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RESEARCH PAPER

Gendered fertility intentions and child schooling: insights on the quantity–quality trade-off from Ethiopia

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Abstract

Fertility decline in human history is a complex enigma. Different triggers have been proposed, among others the increased demand for human capital resulting in parents making a quantity–quality (QQ) trade-off. This is the first study that examines the existence of a QQ trade-off and the possible gender bias by analyzing fertility intentions rather than fertility outcomes. We rely on the unified growth theory to understand the QQ trade-off conceptually and a discrete choice experiment conducted among 426 respondents in Ethiopia to analyze fertility intentions empirically. We confirm the existence of a QQ trade-off only when the number of children is less than six and find that intentions are gendered in two ways: (i) boys are preferred over girls, and (ii) men are willing to trade-off more education in return for more children. Results imply that a focus on both stimulating intentions for education, especially girls' education, and on family size intentions is important to accelerate the demographic transition.

Key words: Choice experiment; demographic transition; education; family planning; sex preferences; unified growth theory

JEL classification: J13; J16; C11

1. Introduction

The world population is predicted to approach 11 billion by 2100 [The World Bank (2022)]. This is more than a 50% increase compared to today's population. The largest growth is expected in sub-Saharan Africa (SSA) with a quadrupling of the population by 2100. Reducing population growth is important from the perspective of reducing environmental pressures and respecting planetary boundaries [Crist *et al.* (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 is one of the most influential theories explaining global population dynamics from high birth and death rates to low birth and death rates [Thompson (1929)]. According to this model, reducing fertility rates is crucial in slowing-down population growth. Different theories exist on the key factors that influence fertility decline, including theories that emphasize (i) risk and mortality, (ii) the cultural diffusion of fertility norms, and (iii) the economic costs and benefits of investing in self and children [Shenk *et al.* (2013)]. Research suggests that important synergies exist between these theories. The economic and investment theory emphasizes increased demand for human capital to be the main trigger for fertility decline. At the macro-level, declining fertility rates have been shown to be correlated with an increase in the investment in human capital in countries who passed the demographic transition [Galor (2012)]. At the household level, parents make trade-offs on how many children to have and how much to invest in each of them [Kugler and Kumar (2011)]. This mechanism, which has become an important motivation for family planning policies in many countries with high prevailing fertility rates, has been called the quantity–quality (QQ) trade-off.

The literature documents this QQ trade-off with both theoretical as well as empirical studies. Theoretical studies propose a wide range of microeconomic models on the QQ trade-off, first introduced by Becker (1960). Empirical studies analyzing the QQ trade-off often focus on education as an indicator of the quality of childrearing and find mixed results [Clarke (2018)]. It is crucial, from both a theoretical and policy perspective, to investigate whether this QQ trade-off exists at household level in SSA, because if high fertility rates and low schooling rates go hand in hand, future generations will be less educated and have more children. Moreover, in many parts of the world, parents have specific preferences for boys over girls, and these preferences may differ for husbands and wives [Norling (2018)]. This gender bias to the disadvantage of girls may also occur in making QQ decisions. This can contribute to high fertility rates and impede the demographic transition in SSA because 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)]. No study has yet revealed the existence of a gender bias in the QQ trade-off.

The literature indicates that fertility behavior is the result of the ability of women to implement their fertility intentions[1] [Hin *et al.* (2011), Günther and Harttgen (2016), Cleland *et al.* (2019), Yeatman *et al.* (2020)]. However, in rural SSA there is still a large gap between fertility intentions and fertility outcomes due to a large prevalence of unwanted fertility [The World Bank (2022)]. It is therefore important to study fertility behavior in general, and the existence of a QQ trade-off in specific, from not only a fertility outcome, but also a fertility intention perspective. To our knowledge, no study has yet looked at the QQ trade-off from an intention perspective. Most

[1]The term *intention* is sometimes used interchangeably with *preferences* and *desires*, although these terms carry different meanings [Machiyama (2015)]. *Desire* is the most idealized personal preference, without assuming any constraints. For instance, an infecund person may desire to have a child. *Intention* implies commitment to a set of behaviors to have or not to have a child taking into account diverse constraints. For instance, a person may not intend to have another child within a year because of financial constraints. *Preference* is a general term used to cover both terms.

empirical studies assume that intentions are exogenously given and focus on analyzing changes in the constraints [Zakharenko (2021)].

This is the first study that examines the existence of (i) a QQ trade-off from an intention perspective and (ii) a possible twofold gender bias in these intentions by gender of the child and/or by gender of the parent. We rely on Galor's (2012) modified theoretical collective household model to understand the QQ trade-off conceptually and to derive testable predictions, which we test empirically using a discrete choice experiment (DCE). A DCE is a survey-based method to reveal people's latent intentions. The DCE was conducted among 426 respondents in the age category 18–25 years in six rural districts in the Southern Nations, Nationalities, and People's Region of Ethiopia, with the aim of studying fertility intentions ex ante (i.e., before completing the reproductive lifetime). In our DCE, both men and women are asked to choose between different hypothetical scenarios, which describe the number of boys and girls and how they would be raised in terms of education. We use mixture-amount models to design the experiment, mixed logit models to evaluate the fertility intentions, and Wald tests and marginal rates of substitution to analyze the existence of the QQ trade-off. This paper brings some particular innovations and contributions to the literature on fertility in low- and middle-income countries.

