-amount model as a starting point to design our DCE and to analyze the resulting data. The use of mixture models and mixture-amount models is not common in the context of DCEs, the exceptions being Ruseckaite et al. (2017), Raghavarao and Wiley (2009), Goos and Hamidouche (2019), Khademi and Timmermans (2012), Zijlstra et al. (2019) and Pradhan et al. (2017).

Because there is no software for designing DCEs for mixture-amount models, we adopted a construction similar to that of Zijlstra et al (2019) and constructed our DCE in two steps using JMP Pro 14 (SAS Institute Inc. 2018) and SAS 9.4 (SAS Institute Inc. 2013). First, for each value a of the total number of children in Table 1, we created a candidate list for the mixture proportions in JMP using an $\{8, a\}$ simplex lattice design for the eight components in Table 1. This ensured that, in all of the alternatives in our DCE, the sum of the eight components matched the total number of children, and resulted in a candidate list of 5,960 possible alternatives. Second, we computed the 60 choice sets with the highest information content in terms of the D-optimality criterion using the OPTEX procedure in SAS. A D-optimal design guarantees precise parameter estimates by minimizing the determinant of the variancecovariance matrix of the parameter estimates (Rose and Bliemer 2009). To create the experimental design with the OPTEX procedure, we had to specify a specific mixture-amount model. We chose a third order Scheffé model for the eight mixture components combined with a polynomial model of order five for the amount effect (Eq. 8):

$$U = \sum_{i=1}^{8} \beta_i x_i + \sum_{i=1}^{7} \sum_{j=1+i}^{8} \beta_{ij} x_i x_j + \sum_{i=1}^{6} \sum_{j=i+1}^{7} \sum_{k=j+1}^{8} \beta_{ijk} x_i x_j x_k + \gamma a + \gamma a^2 + \gamma a^3 + \gamma a^4 + \gamma a^5 + \varepsilon \tag{8}$$

The third order Scheffé model for the mixture variables allows for potential curvature in the relationship between the mixture components and the utility. We added a polynomial model of order five for the amount variable to ensure that the DCE contains intermediate levels for the number of children.

Three adjustments of the candidate list were necessary to avoid unrealistic choice cards in the D-optimal experimental design. First, our initial designs for the DCE included multiple choice sets with extreme options (1 child or 12 children). We solved this by forcing the OPTEX procedure in SAS to include alternatives with at least three proportions different from zero for amount variables larger than two. Second, a large number of choice sets did not include children with primary education. This was solved by excluding possible alternatives in which at least 50% of the children did not have a primary school certificate. Third, we excluded alternatives with an extremely high proportion of boys or girls by adding the constraint that the binomial probability for the proportions had to be larger than 0.1. The final experimental design based on Eq. 8 and involving 60 choice sets can be found in Table C1 in Appendix C.

In our DCE, we did not add an opt-out option because this could lead to a lack of information. Previous research has shown that parents might have self-expressed reasons related to situational influences (e.g. the decision of God) rather than personal dispositional factors

(Farina *et al.* 2001). This research has to be interpreted as an ex ante study which assumes that the respondents do want children in the future.

3.3 Implementation

To administer the DCE to the respondents without imposing a too high cognitive burden, we partitioned the 60 choice sets into five blocks of 12 profiles each and randomly assigned the respondents to one of the five blocks. We used visual aids since the adult literacy ratio in Ethiopia is only 39% (Central Statistical Agency and ICF International 2016). Appropriate images were examined during focus group discussions in four non-sampled villages in the research area. Figure 1 visualizes one of the choice cards, showing that by using the mixture-amount model, a large number of attributes can be included while keeping the choice cards simple.

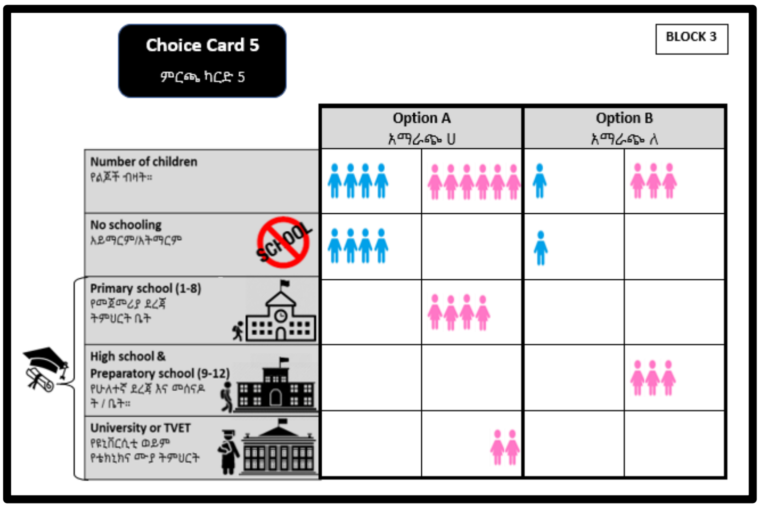

Figure 2: Example of one of the choice cards

We conducted the DCE during the period August-October 2019. Six enumerators collected the data, using tablets and the free software application ‘Open Data Kit’. To reduce measurement error and informational bias, the DCE started with two test cards including one dominant choice card, while the order of the remaining choice cards was randomized between respondents. Subsequently, 12 choice cards from one of the five blocks were presented. As a robustness check, the DCE ended with two duplicates per respondent (Appendix A).

3.4 Analysis

To analyze the DCE data, we used the mixed logit model (MXLM)[7], which is a discrete choice model that allows of revealing preference heterogeneity among respondents (Revelt and Train 1998). We estimated two types of models: a plain mixture-amount model and a mixture-amount model to which the covariate *Gender* was added as an interaction term to investigate the possible difference in preference between male and female respondents. In both models, we dropped one of the linear terms (*Girls No Schooling)* to make the choice model estimable, as explained by Goos and Hamidouche (2019). The parameter estimates of the MXLM quantify the average respondent's preferences.

We tested different mixture-amount models, including those described by Scheffé (1958), Khuri (2006), Kowalski et al. (2000), Pal and Mandal (2012) and Prescott (2004), all with a multiplicative effect of the amount variable to test the QQ trade-off and quadratic or higher order effects for the variable *Number of Children* to mimic the relationship between the parents' utility and the number of children based on the normal distribution of family size in the world (The World Bank 2020). We selected the best mixture-amount model based on the Bayesian Information Criterion (BIC), as recommended by Schwarz (1978). This resulted in the selection of the following model (Eq. 9):

$$E(U) = \left(\sum_{i=1}^{7} \beta_i \, x_i\right) + \, a\left(\sum_{i=1}^{8} \beta_i \, x_i\right) + \, a^2\left(\sum_{i=1}^{8} \beta_i \, x_i\right) \tag{9}$$

We estimated the MXLM via the hierarchical Bayes option in JMP using 10,000 iterations, 5,000 of which were for burn-in. This is equivalent to the maximum likelihood estimation but

---

[7] We also estimated a conditional logit model but the AICc and BIC values indicated that the MXLM fitted the data better, indicating that there is preference heterogeneity among the respondents.

entails a smaller computational burden and time (Huber and Train 2001). We used the maximum likelihood estimates as starting values.

We performed a robustness check to control for attribute non-attendance (ANA) and scale heterogeneity. A description of the methods and results can be found in Appendix A. We found that the experiment is robust to both ANA and scale heterogeneity.

To evaluate the existence of a QQ trade-off, we calculated the marginal rate of substitution (MRS) (Eq. 10) because it is the only measure that can handle non-orthogonal designs without predefined attribute changes, and it focusses on the homogeneity in respondents' preferences (Lancsar, Louviere and Flynn 2007):

$$MRS_{a,x_i} = \frac{\partial U/\partial a}{\partial U/\partial x_i} = \frac{-dx_i}{da} \tag{10}$$

with U the utility, x_i a certain level of schooling and a the number of children (as defined in Table 1). To facilitate interpretation, the MRS is visualized as the slope of several indifference curves along which utilities are constant, implying that the respondent is indifferent between certain combinations of attributes.

To analyze the existence of a gender bias for boys or girls in the QQ trade-off, the indifference curves cannot be compared quantitatively as each graph considers two of the nine attributes *ceteris paribus*. Therefore, we calculated the optimal mixture of schooling at the optimal number of children using a two-step approach. First, we maximized the utility as a function of the variable *Number of Children*. Secondly, we created an area plot for the eight schooling components as a function of the number of children in JMP. The optimal mixture of schooling is found at the intersection with the optimal number of children.

4 Results

4.1 Fertility preferences and the QQ trade-off

Respondents are on average 21 years old, where men are on average older than women, 64% are Protestant and 29% have completed secondary school, with more women having completed the first cycle of secondary school than men (Table 2). Respondents are mainly students (36%) or are employed in the agricultural (22%) or non-agricultural sector (21%). The vast majority of respondents is not married (77%) and has no children (80%). More men (27%) are currently married than women (19%). Respondents with children, have on average two children. The average self-expressed preferred family size is 4 children with, on average, a higher stated preference for boys than for girls (a preferred sex ratio of 1.118) (Table 3). A large share of the respondents (88%) have knowledge about contraception, 60% have never used contraception and 18% are currently using it. The awareness about contraception is significantly higher among male respondents than among female respondents while the use of contraception does not differ with respondents' gender. About 95% of respondents state to have access to contraception in the village, of which 39% state to have never experienced a shortage of contraceptives in the village.

Table 2: Socio-demographic characteristics of the respondents, by gender

Variable	Total		Female		Male		
	Mean	St.	Mean	St.	Mean	St. dev.	
Number of observations	426		209		217		
Age (years)	20.74	2.31	19.89	1.98	21.55	2.33	***
Religion							
Orthodox (%)	33.57		30.62		36.41		
Catholic (%)	0.23		0.00		0.46		
Protestant (%)	63.62		67.94		59.45		*
Traditional religion (%)	1.17		0.48		1.84		
Other religion (Akale, Mekane eyesus and Hawariyat) (%)	1.4		0.96		1.84		
Ethnic group							
Gamo (%)	53.05		52.63		53.46		
Konso (%)	25.59		25.84		25.35		
Derashe (%)	11.50		12.44 10.41 |		10.60		
Other ethnic group (Kusume, Wolaita, Gofa, Zavse, Gidicho and Kore)	9.85		9.10		10.59		
Education							
No Education (%)	3.52		4.31		2.76		
Primary schooling incomplete (%)	14.79		11.98		17.52		
Primary schooling complete (%)	9.62		8.61		10.60		
High school incomplete (%)	8.69		7.18		10.14		
High school complete (%)	32.86		37.32		28.57		*
Preparatory schooling incomplete (%)	1.41		0.48		2.30		
Preparatory schooling complete (%)	6.34		7.66		5.07		
TVET incomplete (%)	11.74		12.92		10.60		
TVET complete (%)	8.21		6.23		10.14		
University - bachelor's degree (%)	2.82		3.35		2.30		
Principal occupation							
Student (%)	36.38		39.23		33.64		
Farmer - own farm (%)	21.83		12.91		30.42		***
Farm worker – hired worker (%)	0.47		0.00		0.92		
Family laborer in the household (%)	11.27		18.18		4.61		**
Non-farm job – self-employment or hired worker (%)	21.13		19.15		23.04		
Looking for a job (%)	8.92		10.53		7.37		
Marital status							
Married (%)	23.00		19.14		26.73		*
Age at first marriage (years) – married respondents	19.12	2.42	17.83	1.93	20.02	2.32	***
Not married (%)	77.00		80.86		73.27		*
Preference to become married (%) – unmarried respondents	85.06		86.98		83.02		
Preferred age at first marriage (years) – unmarried respondents	25.12	2.78	23.83	2.27	26.55	5.59	***

*Note: Comparison between the male and female subgroups is based on: a) for ratio data: an ANOVA test with post-hoc Tukey test (if the normality and homoscedasticity assumption is valid) or a Kruskal-Wallis test with post-hoc Dunn's test accounting for the False Discovery Rate (if the normality and homoscedasticity assumption do not hold) and b) for nominal data: a pairwise Chi Square test accounting for the False Discovery Rate. Significant differences of the mean of the male vs. female subgroups are shown with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.*

Table 3: Respondents' characteristics and preferences concerning childrearing and contraception, by gender

Variable	Total		Female		Male		
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	
Number of observations	426		209		217		
Current children							
Having children (%)	19.48		16.27		22.58		
Current number of children – respondents with children	1.74	1.02	1.71	1.13	1.76	0.95	
Current number of boys – respondents with children	0.89	0.69	0.94	0.68	0.86	0.71	
Current number of girls – respondents with children	0.86	0.84	0.77	0.84	0.92	0.84	
Having deceased children (%)	7.14		8.57		6.12		
Number of deceased children – respondents with deceased children	1.33	0.52	1.33	0.58	1.33	0.58	
Number of deceased boys – respondents with deceased children	0.83	0.75	1.00	1.00	0.67	0.58	
Number of deceased girls – respondents with deceased children	0.5	0.55	0.33	0.58	0.67	0.58	
Age at first child birth (years) – respondents with children	19.71	2.24	18.66	2.10	20.47	2.03	***
Preferred age at first child birth (years) – respondents without children	26.26	3.12	24.91	2.36	27.65	3.20	***
Preferred number of children (self-expressed)							
Total	4.32	1.20	4.29	1.11	4.35	1.28	
Boys	2.28	0.74	2.25	0.66	2.30	0.82	
Girls	2.04	0.70	2.03	0.71	2.05	0.70	
Contraception							
Knowledge about contraception (%)	82.39		76.08		88.48		***
Ever used contraception (%)	40.14		40.19		40.09		
Currently using contraception (%)	17.84		16.27		19.35		
Having access to contraception in this village (%) – respondents with knowledge	95.44		95.60		95.31		
Shortage of contraceptives – Never (%) – respondents with access	39.40		44.08		35.52		
– Few times a year (%) – respondents with access	15.82		13.16		18.03		
– Few times a month (%) – respondents with access	13.43		11.84		14.75		
– Always (%) – respondents with access	0.30		0.66		0.00		
– Don't know (%) – respondents with access	31.04		30.26		31.69		
Preference for access to contraceptives (%) – respondents without access	81.25		100.00		66.67		

*Note: Comparison between the male and female subgroups is based on: a) for ratio data: an ANOVA test with post-hoc Tukey test (if the normality and homoscedasticity assumption is valid) or a Kruskal-Wallis test with post-hoc Dunn's test accounting for the False Discovery Rate (if the normality and homoscedasticity assumption do not hold) and b) for nominal data: a pairwise Chi Square test accounting for the False Discovery Rate. Significant differences of the mean of the male vs. female subgroups are shown with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.*

To analyze fertility preferences, first, the MXLM is estimated for the entire sample (Table 4). The results show that parents derive utility from all the attributes. Thus, quantity, quality and gender are important in fertility preferences. To facilitate the output interpretation of the non-linear model specification, Figure 3 visualizes the interaction effects between the number of children and the eight education levels. For most of the graphs, at any given schooling attribute percentage, utility is lower if the number of children increases, showing that respondents' utility decreases if the number of children increases. Further, the utility follows a decreasing course when the percentage *Girls No Schooling* and *Boys No Schooling* increases, while the utility increases when *Girls Tertiary Schooling* and *Boys Tertiary Schooling* increases, with the highest utility for four to eight children. This shows the high preference for tertiary education and the low preference for no education.

Table 4: Parameter estimates of the plain MXLM

Variable	Posterior mean		Posterior SD	Lower 95% CI	Upper 95% CI
Girls primary schooling	-11.55		22.59	-48.14	25.01
Girls secondary schooling	181.83	*	16.23	155.27	223.54
Girls tertiary schooling	48.26	*	15.72	19.79	90.76
Boys No Schooling	-84.65	*	32.20	-142.32	-32.44
Boys Primary Schooling	166.43	*	20.81	130.05	202.38
Boys Secondary Schooling	14.98		13.11	-11.51	43.03
Boys Tertiary Schooling	86.88	*	21.52	44.99	123.84
Girls No Schooling*Number of Children	-40.84	*	10.54	-57.06	-25.61
Girls Primary Schooling*Number of Children	21.70	*	6.60	10.57	30.73
Girls Secondary Schooling*Number of Children	0.06		3.59	-5.37	8.78
Girls Tertiary Schooling*Number of Children	41.44	*	3.80	35.10	49.53
Boys No Schooling*Number of Children	0.18		4.68	-6.44	9.12
Boys Primary Schooling*Number of Children	-53.48	*	9.42	-68.43	-39.00
Boys Secondary Schooling*Number of Children	13.17	*	3.45	8.46	21.58
Boys Tertiary Schooling*Number of Children	115.72	*	10.13	94.24	132.09
Girls No Schooling*Number of Children^2	1.10		0.84	-0.25	2.45
Girls Primary Schooling*Number of Children^2	-1.76	*	0.50	-2.52	-1.00
Girls Secondary Schooling*Number of Children^2	-2.46	*	0.25	-2.89	-1.93
Girls Tertiary Schooling*Number of Children^2	-3.94	*	0.36	-4.84	-3.39
Boys No Schooling*Number of Children^2	0.20		0.33	-0.40	0.84
Boys Primary Schooling*Number of Children^2	1.99	*	0.54	1.24	3.09
Boys Secondary Schooling*Number of Children^2	-1.58	*	0.30	-2.18	-1.09
Boys Tertiary Schooling*Number of Children^2	-10.07	*	0.88	-11.49	-8.16
AICc			144.35		
BIC			294.59		
-2LL			98.14		

*Note: Significant differences of the posterior mean on a 5% level are indicated with *. The posterior SD refers to the posterior standard deviation.*

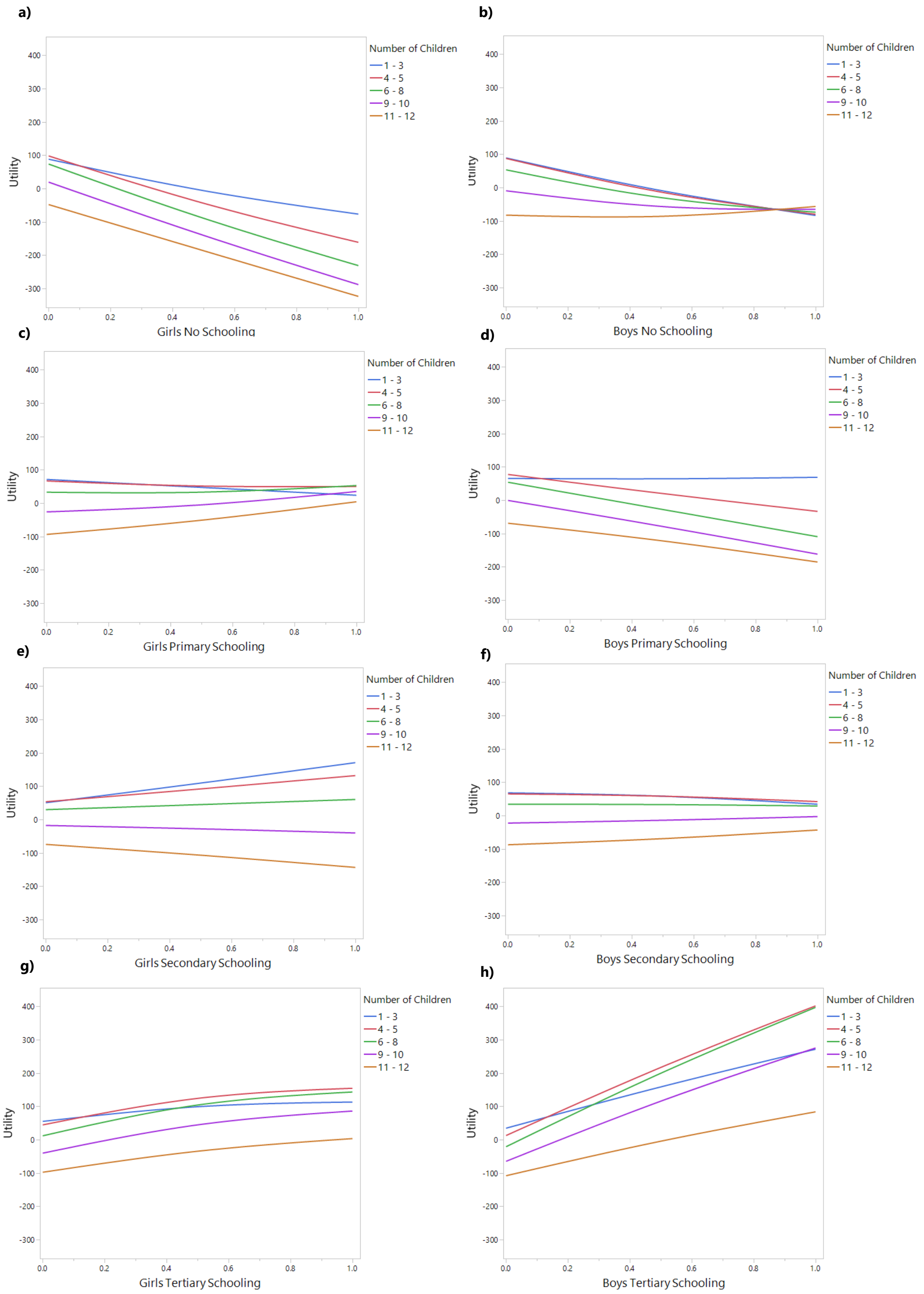

Figure 3: Visualization of the MXLM parameter estimates of respondents' utility in function of the different schooling components for different ranges of the number of children. Note: all results need to be interpreted with respect to the variable Girls No Schooling

To analyze the existence of the QQ trade-off, the MRS is visualized as the slopes of the utility indifference curves (i.e. constant-utility curves) in Figure 4. The MRS should to be interpreted at to the highest utility level as respondents are assumed to maximize their utility during the DCE. A decreasing slope of the utility indifference curves indicates that respondents are willing to trade off education and number of children, whereas an increasing slope indicates that respondents are only willing to accept one more child if more of their children attain a certificate of the corresponding education level. The steepness of the slope shows whether respondents are willing to trade off (in case of a decreasing slope) or gain (in case of an increasing slope) an amount of the quality component for one more child.

Figure 4 reveals that respondents make a QQ trade-off for some of the schooling attributes, as seen in the graphs for no schooling (Figure 4a and b) and tertiary schooling (Figure 4g and h). This cannot be deducted from the graphs on primary and secondary schooling as it remains unclear whether a decreasing slope (e.g. for secondary schooling) indicates respondents' willingness to have a lower (i.e. primary) schooling in return for more children (and thus make a QQ trade-off) or a higher (i.e. tertiary) schooling in return for more children (and thus do not make a QQ trade-off). The QQ trade-off only applies until respondents reach a certain number of children and can be interpreted as respondents' willingness to have fewer children if more of their children can reach a higher level of education, or as respondents' willingness to accept a lower level of education for their children in return for more children until a certain number of children is reached. Figure 5 reveals that, on average, respondents' utility is maximized at 5.75 children, which corresponds closely to the turning point at the highest utility indifference curve, where the MRS is zero, in figure 4 h and g. Beyond this turning point, respondents are only willing to have more children, if their children can reach a higher level of education, indicating that the preference for quality dominates.

Figure 6 shows that, at the utility-maximizing number of 5.75 children, the share of boys over the four education levels (58%) is higher than the share of girls (42%), indicating a preference for boys over girls. Moreover, for tertiary education, which is the preferred level of education, there is a preference for more boys (44%) than girls (24%) indicating a gender bias towards boys in preferences for education.

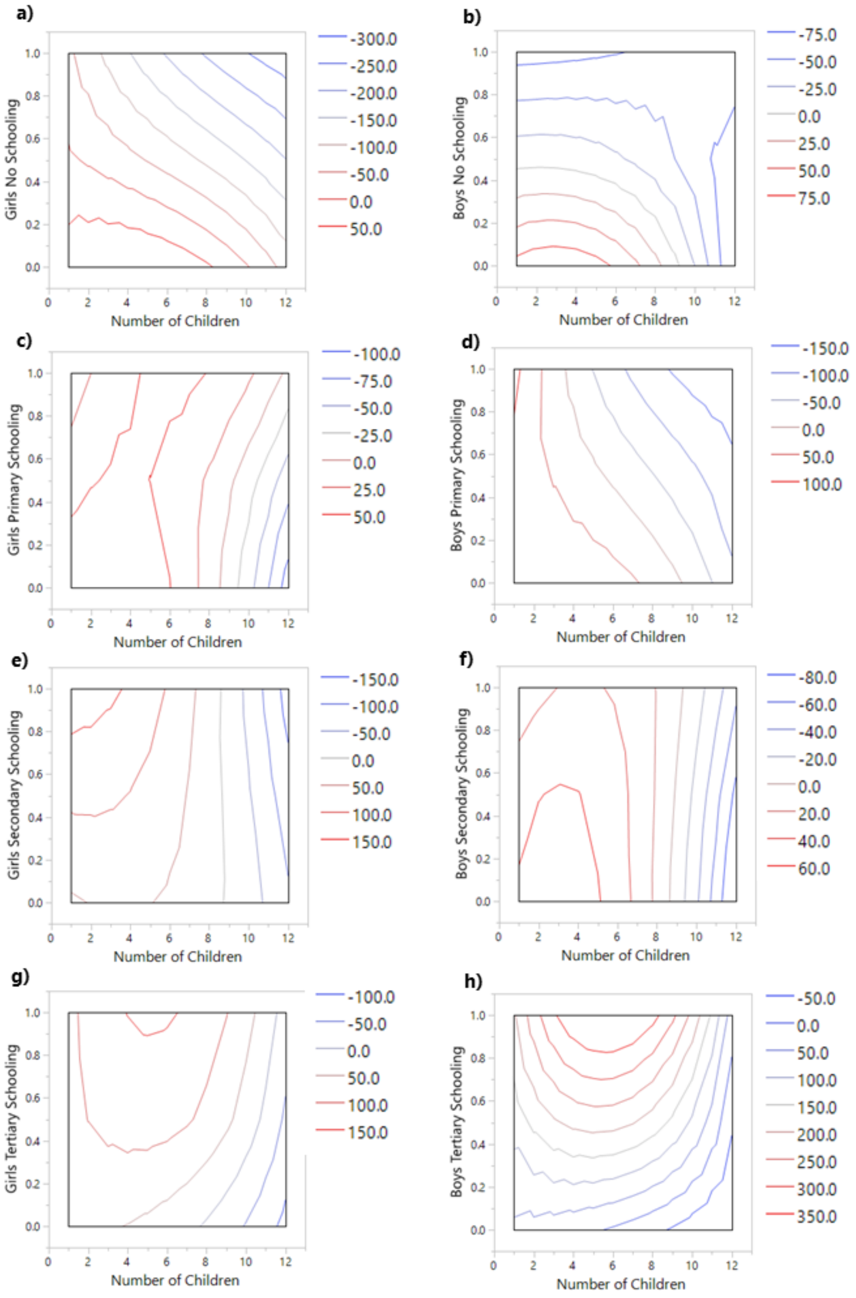

Figure 4: Utility indifference curves for the different schooling components (y-axis) and the number of children (x-axis) to visualize the MRS ceteris paribus. The brightest red lines show the highest constant-utility curves. Note: all results need to be interpreted with respect to Girls No Schooling.