First, different methods have been used to study the QQ trade-off in childrearing, with most studies focusing on fertility outcomes and unidirectional effects. A first group of studies focus on the effect of fertility on education, either using (i) randomized control trials, e.g., looking at the effect of policy reforms on fertility to quantify the effect of fertility on quality of childrearing [Ananat *et al.* (2009), Ananat and Hungerman (2012), Zhong (2017)]; or (ii) quasi-experimental approaches with regression discontinuity designs or instrumental variables such as fertility shocks (i.e., instruments related to the ability to control conception), the occurrence of twins or the gender composition of children [Miller (2009), Angrist *et al.* (2010), Black *et al.* (2010), Becker *et al.* (2010), Kugler and Kumar (2011), Millimet and Wang (2011), Marteleto and de Souza (2012), Ponczek and Souza (2012), Fitzsimons and Malde (2014)]. A second group of studies focus on the effect of parental education on fertility [Buyinza and Hisali (2014), Shapiro and Tenikue (2017), Colleran and Snopkowski (2018)]. We could identify only one study that analyzes the QQ trade-off in both directions simultaneously, which is the study by de la Croix and Perrin (2018) that uses structural equation modelling. Our study takes a different approach and uses a DCE to analyze the QQ trade-off from an intention perspective, which is important as intentions are a key determinant in household-level decisions [Fishbein and Ajzen (2011)]. We estimate the QQ intentions jointly, which is in line with the notion that decisions toward quantity and quality of childrearing are made simultaneously [Cinnirella (2019)]. We focus on education as an indicator for the quality of childrearing because other quality indicators are often considered to be a precondition for children's school performance. Moreover, we contribute to the current empirical evidence focusing on SSA, which is scarce and only analyzes the QQ trade-off from a fertility outcomes perspective. Some recent studies in SSA find evidence for the QQ trade-off [Temel (2013), Bougma *et al.* (2015), Vogl (2016), Ito and Tanaka (2017)] whereas others point to a lack of evidence [Eloundou-Enyegue and Giroux (2012), Kravdal *et al.* (2013), Alidou and Verpoorten (2019)].

Second, fertility intentions may be gendered in two ways, according to the gender of the child and according to the gender of the parent. The gender gap in preference for

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sons or daughters is extensively studied empirically in South-(East) Asia. However, research in SSA is limited. Regarding the gender of the child, the evidence points to a preference for boys' education over girls' education in SSA, including Ethiopia [Kazeem *et al.* (2010), Mani *et al.* (2013), Tesfu and Gurmu (2013), Taş *et al.* (2014), Kuépié *et al.* (2015), Bérenger and Verdier-Chouchane (2016), Vimefall *et al.* (2017)]. However, there is mixed evidence on preference for boys or girls in Ethiopia and SSA in general [Basu and De Jong (2010), Fuse (2010), Mekonnen and Worku (2011), Rossi and Rouanet (2015), Berlie and Alamerew (2018), Eliason *et al.* (2018), Flato (2018), Norling (2018), Chao *et al.* (2019)]. Regarding the gender of the parent, few studies consider individual-level preferences. Some recent studies in SSA find that men report higher fertility, son, and human capital preference than women [Sahn *et al.* (2010), Norling (2018), Ibrahim and Arulogun (2019)]. To our knowledge, there is only one study on child-gendered preferences in the QQ trade-off in SSA in particular [Alidou and Verpoorten (2019)]. This study estimates a causal relation, considers only gender preferences in education, and uses historical data. Our paper goes beyond previous studies by jointly analyzing intentions for quantity and quality and focusing on twofold gender biases, based on experimental data.

Third, to measure fertility intentions, 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, problems with comparison, and influence by factors other than family size intention [Field *et al.* (2016)]. To our knowledge, we are the first to apply a DCE method to study fertility intentions and thereby circumvent these disadvantages in analyzing fertility intentions. 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 intentions. The DCE is designed using a mixture-amount model. This model is highly appropriate to jointly disentangle the intention for different types of education (i.e., the mixture or quality) and the preferred family size (i.e., the amount or quantity), and is based on pioneering work of some authors [Raghavarao and Wiley (2009), Khademi and Timmermans (2012), Ruseckaite *et al.* (2017), Goos and Hamidouche (2019), Zijlstra *et al.* (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 (2022)]. The majority of households face budget constraints, child labor is still common and the provision of high-quality public education is low, implying that the opportunity cost of education is high [Alidou and Verpoorten (2019)]. With a current total fertility rate[2] 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. How fast the transition will go and how large the resulting population expansion will be crucially depend on how fast fertility rates will drop.

[2]This is a hypothetical measure for the average number of children that would be born per woman according to the same fertility behavior across the population until the end of her reproductive life (assumed from 15 to 49 years) as determined in a given year [Hinde (1998)].