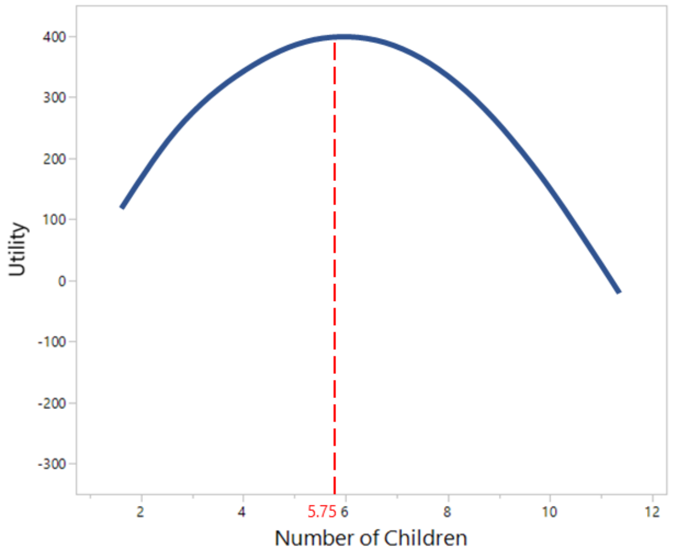

Figure 5: Visualization of the MXLM parameter estimates for the variable 'number of children' with indication of the maxima in red

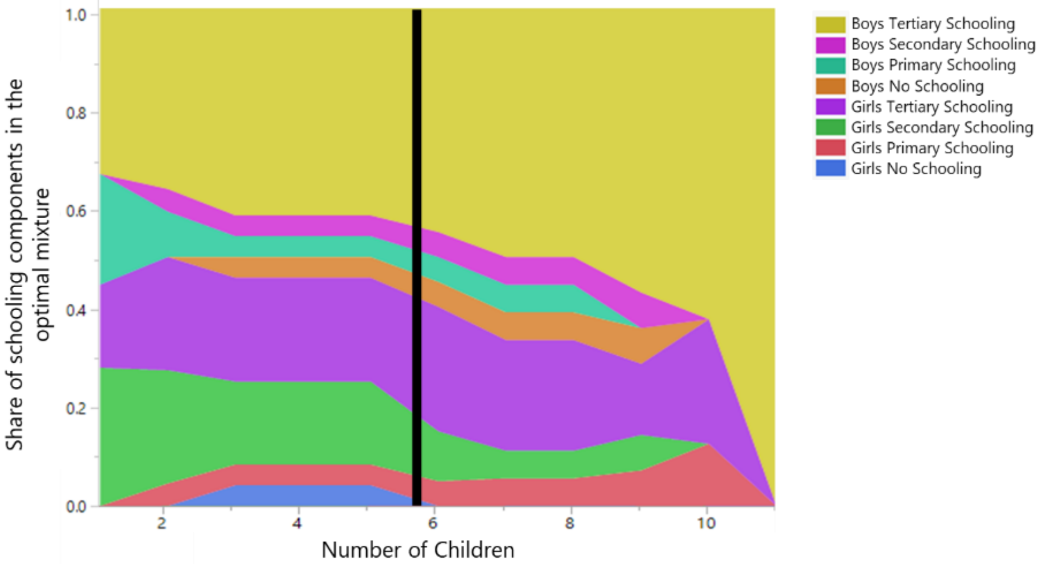

Figure 6: Optimal mixtures for the schooling components as a function of the highest desirable number of children as derived above (indicated by the black line). Note: all results need to be interpreted with respect to Girls No Schooling.

4.2 Heterogeneity in fertility preferences and the QQ trade-off

To analyze the heterogeneity in fertility preferences between male and female respondents, the MXLM with the variable *Gender* as a covariate is estimated (Table 5). The output shows that there are significant differences in the preferences between male and female respondents for 13 of the 23 parameters. Figure C2 and C3 in Appendix C visualize the interaction effects between the number of children and the eight education levels, showing similar patterns in the utility levels for male and female respondents but a wider variance in utility levels for female respondents.

The analysis of the MRS reveals that both male and female respondents make a similar QQ trade-off except for *Boys Secondary Schooling* (Figure C4 and C5 in Appendix C). Figure 7 reveals that men’s utility is maximized at 5.98 children and women’s at 5.62 children. Regarding a possible gender preference in quantity, Figure 8 shows that male respondents have a preference for boys (58%, which is equal to the share of boys over the 4 education levels), while women seem to have no preference (50%). Moreover, men’s utility is maximized if most of their children are boys who can finish tertiary school (44%) followed by girls who can finish tertiary school (25%), while women’s utility is optimal if most of their children are boys who complete tertiary school (30%), followed by girls who finish tertiary (23%) or secondary (20%) school. Both elements of the trade-off therefore seem to be gender biased (except the number of children for women).

Table 5: Parameter estimates of the plain MXLM with interaction effects of the dummy variable gender (Female = 1; Male= 0)

Variable	Posterior mean		Posterior SD	Lower 95% CI	Upper 95% CI
Girls primary schooling	-219.14	*	18.76	-258.40	-186.34
Girls secondary schooling	19.85		21.16	-20.47	55.59
Girls tertiary schooling	-83.95	*	27.29	-136.00	-28.61
Boys No Schooling	-294.56	*	31.67	-352.44	-235.63
Boys Primary Schooling	212.63	*	41.63	146.77	297.16
Boys Secondary Schooling	-147.65	*	27.47	-203.67	-101.73
Boys Tertiary Schooling	-129.81	*	53.35	-213.91	-8.53
Girls No Schooling*Number of Children	-122.17	*	18.77	-160.11	-93.60
Girls Primary Schooling*Number of Children	34.43	*	8.67	17.68	50.31
Girls Secondary Schooling*Number of Children	32.54	*	6.93	20.08	45.45
Girls Tertiary Schooling*Number of Children	60.41	*	6.75	42.89	70.99
Boys No Schooling*Number of Children	1.54		8.56	-19.21	14.40
Boys Primary Schooling*Number of Children	-127.95	*	15.85	-153.75	-96.80
Boys Secondary Schooling*Number of Children	6.70		5.46	-4.71	16.67
Boys Tertiary Schooling*Number of Children	184.32	*	20.80	136.98	210.76
Girls No Schooling*Number of Children^2	6.42	*	1.93	4.02	10.53
Girls Primary Schooling*Number of Children^2	-2.81	*	0.75	-4.24	-1.52
Girls Secondary Schooling*Number of Children^2	-6.41	*	0.79	-8.03	-5.07
Girls Tertiary Schooling*Number of Children^2	-6.38	*	0.54	-7.36	-4.96
Boys No Schooling*Number of Children^2	-0.45		0.59	-1.61	0.70
Boys Primary Schooling*Number of Children^2	5.25	*	1.00	2.47	7.07
Boys Secondary Schooling*Number of Children^2	-1.37	*	0.68	-2.94	-0.26
Boys Tertiary Schooling*Number of Children^2	-15.42	*	1.71	-18.08	-11.83
Gender*Girls Primary Schooling	-14.74		37.82	-80.65	69.21
Gender*Girls Secondary Schooling	56.14		45.58	-37.10	133.06
Gender*Girls Tertiary Schooling	-106.51	*	41.41	-178.01	-16.79
Gender*Boys No Schooling	-238.43	*	74.51	-383.66	-67.46
Gender*Boys Primary Schooling	-8.46		37.04	-79.21	65.23
Gender*Boys Secondary Schooling	-21.10		53.65	-179.64	63.59
Gender*Boys Tertiary Schooling	-90.65	*	47.53	-192.58	-10.65
Gender*Girls No Schooling*Number of Children	-101.74	*	11.05	-124.05	-77.12
Gender*Girls Primary Schooling*Number of Children	-0.05		10.15	-19.71	18.24
Gender*Girls Secondary Schooling*Number of Children	37.33	*	13.54	16.50	63.37
Gender*Girls Tertiary Schooling*Number of Children	91.55	*	11.86	70.63	112.15
Gender*Boys No Schooling*Number of Children	13.53		20.13	-30.24	47.23
Gender*Boys Primary Schooling*Number of Children	-15.45		14.43	-44.01	6.13
Gender*Boys Secondary Schooling*Number of Children	80.26	*	16.99	53.34	118.32
Gender*Boys Tertiary Schooling*Number of Children	119.43	*	14.17	92.26	142.15
Gender*Girls No Schooling*Number of Children^2	8.38	*	1.40	5.57	10.91
Gender*Girls Primary Schooling*Number of Children^2	-0.02		0.82	-1.70	1.57
Gender*Girls Secondary Schooling*Number of Children^2	-5.02	*	1.01	-6.98	-3.07
Gender*Girls Tertiary Schooling*Number of Children^2	-7.09	*	1.06	-9.25	-5.40
Gender*Boys No Schooling*Number of Children^2	-1.25		1.91	-4.44	2.25
Gender*Boys Primary Schooling*Number of Children^2	-2.88		1.84	-6.67	0.14
Gender*Boys Secondary Schooling*Number of Children^2	-10.57	*	1.53	-12.98	-7.76
Gender*Boys Tertiary Schooling*Number of Children^2	-11.60	*	1.54	-13.91	-8.71
AICc			89.72		
BIC			226.91		
-2LL			47.54		

*Note: Significant differences of the posterior mean on a 5% level are indicated with *. The posterior SD refers to the posterior standard deviation.*

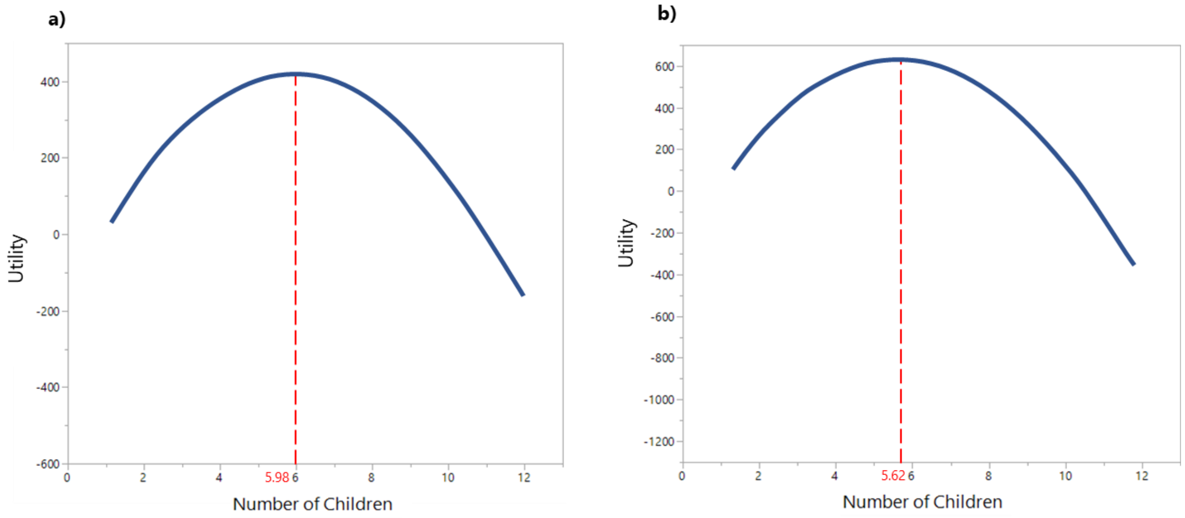

Figure 7: Visualization of the MXLM parameter estimates for the variable 'number of children' for a) male respondents and b) female respondents with indication of the maxima in red

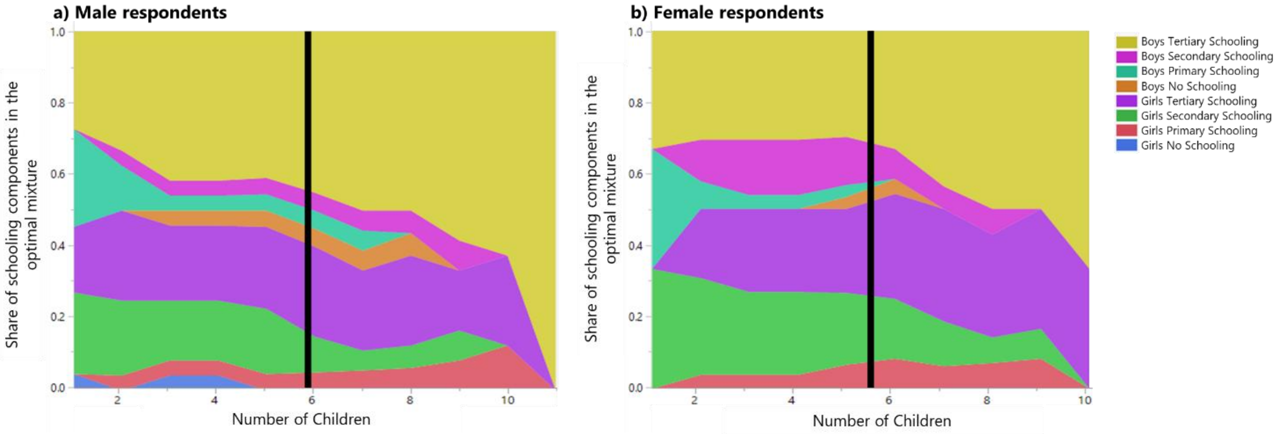

Figure 8: Optimal mixtures for a) the male and b) the female respondents from the MXLM for the schooling components as a function of the highest desirable number of children as derived above (indicated by the black line). Note: all results need to be interpreted with respect to Girls No Schooling.

5 Discussion

Our analysis documents the existence of a QQ trade-off in childrearing that is rooted in fertility preferences. Our results show a QQ trade-off at a lower quantity of children, and a dominance of the quality of childrearing at a higher number of children. We find a utility-maximizing point at 5.75 children on average, which corresponds to a turning point in the QQ trade-off beyond which respondents are only willing to have more children if more of them can complete a high level of education, indicating that the preference for quality dominates. The QQ trade-off is gendered in two ways. First, the results show that respondents have a preference for boys over girls, both in terms of the quantity and quality of childrearing. Second, we find that men generally have a higher preference for more sons than women, and that both men and women prefer a higher education for boys over a higher education for girls. The latter preference is more pronounced for men.

Our findings show that the QQ trade-off as described in the theoretical considerations in section 2 holds, but not over the whole range of hypothetical numbers of children. The QQ trade-off only applies until the utility-maximizing number of children is reached. Moreover, the model put forward in section 2 posits that an increase in the demand for human capital will lead to a pure substitution effect in the quality of upbringing. However, since the QQ trade-off applies only to a range of hypothetical numbers of children below the utility-maximizing number of children, our results imply that stimulating education will have no clear effect on fertility. As a result of the U-shaped indifference curves, fertility levels will either rise or fall. These empirical findings document that theoretical models on fertility need further fine-tuning to better capture nuances in fertility preferences and in QQ trade-offs.

This is the first study that uses a DCE to analyze the QQ trade-off by jointly estimating the QQ preferences. Previous studies focus on actual fertility outcomes rather than fertility preferences and use external instruments or natural experiments to study the effect of fertility on quality of childrearing. Only one study focused on a gendered QQ trade-off by identifying the causal relationship between family size and schooling by gender of the child using twinning as instrument (Alidou and Verpoorten 2019). Compiling 86 surveys from 34 countries in sub-Saharan Africa, they find no effect of family size on schooling by gender of the child, except for the subsample with families of three children they find a positive effect on boys’ schooling and for the subsample with families with at least four children they reveal a negative effect on girls’ schooling. A recent review of these studies suggest that the trade-off is small or non-existent and can be non-linear (Clarke 2018). We do find a QQ trade-off and confirm that this trade-off can be non-linear. In addition, our study is the first study that reveals that there is a trade-off below a certain number of children only.

The existence of a QQ trade-off over a range of the hypothetical number of children shows that a focus on education and fertility is complementary. Stimulating education (e.g. via increased availability, accessibility and affordability) can have two effects on fertility levels, either increasing or decreasing TFR. Our results imply that in the short run there is no clear-cut effect of stimulating education on fertility levels at the household level. In the long run however, education might reduce TFR as more educated parents are likely to have fewer children – as was pointed out by other researchers (Behrman 2015; Colleran and Snopkowski 2018). In addition, we observe a gendered preference for more boys, that applies mainly to men, and a gendered preference for boys' education over girls' education, that applies to both men and women. These gendered preferences, along with a documented positive correlation between low female education and high fertility (Becker, Cinnirella and Woessmann 2013; Brée and De La Croix 2019), call for attention to awareness raising about reducing fertility among men and to stimulating in particular girls' education to decrease fertility in the long run.

Our results reveal that the average utility-maximizing number of children in the research area is 5.75. This is slightly higher than the current observed TFR of 4.9 in the Gamo Gofa Zone and 5.6 in the Segen People's Zone (Teklu, Sebhatu and Gebreselassie 2013) and higher than the average self-expressed preferred family size of 4.32. The gap we observe between the latent and self-expressed preferred number of children is in line with a reported gap between an ideal and actual family size in the literature that ranges from one to two children (Bongaarts and Casterline 2013; Günther and Harttgen 2016; Trinitapoli and Yeatman 2018). This gap can be explained by (i) an inherent higher ideal family size[8] or (ii) by an unmet demand for contraception (Angeles, Guilkey and Mroz 2005; Kim 2010; Bongaarts and Casterline 2013; Günther and Harttgen 2016). The latter likely plays a role in our research area, given that 24% of female respondents have no knowledge about contraception, that 5% of respondents indicates to have no access at all to contraceptives in the villages and another 30% indicates that access to contraceptives is problematic. Yet, fertility preferences in the research area are high as well. The effectiveness of family planning policies and programs could improve through a complementary focus on reducing the prevailing family size norm and through more effective targeting of support in access to contraception to men and women with an actual demand for contraception. For effective family planning, demand for less children must precede the will to control fertility.

Our research demonstrates the usefulness of the DCE method for analyzing trade-offs in fertility preferences. A particular limitation of this research relates to the inability to derive standard deviations for the optimal number of children with the used software. Suggestions for further research are to relate fertility preferences and trade-offs to respondents' income levels to see if existential uncertainty affects the relationship. Further, the effect of parental education should be assessed to see if a higher parental education results in a reinforcing effect through a higher preference for higher education.

6 Conclusion

This paper analyses ex-ante fertility preferences to reveal the existence of a QQ trade-off in childrearing and twofold gendered preference, by gender of the respondent and by gender of the child. This is done through a DCE and a survey in six rural districts in southern Ethiopia.

---

[8] This gap could also be attributed to the fact that no 'opt-out' option is added to the DCE so that respondents needed to choose one of the two options on the choice cards.

Our study confirms the existence of a QQ trade-off below the utility-maximizing number of on average 5.75 children, and a dominance of quality of childrearing at higher numbers of children. Moreover, we find gendered preferences for boys in both the quantity and quality of childrearing, with men's gender bias in preferences towards boys more outspoken than women's gender bias in preferences.

Our study implies that education is a key factor in the decline in fertility rates during stage three of the demographic transition model (i.e. the late transitional stage). SSA countries are assumed to currently go through the second or third stage of the demographic transition model. To spur the decline in fertility rates, a focus is needed on both stimulating education and on changing norms about the ideal family size, as our results show that stimulating education can have both a positive and a negative effect on fertility levels. The gender bias to the disadvantage of girls we find, can possibly impede a further decline in fertility rates. A focus on girls' education is particularly important in light of accelerating the demographic transition in SSA.

References

Alidou ,S. and Verpoorten ,M. (2019) ‘Family size and schooling in Sub-Saharan Africa: Testing the quantity-quality trade-off’, *Journal of Population Economics*, 32(4), pp. 1353–1399. doi: 10.1007/s00148-019-00730-z.

Ananat ,E. O. *et al.* (2009) ‘Abortion and selection’, *Review of Economics and Statistics*, 91(1), pp. 124–136. doi: 10.1162/rest.91.1.124.

Ananat ,E. O. and Hungerman ,D. M. (2012) ‘The power of the pill for the next generation: Oral contraception’s effects on fertility, abortion, and maternal and child characteristics’, *Review of Economics and Statistics*, 94(1), pp. 37–51. doi: 10.1162/REST_a_00230.

Angeles ,G., Guilkey ,D. K. and Mroz ,T. A. (2005) ‘The Effects of Education and Family Planning Programs on Fertility in Indonesia’, *Source: Economic Development and Cultural Change*, 54(1), pp. 165–201. doi: 10.1086/431261.

Angrist ,J., Lavy ,V. and Schlosser ,A. (2010) ‘Multiple Experiments for the Causal Link between the Quantity and Quality of Children’, *Journal of Labor Economics*, 28(4), pp. 773–824. doi: 10.1086/653830.

Atake ,E.-H. and Gnakou Ali ,P. (2019) ‘Women’s empowerment and fertility preferences in high fertility countries in Sub-Saharan Africa’, *BMC Women’s Health*, 19(54). doi: 10.1186/s12905-019-0747-9.

Basu ,D. and De Jong ,R. (2010) ‘Son targeting fertility behavior: Some consequences and determinants’, *Demography*, 47(2), pp. 521–536. doi: 10.4324/9780203939451-14.

Becker ,G. S. (1960) ‘An economic analysis of fertility’, in *Demographic and economic change in developed countries*. Colombia: Columbia University Press, pp. 209–240.

Becker ,G. S., Murphy ,K. M. and Tamura ,R. (1990) ‘Human capital, fertility, and economic growth’, *Journal of Political Economy*, 98(5), pp. 12–37. doi: 10.1086/261723.

Becker ,G. S. and Tomes ,N. (1976) ‘Child endowments and the quantity and quality of children’, *Journal of Political Economy*, 84(4), pp. 143–162. doi: 10.2307/1831106.

Becker ,N. G. and Lewis ,H. G. (1973) ‘On the interaction between the quantity and quality of children’, *Journal of political Economy*, 81, pp. 279–288. doi: 10.1086/260166.

Becker ,S. O., Cinnirella ,F. and Woessmann ,L. (2010) ‘The trade-off between fertility and education: Evidence from before the demographic transition’, *Journal of Economic Growth*, 15, pp. 177–204. doi: 10.1007/s10887-010-9054-x.

Becker ,S. O., Cinnirella ,F. and Woessmann ,L. (2013) ‘Does women’s education affect fertility? Evidence from pre-demographic transition Prussia’, *European Review of Economic History*. Oxford University Press, pp. 24–44. doi: 10.1093/ereh/hes017.

Behrman ,J. A. (2015) ‘Does schooling affect women’s desired fertility? Evidence from Malawi, Uganda, and Ethiopia’, *Demography*, 52(3), pp. 787–809. doi: 10.1007/s13524-015-0392-3.

Bérenger ,V. and Verdier-Chouchane ,A. (2016) ‘Child labour and schooling in South Sudan and Sudan: Is there a gender preference?’, *African Development Review*, 28(S2), pp. 177–190. doi: 10.1111/1467-8268.12200.

Berlie ,A. and Alamerew ,Y. (2018) ‘Determinants of fertility rate among reproductive age women (15-49) in Gonji-Kollela District of the Amhara National Regional State, Ethiopia’, *Ethiopian Journal of Health Development*, 32(3), pp. 1–12.

Black ,S. E., Devereux ,P. J. and Salvanes ,K. G. (2010) ‘Small family, smart family? Family size and the IQ scores of young men’, *Journal of Human Resources*, 45(1), pp. 33–58. doi: 10.3368/jhr.45.1.33.

Bongaarts ,J. (1978) ‘A Framework for Analyzing the Proximate Determinants of Fertility’, *Population and Development Review*, 4(1), pp. 105–132. doi: 10.2307/1972149.

Bongaarts ,J. (2011) ‘Can family planning programs reduce high desired family size in Sub-Saharan Africa?’, *International Perspectives on Sexual and Reproductive Health*, 37(4), pp. 209–216. doi: 10.1363/3720911.

Bongaarts ,J. (2016) ‘Development: Slow down population growth’, *Nature*. Nature Publishing Group, pp. 409–412. doi: 10.1038/530409a.

Bongaarts ,J. and Casterline ,J. (2013) ‘Fertility transition: Is Sub-Saharan Africa different?’, *Population and Development Review*, 38, pp. 153–168. doi: 10.1111/j.1728-4457.2013.00557.x.

Bougma ,M., LeGrand ,T. K. and Kobiané ,J.-F. (2015) ‘Fertility limitation and child schooling in Ouagadougou: Selective fertility or resource dilution?’, *Studies in Family Planning*, 46(2), pp. 177–199. doi: 10.1111/j.1728-4465.2015.00023.x.

Bougma ,M., LeGrand ,T. K. and Kobiané ,J. F. (2015) ‘Fertility decline and child schooling in urban settings of Burkina Faso’, *Demography*, 52(1), pp. 281–313. doi: 10.1007/s13524-014-0355-0.

Brée ,S. and De La Croix ,D. (2019) ‘Key forces behind the decline of fertility: Lessons from childlessness in Rouen before the industrial revolution’, *Cliometrica*, 13, pp. 25–54. doi: 10.1007/s11698-017-0166-9.

Central Statistical Agency (2012) *Census 2007 Report*.

Central Statistical Agency and ICF International (2016) *Ethiopia demographic and health survey 2016*.

Chao ,F. *et al.* (2019) ‘Systematic assessment of the sex ratio at birth for all countries and estimation of national imbalances and regional reference levels’, *Proceedings of The Royal Society B - Biological Sciences*, 116(19), pp. 9303–9311. doi: 10.1073/pnas.1812593116.

Cinnirella ,F. (2019) ‘Marital fertility and investment in children’s education’, in *Cliometrics of the Family. Studies in Economic History*. Basel: Springer, pp. 33–54. doi: 10.1007/978-3-319-99480-2_3.

Cinnirella ,F. and Streb ,J. (2017) ‘The role of human capital and innovation in economic development: Evidence from post-Malthusian Prussia’, *Journal of Economic Growth*, 22(2), pp. 193–227. doi: 10.1007/s10887-017-9141-3.

Clarke ,D. (2018) ‘Children and their parents: a review of fertility and causality’, *Journal of Economic Surveys*, 32(2), pp. 518–540. doi: 10.1111/joes.12202.

Colleran ,H. and Snopkowski ,K. (2018) ‘Variation in wealth and educational drivers of fertility decline across 45 countries’, *Population Ecology*, 60, pp. 155–169. doi: 10.1007/s10144-018-

0626-5.

Crist ,E., Mora ,C. and Engelman ,R. (2017) ‘The interaction of human population, food production, and biodiversity protection’, *Science*. American Association for the Advancement of Science, pp. 260–264. doi: 10.1126/science.aal2011.

Eliason ,S. *et al.* (2018) ‘Sex composition of living children in a matrilineal inheritance system and its association with pregnancy intendedness and postpartum family planning intentions in rural Ghana’, *Reproductive health*, 15(1), p. 187. doi: 10.1186/s12978-018-0616-2.

Eloundou-Enyegue ,P. M. and Giroux ,S. C. (2012) ‘Fertility transitions and schooling: From micro- to macro-level associations’, *Demography*, 49(4), pp. 1407–1432. doi: 10.1007/s13524-012-0131-y.

Ethiopian Society of Population Studies (2008) *Levels, trends and determinants of lifetime and desired fertility in Ethiopia: Findings from EDHS 2005*. Addis Ababa.

Farina ,P. *et al.* (2001) *Fertility and family change in Ethiopia*. Addis Ababa & Roma.

Fernihough ,A. (2017) ‘Human capital and the quantity–quality trade-off during the demographic transition’, *Journal of Economic Growth*, 22(1), pp. 35–65. doi: 10.1007/s10887-016-9138-3.

Fitzsimons ,E. and Malde ,B. (2014) ‘Empirically probing the quantity-quality model’, *Journal of Population Economics*, 27(1), pp. 33–68. doi: 10.1007/s00148-013-0474-8.

Flato ,M. (2018) ‘The differential mortality of undesired infants in Sub-Saharan Africa’, *Demography*, 55(1), pp. 271–294. doi: 10.1007/s13524-017-0638-3.

Fuse ,K. (2010) ‘Descriptive findings variations in attitudinal gender preferences for children across 50 less-developed countries’, *Demographic Research*, 23(36), pp. 1031–1048. doi: 10.4054/DemRes.2010.23.36.

Galor ,O. (2012) ‘The demographic transition: Causes and consequences’, *Cliometrica*, 6(1), pp. 1–28. doi: 10.1007/s11698-011-0062-7.

Goos ,P. and Hamidouche ,H. (2019) ‘Choice models with mixtures: An application to a cocktail experiment’, *Food Quality and Preference*, 77, pp. 135–146. doi: 10.1016/j.foodqual.2019.04.006.

Günther ,I. and Harttgen ,K. (2016) ‘Desired fertility and number of children born across time and space’, *Demography*, 53(1), pp. 55–83. doi: 10.1007/s13524-015-0451-9.

Hess ,S. and Rose ,J. M. (2012) ‘Can scale and coefficient heterogeneity be separated in random coefficients models?’, *Transportation*, 39(6), pp. 1225–1239. doi: 10.1007/s11116-012-9394-9.

Huber ,J. and Train ,K. E. (2001) ‘On the similarity of classical and Bayesian estimates of individual mean partworths’, *Marketing Letters*, 12(3), pp. 259–269.

Ito ,T. and Tanaka ,S. (2017) ‘Abolishing user fees, fertility choice, and educational attainment’, *Journal of Development Economics*, 130, pp. 33–44. doi: 10.1016/j.jdeveco.2017.09.006.

Kazeem ,A., Jensen ,L. and Stokes ,C. S. (2010) ‘School attendance in Nigeria: Understanding the impact and intersection of gender, urban-rural residence, and socioeconomic status’, *Comparative Education Review*, 54(2), pp. 295–319. doi: 10.1086/652139.

Khademi ,E. and Timmermans ,H. (2012) ‘Application of mixture-amount choice experiment for accumulated transport charges’, *Procedia - Social and Behavioral Sciences*, 54, pp. 483–492. doi: 10.1016/j.sbspro.2012.09.766.

Khuri ,A. I. (2006) *Response surface methodology and related topics*. Toh Tuck Link: World Scientific Publishing Co. doi: 10.1142/5915.

Kim ,J. (2010) ‘Women’s Education and Fertility: An Analysis of the Relationship between Education and Birth Spacing in Indonesia’, *Economic Development and Cultural Change*, 58(4), pp. 739–774. doi: 10.1086/649638.

Kowalski ,S. M., Cornell ,J. A. and Vining ,G. G. (2000) ‘A new model and class of designs for mixture experiments with process variables’, *Communications in Statistics - Theory and Methods*, 29(9–10), pp. 2255–2280. doi: 10.1080/03610920008832606.

Kravdal ,Ø., Kodzi ,I. and Sigle-Rushton ,W. (2013) ‘Effects of the number and age of siblings on educational transitions in Sub-Saharan Africa’, *Studies in Family Planning*, 44(3), pp. 275–297. doi: 10.1111/j.1728-4465.2013.00358.x.

Kuépié ,M., Shapiro ,D. and Tenikue ,M. (2015) ‘Access to schooling and staying in school in selected Sub-Saharan African countries’, *African Development Review*, 27(4), pp. 403–414. doi: 10.1111/1467-8268.12156.

Kugler ,A. and Kumar ,S. (2011) *Kumar, S., & Kugler, A. (2011). Testing the children quantity-quality trade-off in India. IDEAS Working Paper Series from RePEc.* 42487.

Lancsar ,E., Louviere ,J. and Flynn ,T. (2007) ‘Several methods to investigate relative attribute impact in stated preference experiments’, *Social Science and Medicine*, 64(8), pp. 1738–1753. doi: 10.1016/j.socscimed.2006.12.007.

Lawson ,D. W. and Borgerhoff Mulder ,M. (2016) ‘The offspring quantity-quality trade-off and human fertility variation’, *Philosophical transactions Series B - Biological sciences*, 371(1692), p. 20150145. doi: 10.1098/rstb.2015.0145.

Mani ,S., Hoddinott ,J. and Strauss ,J. (2013) ‘Determinants of schooling: Empirical evidence from rural Ethiopia’, *Journal of African Economies*, 22(5), pp. 693–731. doi: 10.1093/jae/ejt007.

Marteleto ,L. J. and de Souza ,L. R. (2012) ‘The Changing Impact of Family Size on Adolescents’ Schooling: Assessing the Exogenous Variation in Fertility Using Twins in Brazil’, *Demography*, 49(4), pp. 1453–1477. doi: 10.1007/s13524-012-0118-8.

Mekonnen ,W. and Worku ,A. (2011) ‘Determinants of fertility in rural Ethiopia: The case of Butajira Demographic Surveillance System (DSS)’, *Public Health*, 11(1), p. 782. doi: 10.1186/1471-2458-11-782.

Miller ,A. R. (2009) ‘Motherhood delay and the human capital of the next generation’, in *American Economic Review*, pp. 154–158. doi: 10.1257/aer.99.2.154.

Millimet ,D. L. and Wang ,L. (2011) ‘Is the Quantity-Quality Trade-Off a Trade-Off for All, None, or Some?’, *Economic Development and Cultural Change*, 60(1), pp. 155–195. doi: 10.1086/661216.

Moav ,O. (2005) ‘Cheap children and the persistence of poverty’, *The Economic Journal*, 115, pp. 88–110. doi: 10.1111/j.1468-0297.2004.00961.x.

Norling ,J. (2018) ‘Measuring heterogeneity in preferences over the sex of children’, *Journal of Development Economics*, 135, pp. 199–221. doi: 10.1016/j.jdeveco.2018.07.004.

Pal ,M. and Mandal ,N. K. (2012) ‘Optimum designs for estimation of parameters in a quadratic mixture-amount model’, *Communications in Statistics-Theory and Methods*, 41(4), pp. 665–673. doi: 10.1080/03610926.2010.529538.

Ponczek ,V. and Souza ,A. P. (2012) ‘New evidence of the causal effect of family size on child quality in a developing country’, *Journal of Human Resources*, 47(1), pp. 64–106. doi: 10.3368/jhr.47.1.64.

Pradhan ,U. K. *et al.* (2017) ‘Design and analysis of mixture experiments with process variable’, *Communications in Statistics - Theory and Methods*, 46(1), pp. 259–270. doi: 10.1080/03610926.2014.990104.

Prescott ,P. (2004) ‘Modelling in mixture experiments including interactions with process variables’, *Quality Technology & Quantitative Management*, 1(1), pp. 87–103. doi: 10.1080/16843703.2004.11673066.

Raghavarao ,D. and Wiley ,J. B. (2009) ‘Conjoint measurement with constraints on attribute levels: A mixture-amount model approach’, *International Statistical Review*, 77(2), pp. 167–178. doi: 10.1111/j.1751-5823.2009.00077.x.

Revelt ,D. and Train ,K. E. (1998) ‘Mixed logit with repeated choices: Households’ choices of appliance efficiency level’, *Review of Economics and Statistics*, 80(4), pp. 647–657. doi: 10.1162/003465398557735.

Rose ,J. M. and Bliemer ,M. C. J. (2009) ‘Constructing Efficient Stated Choice Experimental Designs’, *Transport Reviews*, 29(5), pp. 587–617. doi: 10.1080/01441640902827623.

Rossi ,P. and Rouanet ,L. (2015) ‘Gender preferences in Africa: A comparative analysis of fertility choices’, *World Development*, 72, pp. 326–345. doi: 10.1016/j.worlddev.2015.03.010.

Ruseckaite ,A., Goos ,P. and Fok ,D. (2017) ‘Bayesian D-optimal choice designs for mixtures’, *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, 66(2), pp. 363–386. doi: 10.1111/rssc.12174.

SAS Institute Inc. (2013) ‘SAS 9.4’. Cary, U. S.

SAS Institute Inc. (2018) ‘JMP Pro 14’. Cary, U. S.

Scheffé ,H. (1958) ‘Experiments with mixtures’, *Journal of the Royal Statistical Society: Series B (Methodological)*, 20(2), pp. 344–360. doi: 10.1111/j.2517-6161.1958.tb00299.x.

Schwarz ,G. (1978) ‘Estimating the dimension of a model’, *The Annals of Statistics*, 6(2), pp. 461–464. doi: 10.1214/aos/1176344136.

Taş ,E. O., Reimão ,M. E. and Orlando ,M. B. (2014) ‘Gender, ethnicity, and cumulative disadvantage in education outcomes’, *World Development*, 64, pp. 538–553. doi: 10.1016/j.worlddev.2014.06.036.

Teklu ,H., Sebhatu ,A. and Gebreselassie ,T. (2013) *Components of fertility change in Ethiopia: Further analysis of the 2000, 2005, and 2011 demographic and health surveys*. Addis Ababa.

Temel ,T. (2013) ‘Family size, human capital and growth: Structural path analysis of Rwanda’, *Journal of Economic Development*, 38(4), pp. 39–73.

Tesfu ,S. T. and Gurmu ,S. (2013) ‘Mother’s gender preferences and child schooling in Ethiopia’, *Atlantic Economic Journal,* 41, pp. 265–277. doi: 10.1007/s11293-013-9366-2.

The World Bank (2019) *World Population Prospects: The 2019 revision*. New York.

The World Bank (2020) *DataBank World Bank*. Available at: https://data.worldbank.org/indicator/ (Accessed: 23 March 2019).

Thompson ,W. S. (1929) ‘Population’, *American Journal of Sociology,* 34, pp. 959–975. doi: 10.1086/214874.

Thurstone ,L. L. (1927) ‘A law of comparative judgment’, *Psychological Review,* 101(2), pp. 266–270. doi: 10.1037/h0070288.

Trinitapoli ,J. and Yeatman ,S. (2018) ‘The flexibility of fertility preferences in a context of uncertainty’, *Population and Development Review,* 44(1), pp. 87–116. doi: 10.1111/padr.12114.

United Nations (2019) *Human Development Reports*. Available at: http://hdr.undp.org/en/countries/profiles/ETH (Accessed: 22 April 2019).

Vimefall ,E., Andrén ,D. and Levin ,J. (2017) ‘Ethnolinguistic background and enrollment in primary education: Evidence from Kenya’, *African Development Review,* 29(1), pp. 81–91. doi: 10.1111/1467-8268.12241.

Vogl ,T. S. (2016) ‘Differential fertility, human capital, and development’, *The Review of Economic Studies,* 83(1), pp. 365–401. doi: 10.1093/restud/rdv026.

Willis ,R. J. (1973) ‘A new approach to the economic theory of fertility behavior’, *Journal of Political Economy,* 81(2), pp. 14–64. doi: 10.1086/260152.

Zijlstra ,T., Goos ,P. and Verhetsel ,A. (2019) ‘A mixture-amount stated preference study on the mobility budget’, *Transportation Research Part A - Policy,* 126, pp. 230–246. doi: 10.1016/j.tra.2019.06.009.

Appendix A: Robustness checks

A1. Attribute Non-Attendance (ANA)

ANA occurs when respondents do not consider a certain attribute in making a trade-off between the alternatives. To check for ANA, we used two methods. First, the DCE included the question of possible ignorance of an attribute after each choice card (i.e. choice card stated ANA) and after the whole DCE (i.e. serial stated ANA). Afterwards, we compared the 'standard' MXLM with a MXLM with dummy variables for the most ignored attributes to investigate whether these respondents have different preferences. Second, we checked for ANA using the endogenous attribute non-attendance logit model (EAAlogit) via the 'eaalogit' command in Stata. Since the EAAlogit could not estimate the plain mixture-amount model with the main effects, we gradually build up the non-attendance pattern. We then compared the EAAlogit model with a conditional logit model (CLM) because both models assume preference homogeneity. We estimated the CLM via the Firth penalized-likelihood estimation procedure in JMP.

With regard to **serial stated ANA**, Table A1 shows that 84% of the respondents stated that took all attributes into account during the DCE. Moreover, 47% of the respondents stated that they considered all attributes equally important. In addition, the attributes *gender of the children* and *no schooling* were somewhat ignored (by 7% and 7% of the respondents respectively) and considered least important (20% vs 27% respectively). Therefore, we analyzed these two possibly ignored attributes analyzed via a MXLM with the addition of dummy variables for these two attributes (Table A3). This shows that, compared with the 'standard' MXLM, respondents who indicated that they did not consider certain attributes when making their choice, have almost no significantly different preferences (indicated by the interaction terms of the dummy variables and the attributes). This holds except for respondents who stated that they had ignored the attribute *gender of the children*; they have an even higher preference for girls going to primary, secondary and tertiary education and boys going to tertiary education. They also have a lower preference for the number of children. Respondents who indicated that they had ignored the attribute *no schooling*, have a higher preference for the number of girls going to tertiary education and boys to secondary education. Moreover, they have a lower preference for the number of children. This shows that there is only a low level of evidence for ANA according to serial stated ANA.

The results of **choice task stated ANA** show that 40% of choices were based on gender and education level (Table A2). 26% of the respondents explicitly took the education level into account and 23% of the choices was based on gender differences of the alternatives. This is consistent with the results of the serial stated ANA, as the attributes considered most important are also reported as the least ignored/least important, with the exception of the number of children.

Inferred ANA via the EAAlogit model reveals that the significance levels, the sign and the magnitude of the variables are similar when compared with the 'standard' CLM (Table A3). However, three gamma coefficients (γ) are significant, indicating that there is some evidence for ANA. This is the case for the *Girls Tertiary Schooling*, *Boys Tertiary Schooling* and *Number of Children* with corresponding probabilities of ANA of 19%, 21% and 35% respectively (based on the gamma coefficients; calculations not shown here). Nevertheless, for the EAAlogit model, the effects of *Girls Tertiary Schooling*, *Boys Tertiary Schooling* and *Number of Children* increase and the AICc and BIC improve compared to the 'standard' CLM.

Overall, there is little evidence for ANA. However, there is little agreement between the results of stated and inferred ANA. The reason could be that the design of the DCE is based on a mixture model, which makes it very difficult to ignore one of the attributes due to the collinearity (i.e. linear dependence) of the variables. Therefore, our experiment is assumed to be quite robust to ANA and we did not take ANA into account in the further analysis.

Table A1: Results of serial stated ANA

Attributes	Ignored			Least important			
	Total	Female	Male	Total	Female	Male	
Gender of the children (%)	6.57	7.37	5.74	19.72	20.74	18.66	
Number of the children (%)	1.64	2.30	0.96	5.87	6.45	5.26	
No schooling (%)	6.81	6.45	7.18	27.00	22.12	32.06	**
Education level (%)	0.23	0.00	0.48	0.23	0.46	0.00	
All attributes are considered/equally important (%)	83.98	84.33	85.65	47.18	50.23	44.02	

*Note: The first column indicates which attributes respondent stated to have ignored and the second column indicates which attributes respondents found least important. Comparison between the male and female subgroups was based the pairwise Chi Square test accounting for the False Discovery Rate. Significant differences of the mean of the male vs. female subgroups are shown with * p < 0.1, ** p < 0.05, *** p < 0.01.*

Table A2: Choice task stated attribute attendance

Attributes	Total	Female	Male
Gender of the children (%)	22.57	21.85	23.27
Number of children (%)	3.74	3.35	4.11
Education level (%)	26.37	27.11	25.65
Sex of the children and number of children (%)	1.45	1.83	1.08
Sex of the children and education level (%)	39.69	39.79	39.59
Number of children and education level (%)	4.36	4.47	4.26
Gender of the children, number of children and education level (%)	1.82	1.59	2.04

*Note: Numbers indicate the attributes the respondents took into account for making each choice. Comparison between the male and female subgroups was based the pairwise Chi Square test accounting for the False Discovery Rate. Significant differences of the mean of the male vs. female subgroups are shown with * p < 0.1, ** p < 0.05, *** p < 0.01.*

Table A3: Parameter estimates of the 'standard' MXLM and the 'standard' CLM for comparison with the models to account for ANA

Variable	MXLM				Serial stated ANA				Serial stated ANA				CLM				Inferred ANA via EAAlogit			
	Posterior		Lower CI	Upper	Mean		Lower CI 95%	Upper CI 95%	Mean		Lower CI	Upper CI	Mean		Lower	Upper	Mean		Lower	Upper
Girls primary schooling	1.38	*	0.90	1.93	1,20	*	0,63	1,73	1,51	*	0,94	2,02	0.91	*	0.53	1.29	0.94	*	0.55	1.33
Girls secondary schooling	2.40	*	1.88	2.90	2,30	*	1,75	2,77	2,55	*	1,98	3,10	1.54	*	1.14	1.94	1.80	*	1.37	2.23
Girls tertiary schooling	4.14	*	3.56	4.70	3,90	*	3,31	4,47	4,26	*	3,70	4,81	2.68	*	2.29	3.08	3.82	*	3.25	4.39
Boys No Schooling	1.45	*	0.87	2.00	1,44	*	0,88	2,07	1,60	*	0,98	2,17	0.86	*	0.43	1.29	1.12	*	0.63	1.61
Boys Primary Schooling	0.89	*	0.40	1.40	0,72	*	0,20	1,23	1,02	*	0,43	1,59	0.46	*	0.04	0.87	0.46	*	0.03	0.90
Boys Secondary Schooling	1.78	*	1.30	2.21	1,65	*	1,15	2,14	1,83	*	1,21	2,36	1.35	*	0.96	1.75	1.30	*	0.90	1.71
Boys Tertiary Schooling	5.56	*	4.84	6.30	5,16	*	4,47	5,80	5,88	*	5,22	6,59	3.77	*	3.32	4.24	5.63	*	5.02	6.23
Number of Children	-0.24	*	-0.26	-0.22	-0,24	*	-0,26	-0,21	-0,24	*	-0,27	-0,22	-0.15	*	-0.16	-0.14	-0.29	*	-0.32	-0.26
Girls primary schooling*Dummy_gender					27,1	*	11,56	42,79												
Girls secondary schooling*Dummy_gender					12,1	*	0,36	21,95												
Girls tertiary schooling*Dummy_gender					59,5	*	43,68	74,50												
Boys No Schooling*Dummy_gender					9,53		-14,36	32,61												
Boys Primary Schooling*Dummy_gender					10,4		-5,81	25,00												
Boys Secondary Schooling*Dummy_gender					7,73		-14,18	22,91												
Boys Tertiary Schooling*Dummy_gender					90,5	*	73,93	111,8												
Number of Children*Dummy_gender					-3,26	*	-5,16	-1,83												
Girls primary schooling*Dummy_no_schooling									-3,68		-10,42	3,77								
Girls secondary schooling*Dummy_no_schooling									5,14		-1,64	11,7								
Girls tertiary schooling*Dummy_no_schooling									17,0	*	8,05	26,9								
Boys No Schooling*Dummy_no_schooling									-1,67		-14,05	11,1								
Boys Primary Schooling*Dummy_no_schooling									-6,81		-16,33	1,54								
Boys Secondary Schooling *Dummy_no_schooling									8,96	*	0,62	19,6								
Boys Tertiary Schooling*Dummy_no_schooling									0,66		-9,29	9,92								
Number of Children*Dummy_no_schooling									-1,17	*	-1,87	-0,57								
γ (FTertiary)																	1.44	*	0.72	2.16
γ (MTertiary)																	1.31	*	0.91	1.70
γ (NChildren)																	0.63	*	0.36	0.90
AICc	4230.75				4071,92				4056,04				5646.40				5425.15			
BIC	4283.05				4176,47				4160,60				5698.69				5497.06			
-2LL	4214.72				4039,81				4023,94				5592.19				5403.10			

*Note: Significant differences of the (posterior) mean on a 5% level are indicated with *. The first and second model that accounts for ANA includes interaction effects of the dummy variables gender and no schooling respectively (Ignored = 1; Not ignored = 0) with the main effects of the attributes. The third model takes ANA into account via the endogenous attribute attendance model (EAAlogit) where γ indicates the gamma coefficient used to calculate the probability of ANA. Since the EAAlogit model was not able to estimate the plain mixture-amount model with the main effects, the non-attendance pattern was gradually build up. This is the reason that only three gamma coefficients are shown in the output.*

A2. Scale heterogeneity

Scale heterogeneity occurs when the error variance is not constant across respondents due to a different ability to understand and perform the DCE. To investigate the presence of scale heterogeneity, we used two methods. First, we included two duplicates of the choice cards after the DCE. Afterwards, we compared the ‘standard’ MXLM with a MXLM with dummy variables for the respondents who gave different answers on the duplicates, to investigate a discrepancy in preferences. Second, we analyzed scale heterogeneity via the scaled MXLM (also called the generalized multinomial logit model II) with the ‘gmnl’ command in Stata. We then compared the scaled MXLM (accounting for both preference and scale heterogeneity) with the ‘standard’ MXLM (accounting only for preference heterogeneity).

Regarding the first method, the use of duplicates, the results show that 90% of the respondents gave the same answer to the duplicated choice card. Table A4 shows that, compared to the 'standard' MXLM, the respondents who gave different answers to the duplicates have different preferences for *Girls Tertiary Schooling*, *Boys No Schooling* and *Boys Tertiary Schooling* (indicated by the interaction terms of the dummy variables and the attributes). This suggests that there is evidence of scale heterogeneity.

Second, the results of the scaled MXLM show that the significance, sign and magnitude of the variables are similar to the ‘standard’ MXLM (Table A4). However, the scale parameter (τ) is significant which provides evidence for some scale heterogeneity. Nevertheless, if the scale parameter is included in the model, the AICc and BIC do not improve for the scaled MXLM compared to the ‘standard’ MXLM.

Overall, there is a small indication of scale heterogeneity. However, we accounted for scale heterogeneity in the design by starting the DCE with a trial of two test cards to minimise the differences in ability to understand the task. Moreover, Hess and Rose (2012) argue that it is not completely possible to disentangle preference and scale heterogeneity with current models. Therefore, we did not take into account scale heterogeneity in the further analysis.

Table A4: Parameter estimates of the ‘standard’ MXLM for comparison with the models to account for scale heterogeneity.

Variable	MXLM				MXLM with interaction of duplicates				Scaled MXLM			
	Posterior Mean		Lower CI 95%	Upper CI	Mean		Lower CI	Upper CI	Mean		Lower CI	Upper CI
Girls primary schooling	1.38	*	0.90	1.93	1.59	*	1.09	2.08	2.11	*	1.33	2.89
Girls secondary schooling	2.40	*	1.88	2.90	2.61	*	2.06	3.15	2.87	*	2.05	3.70
Girls tertiary schooling	4.14	*	3.56	4.70	4.28	*	3.70	4.86	4.82	*	3.68	5.96
Boys No Schooling	1.45	*	0.87	2.00	1.32	*	0.70	1.95	1.84	*	1.07	2.60
Boys Primary Schooling	0.89	*	0.40	1.40	0.98	*	0.45	1.51	1.42	*	0.70	2.13
Boys Secondary Schooling	1.78	*	1.30	2.21	1.91	*	1.39	2.44	2.47	*	1.69	3.24
Boys Tertiary Schooling	5.56	*	4.84	6.30	5.76	*	5.04	6.47	6.77	*	5.34	8.20
Number of Children	-0.24	*	-0.26	-0.22	-0.25	*	-0.28	-0.23	-0.24	*	-0.29	-0.19
τ									0.83	*	0.62	1.03
Girls primary schooling*Dummy_duplicate					-0.40		-2.39	1.60				
Girls secondary schooling*Dummy_duplicate					0.92		-0.87	2.71				
Girls tertiary schooling*Dummy_duplicate					3.81	*	1.45	6.18				
Boys No Schooling*Dummy_duplicate					4.42	*	1.56	7.28				
Boys Primary Schooling*Dummy_duplicate					0.05		-2.17	2.26				
Boys Secondary Schooling*Dummy_duplicate					0.23		-1.94	2.41				
Boys Tertiary Schooling*Dummy_duplicate					4.86	*	1.72	8.00				
Number of Children*Dummy_duplicate					-0.18		-0.31	-0.06				
AICc	4230.75				3993.50				5433.77			
BIC	4283.05				4098.06				5492.61			
-2LL	4214.72				3961.40				-5415.74			

*Note: Significant differences of the mean of the posterior mean on a 5% level are indicated with *. The first model that accounts for scale heterogeneity includes interaction effects of the dummy variable for the answer on the duplicate (Different answer = 1; Same answer = 0) with the main effects of the attributes. The second model takes scale heterogeneity into account via the scaled MXLM where tau is the scale parameter.*

Appendix B: Solution of the theoretical model

The maximization problem to be solved is:

$$\{ \mathrm{e_b}, \mathrm{e_g}, n\} = argmax\{(1 - \gamma) * \ln(\mathrm{c}) + \gamma * [\ln(n) + \ln(h_b^{\alpha} + h_g^{\beta})]\} \tag{B1}$$

Subject to:

$$\tau * n * y + c \leq y \tag{B2}$$

The solution proceeds in two steps. First, solve for *n*. From Eq. B2:

$$c = \mathrm{y} - \tau * n * y \tag{B3}$$

Substitution in Eq. B1 gives:

$$U = (1 - \gamma) * \ln(\mathrm{y} - \tau * n * y) + \gamma * \left[\ln(n) + \ln\left(h_b^{\alpha} + h_g^{\beta}\right)\right] \tag{B4}$$

The first-order condition for *n* is:

$$\frac{-(1 - \gamma) * \mathrm{y} * \tau}{\mathrm{y} - \tau * n * y} + \frac{\gamma}{\mathrm{n}} = 0 \tag{B5}$$

Solving this equation results in:

$$n = \frac{\gamma}{\tau} = \frac{\gamma}{\tau^{\mathrm{q}} + \tau_{\mathrm{b}}^{\mathrm{e}} * \mathrm{e_b} + \tau_{\mathrm{g}}^{\mathrm{e}} * \mathrm{e_g}}. \tag{B6}$$

Second, solve for e_b. From Eq. B3 and B6:

$$n = \frac{\mathrm{y} - \mathrm{c}}{y * (\tau^{\mathrm{q}} + \tau_{\mathrm{b}}^{\mathrm{e}} * \mathrm{e_b} + \tau_{\mathrm{g}}^{\mathrm{e}} * \mathrm{e_g})} \tag{B7}$$

Substitution in Eq. 1 gives:

$$U = (1 - \gamma) * \ln(\mathrm{c}) + \gamma * \left[\ln\left(\frac{\mathrm{y} - \mathrm{c}}{y * \left(\tau^{\mathrm{q}} + \tau_{\mathrm{b}}^{\mathrm{e}} * \mathrm{e_b} + \tau_{\mathrm{g}}^{\mathrm{e}} * \mathrm{e_g}\right)}\right) + \ln\left(h_b^{\alpha} + h_g^{\beta}\right)\right] \tag{B8}$$

$$= (1 - \gamma) * \ln(\mathrm{c}) + \gamma * \{\ln(\mathrm{y} - \mathrm{c}) - \ln[\mathrm{y} * (\tau^{\mathrm{q}} + \tau_{\mathrm{b}}^{\mathrm{e}} * \mathrm{e_b} + \tau_{\mathrm{g}}^{\mathrm{e}} * \mathrm{e_g})] + \ln\left(h_b^{\alpha} + h_g^{\beta}\right)\}$$

The first-order condition for e_b is:

$$\frac{-\gamma * \tau_{\mathrm{b}}^{\mathrm{e}}}{\tau^{\mathrm{q}} + \tau_{\mathrm{b}}^{\mathrm{e}} * \mathrm{e_b} + \tau_{\mathrm{g}}^{\mathrm{e}} * \mathrm{e_g}} + \frac{\gamma * \alpha * \frac{\partial \mathrm{h}_{\mathrm{b}}^{\alpha-1}}{\partial e_b}}{h_b^{\alpha} + h_g^{\beta}} = 0 \tag{B9}$$

Solving this equation for *e_b* results in:

$$\tau_{\mathrm{b}}^{\mathrm{e}} * (h_b^{\alpha} + h_g^{\beta}) = \alpha * \frac{\partial \mathrm{h}_{\mathrm{b}}^{\alpha-1}}{\partial e_b} * (\tau^{\mathrm{q}} + \tau_{\mathrm{b}}^{\mathrm{e}} * \mathrm{e_b} + \tau_{\mathrm{g}}^{\mathrm{e}} * \mathrm{e_g}) \tag{B10}$$

Similar, solving for e_g results in:

$$\tau_{\mathrm{g}}^{\mathrm{e}} * (h_b^{\alpha} + h_g^{\beta}) = \beta * \frac{\partial \mathrm{h}_{\mathrm{g}}^{\beta-1}}{\partial e_g} * (\tau^{\mathrm{q}} + \tau_{\mathrm{b}}^{\mathrm{e}} * \mathrm{e_b} + \tau_{\mathrm{g}}^{\mathrm{e}} * \mathrm{e_g}). \tag{B11}$$

Appendix C: Supplementary material

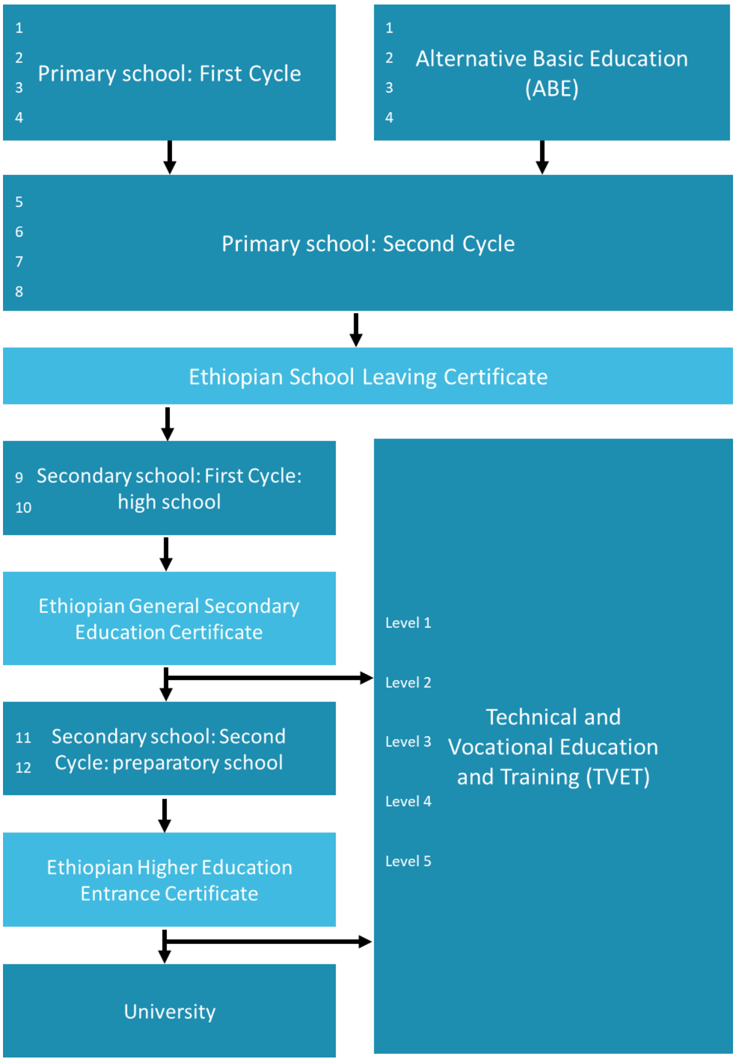

Figure C1: Visualization of the educational system in Ethiopia

Table C1: Experimental design of the DCE

		Option A											Option B										
Block	Set	a	x_1	x_{11}	x_{12}	x_{13}	x_{14}	x_2	x_{21}	x_{22}	x_{23}	x_{24}	a	x_1	x_{11}	x_{12}	x_{13}	x_{14}	x_2	x_{21}	x_{22}	x_{23}	x_{24}
1	1	1	0	0	0	0	0	1	0	0	1	0	3	3	1	2	0	0	0	0	0	0	0
	2	1	1	0	0	1	0	0	0	0	0	0	4	1	0	0	1	0	3	0	0	1	2
	3	3	0	0	0	0	0	3	1	0	2	0	3	0	0	0	0	0	3	0	2	1	0
	4	3	0	0	0	0	0	3	1	0	0	2	10	6	0	0	0	6	4	4	0	0	0
	5	3	3	1	1	1	0	0	0	0	0	0	4	2	1	0	1	0	2	0	0	0	2
	6	2	0	0	0	0	0	2	0	0	1	1	8	6	0	0	0	6	2	2	0	0	0
	7	3	3	0	3	0	0	0	0	0	0	0	10	4	2	2	0	0	6	2	0	0	4
	8	5	3	1	0	2	0	2	1	0	1	0	12	8	4	0	4	0	4	0	0	0	4
	9	5	4	0	2	0	2	1	1	0	0	0	12	8	4	0	4	0	4	0	0	4	0
	10	5	4	0	0	2	2	1	0	0	1	0	5	4	2	2	0	0	1	0	1	0	0
	11	2	2	0	1	1	0	0	0	0	0	0	10	4	0	4	0	0	6	0	0	6	0
	12	9	6	3	3	0	0	3	0	0	0	3	12	6	2	0	0	4	6	2	0	0	4
2	1	5	1	1	0	0	0	4	1	3	0	0	5	4	1	0	0	3	1	1	0	0	0
	2	5	4	1	3	0	0	1	1	0	0	0	12	4	0	4	0	0	8	2	0	0	6
	3	1	0	0	0	0	0	1	0	0	0	1	4	3	0	3	0	0	1	0	0	0	1
	4	1	1	0	1	0	0	0	0	0	0	0	5	4	2	0	2	0	1	0	0	1	0
	5	10	6	2	0	4	0	4	0	0	0	4	3	0	0	0	0	0	3	1	1	1	0
	6	10	4	4	0	0	0	6	0	0	6	0	3	0	0	0	0	0	3	0	0	3	0
	7	8	2	0	0	0	2	6	0	2	4	0	12	8	0	0	8	0	4	0	0	4	0
	8	12	4	0	4	0	0	8	4	0	4	0	3	3	1	0	1	1	0	0	0	0	0
	9	3	2	1	0	0	1	1	0	0	0	1	12	4	4	0	0	0	8	0	4	0	4
	10	3	0	0	0	0	0	3	0	3	0	0	9	6	0	3	3	0	3	0	0	3	0
	11	3	1	0	0	1	0	2	1	0	1	0	5	1	1	0	0	0	4	1	0	3	0
	12	2	0	0	0	0	0	2	0	1	1	0	12	6	0	0	0	6	6	0	0	6	0
3	1	2	1	0	0	0	1	1	0	0	0	1	5	1	0	1	0	0	4	2	0	0	2
	2	3	3	1	0	2	0	0	0	0	0	0	2	2	0	0	1	1	0	0	0	0	0
	3	2	1	0	1	0	0	1	0	1	0	0	3	0	0	0	0	0	3	0	1	0	2
	4	3	0	0	0	0	0	3	1	0	1	1	5	2	0	2	0	0	3	2	0	1	0
	5	10	6	0	4	0	2	4	4	0	0	0	4	3	0	0	3	0	1	1	0	0	0
	6	5	1	1	0	0	0	4	1	0	0	3	12	4	0	4	0	0	8	4	0	0	4
	7	3	1	0	0	0	1	2	1	1	0	0	5	4	1	0	0	3	1	1	0	0	0
	8	3	0	0	0	0	0	3	1	2	0	0	5	3	0	1	2	0	2	2	0	0	0
	9	12	4	0	0	4	0	8	4	0	4	0	2	1	0	0	1	0	1	0	1	0	0
	10	5	1	0	0	1	0	4	2	2	0	0	12	4	4	0	0	0	8	0	0	4	4
	11	5	2	1	0	0	1	3	1	2	0	0	12	8	0	0	8	0	4	0	0	0	4
	12	2	1	0	1	0	0	1	0	0	0	1	9	6	0	0	0	6	3	0	0	0	3
4	1	10	4	0	4	0	0	6	2	0	4	0	5	2	2	0	0	0	3	0	0	0	3
	2	2	1	0	0	1	0	1	0	0	0	1	12	4	0	0	0	4	8	4	0	0	4
	3	1	1	0	0	0	1	0	0	0	0	0	12	4	0	0	0	4	8	0	8	0	0
	4	3	0	0	0	0	0	3	1	1	0	1	8	6	0	6	0	0	2	2	0	0	0
	5	10	6	4	0	0	2	4	0	4	0	0	3	1	0	0	1	0	2	1	0	0	1
	6	5	1	1	0	0	0	4	0	0	4	0	5	4	2	0	0	2	1	0	0	1	0
	7	10	6	4	0	0	2	4	0	0	0	4	12	8	2	0	0	6	4	0	4	0	0
	8	9	6	3	0	3	0	3	0	3	0	0	4	2	0	2	0	0	2	0	0	2	0
	9	8	2	0	2	0	0	6	0	4	0	2	12	4	0	0	0	4	8	4	0	4	0
	10	8	4	2	2	0	0	4	0	4	0	0	5	4	2	2	0	0	1	0	0	1	0
	11	3	1	0	1	0	0	2	1	1	0	0	12	4	0	0	4	0	8	4	4	0	0
	12	12	4	4	0	0	0	8	0	4	4	0	9	6	0	0	3	3	3	3	0	0	0
5	1	5	2	2	0	0	0	3	0	3	0	0	12	8	0	4	4	0	4	4	0	0	0
	2	12	8	0	0	4	4	4	4	0	0	0	5	1	0	0	0	1	4	2	0	2	0
	3	1	0	0	0	0	0	1	0	1	0	0	12	8	0	8	0	0	4	0	4	0	0
	4	5	3	0	3	0	0	2	2	0	0	0	2	2	0	1	0	1	0	0	0	0	0
	5	4	2	1	0	0	1	2	0	0	2	0	10	6	0	0	0	6	4	0	4	0	0
	6	10	6	2	4	0	0	4	0	0	4	0	3	3	1	1	0	1	0	0	0	0	0
	7	3	2	0	0	0	2	1	0	1	0	0	10	4	0	0	4	0	6	4	0	0	2
	8	3	3	1	0	0	2	0	0	0	0	0	5	4	2	0	2	0	1	0	0	0	1
	9	12	4	0	0	4	0	8	0	8	0	0	3	1	0	0	0	1	2	1	0	0	1
	10	8	4	0	0	4	0	4	0	0	4	0	12	8	4	0	4	0	4	0	4	0	0
	11	8	2	0	2	0	0	6	0	0	0	6	2	0	0	0	0	0	2	0	1	0	1
	12	5	1	1	0	0	0	4	1	0	3	0	5	4	1	0	3	0	1	1	0	0	0

Note: a is the amount, x_{11}-x_{14} the number of girls attending no schooling, primary, secondary or tertiary schooling respectively and x_{21}-x_{24} are the number of boys attending no schooling, primary, secondary or tertiary schooling respectively.

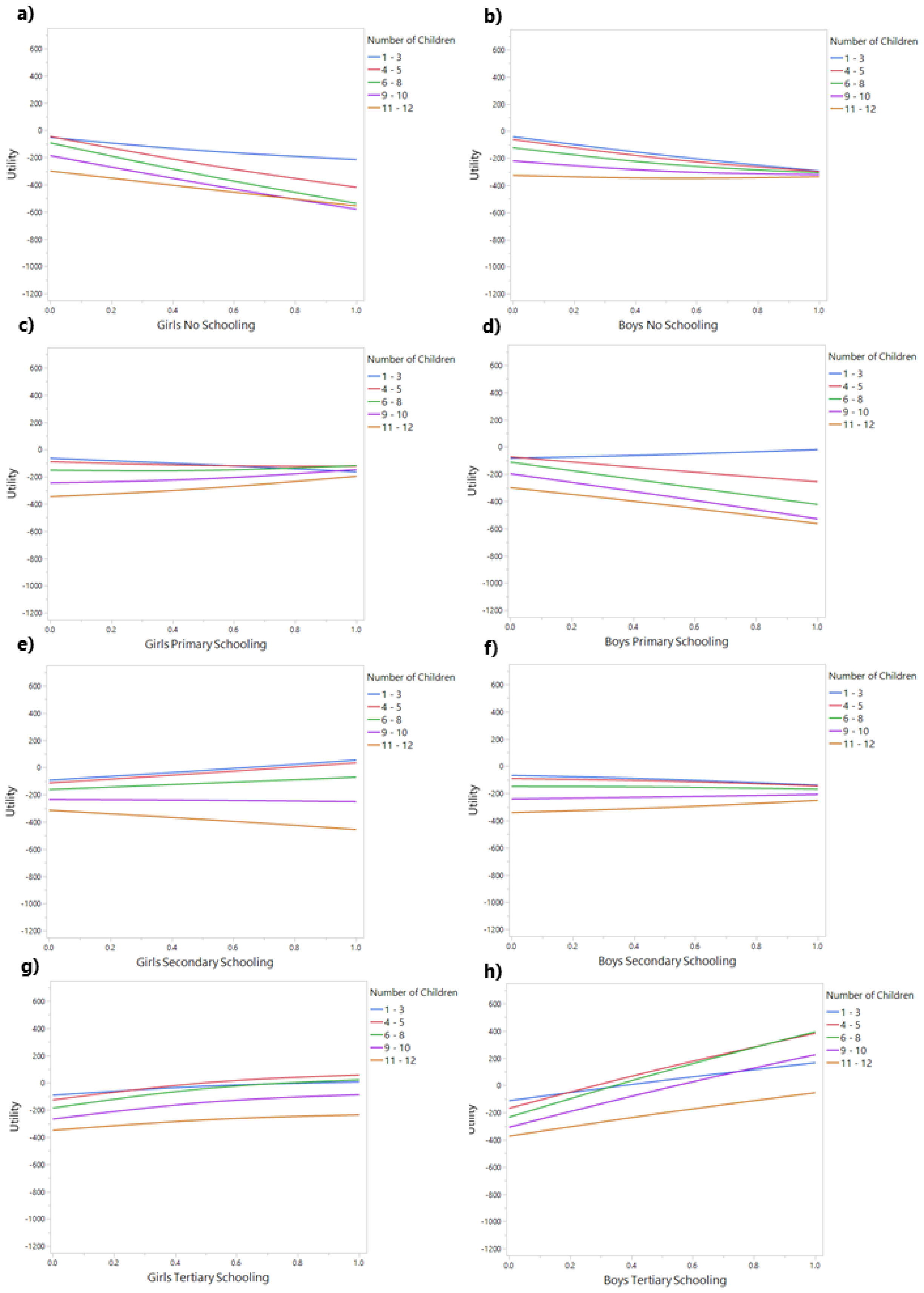

Figure C2: Visualization of the MXLM parameter estimates of male respondents' utility in function of the different schooling components for different ranges of the number of children. Note: all results need to be interpreted with respect to the variable Girls No Schooling.

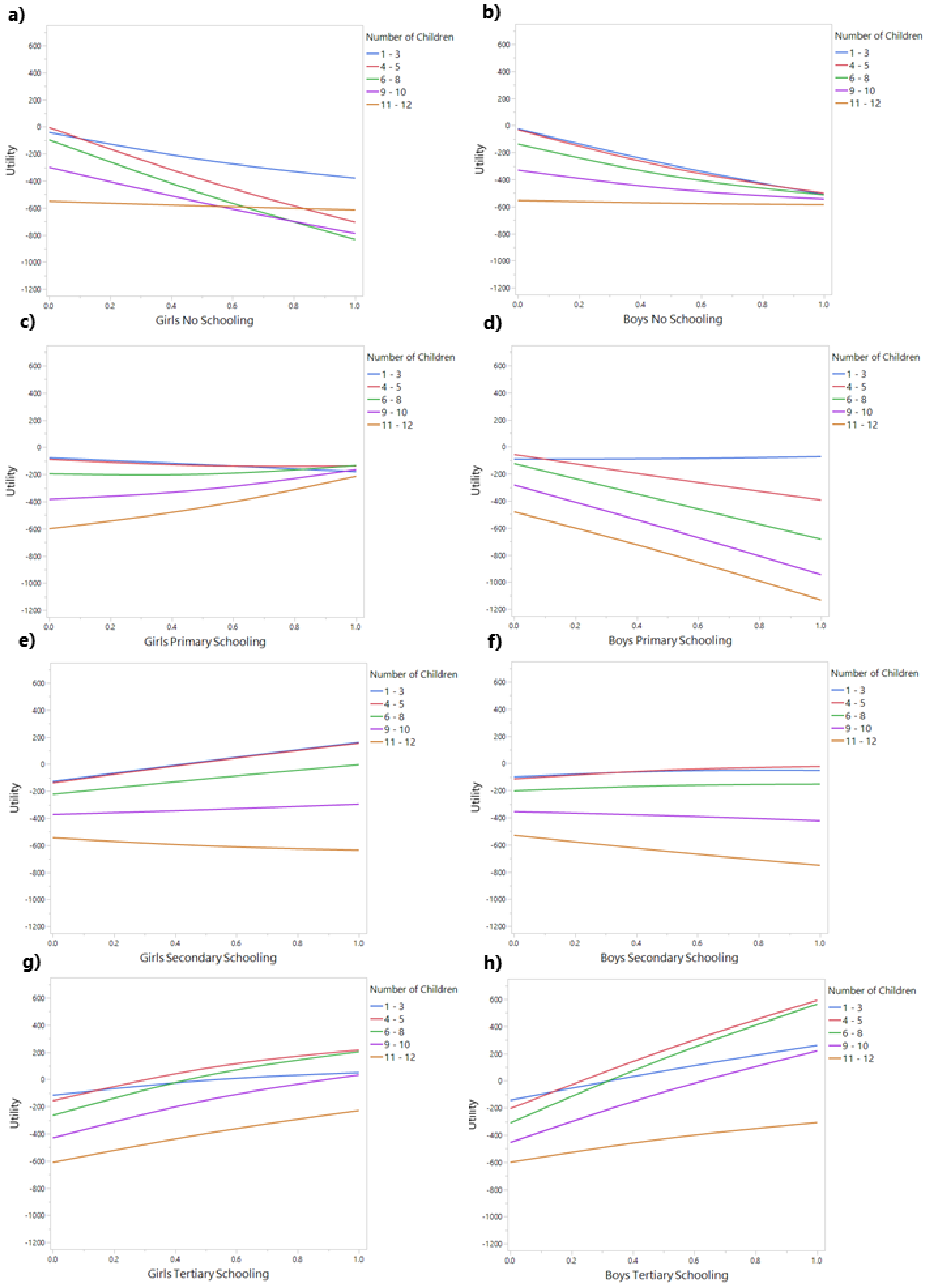

Figure C3: Visualization of the MXLM parameter estimates of female respondents' utility in function of the different schooling components for different ranges of the number of children. Note: all results need to be interpreted with respect to the variable Girls No Schooling.

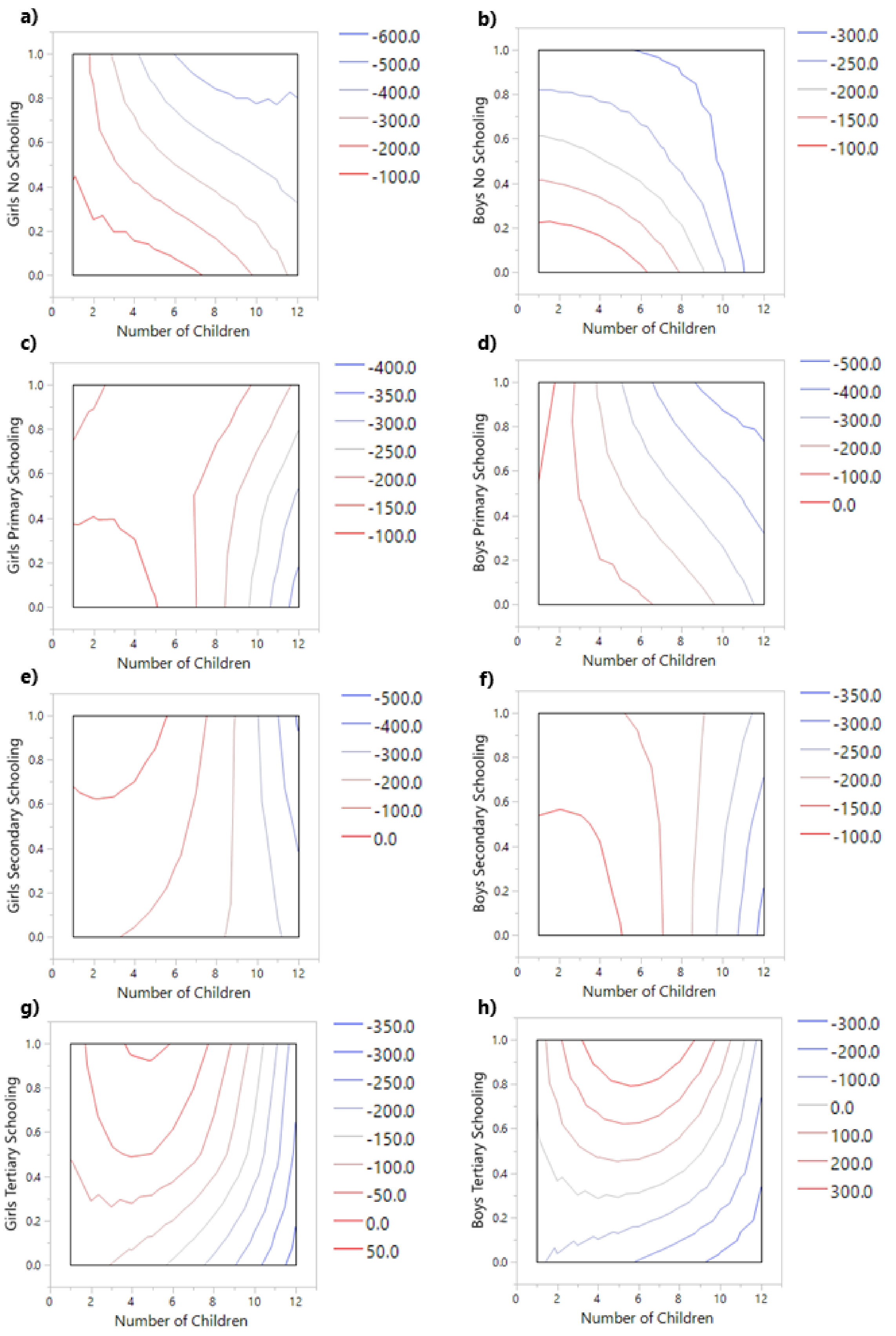

Figure C4: Utility indifference curves for the different schooling components (y-axis) and the number of children (x-axis) to visualize the MRS ceteris paribus for the male respondents of the MXLM. The brightest red lines show the highest constant-utility curves. Note: all results need to be interpreted with respect to Girls No Schooling.

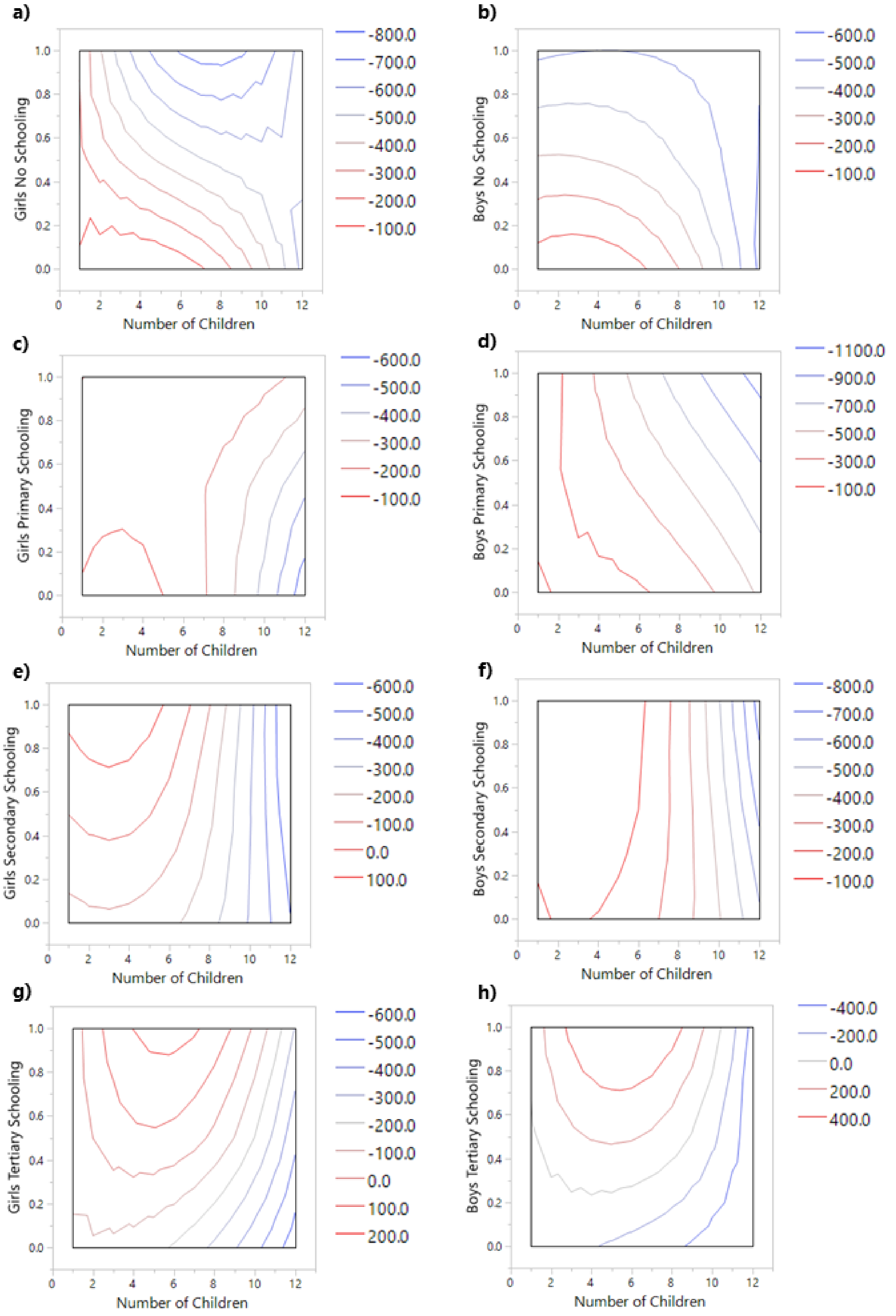

Figure C5: Utility indifference curves for the different schooling components (y-axis) and the number of children (x-axis) to visualize the MRS ceteris paribus for the female respondents of the MXLM. The brightest red lines show the highest constant-utility curves. Note: all results need to be interpreted with respect to Girls No Schooling.