The remainder of the paper is structured as follows: section 2 presents the conceptual framework linking fertility intentions to behavior and outlines the theoretical framework to understand the theoretical basis of the QQ trade-off and to derive testable predictions. Section 3 describes the dataset, the DCE design, and estimation strategy. Section 4 presents results on the fertility intentions and the QQ trade-off. Section 5 discusses the results and provides policy recommendations. Section 6 summarizes and concludes.

2. Concepts and theory

2.1 Linking fertility intentions to outcomes

Fertility intentions can indicate the degree of voluntary control over reproductive outcomes, and are therefore important for analyzing individual fertility behavior [Hin *et al.* (2011), Günther and Harttgen (2016), Cleland *et al.* (2019), Yeatman *et al.* (2020)]. Different theories exist about the link between intentions and actual behavior [see Kodzi *et al.* (2010) for an overview]. We draw on the theory of reasoned action and planned behavior (Figure 1), which explains the mechanism leading to the formation of intentions and the interrelation between intentions and subsequent behavior [Fishbein and Ajzen (2011)]. This theory states that attitudes toward behavior, subjective norms, and perceived behavioral control[3] jointly affect the intention to act, which are, to the extent that people are in reality capable of attaining their intentions or have actual control, expected to result in the behavior in question. The three factors affecting intentions are determined by individual, social, and information-related factors. According to this theory, intentions explain most of the variability in observed behavior.

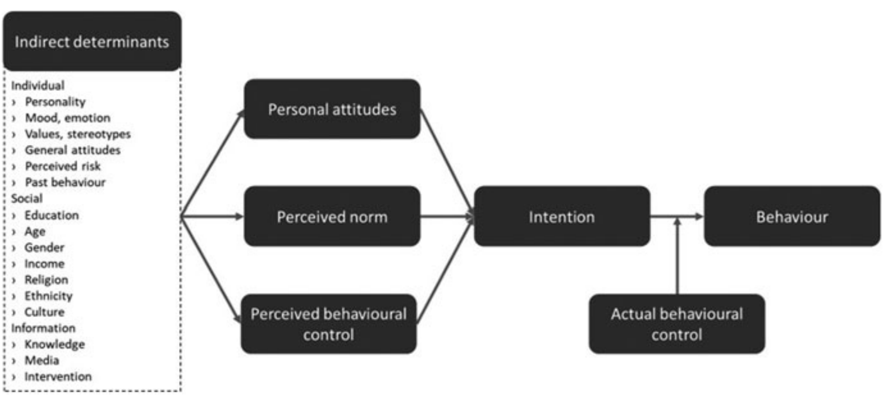

Figure 1. Conceptual framework based on Fishbein and Ajzen (2011).

[3]Personal attitudes are people's positive or negative evaluation of performing the behavior in question. Perceived norms are perceived expectations and behaviors of important referent individuals or groups, combined with the person's motivation to comply with the referents in question. Perceived behavioral control is defined as beliefs about personal and environmental factors that can impede or facilitate their attempts to carry out the behavior.

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The theory of reasoned action and planned behavior has been used and adapted in the fertility literature [Miller *et al.* (2004), Liefbroer (2011), Ajzen and Klobas (2013)]. Personal attitudes are similar to the concept of fertility desires. Perceived norms resemble norms of social groups (e.g., neighborhood, religion, ethnicity, etc.). Perceived behavioral control equals the control one believes to have taking into account the availability and knowledge of contraceptives; financial, time, and institutional constraints; and rates of child mortality. Intentions can be thought of as desires to have children taking into account personal attitudes, perceived norms, and perceived behavioral control. In the empirical section of the paper, we measure these fertility intentions.

2.2 Theoretical quantity–quality framework

Three micro-economic theories exist that aim to explain the main triggers for the fertility decline along the demographic transition: (i) the risk and mortality theory, (ii) the cultural diffusion theory, and (iii) the economic and investment theory. The QQ trade-off originates from the latter theory which was founded by Becker (1960).[4] Becker argues that technological progress leads to an increased demand for human capital and a corresponding increase in the opportunity cost of parenthood, resulting in a reallocation of these resources from the quantity to the quality component of childrearing, and hence a QQ trade-off. Despite the critique on the Beckerian school that budget and time resources are not the only constraints people face [Blake (1968), Sawhill (1977)], the original theoretical underpinnings are useful to understand the QQ trade-off conceptually. We point to other possible perceived constraints in the conceptual discussion above and take these implicitly into account in the empirical analysis by measuring intentions in our DCE.

Becker's theory was later extended by Becker and Lewis (1973), Willis (1973), Becker and Tomes (1976), Becker *et al.* (1990), and Moav (2005) [see Doepke (2015) for an overview]. Whereas former theories model the demographic transition from stagnation to modern economic growth as discontinuous changes, recently much more attention goes to the unified growth theory that models this transition in a single framework. We present a simple extension to the unified growth model of Galor (2012) to understand the QQ trade-off conceptually and to derive testable predictions which we analyze empirically. We extend the model in two dimensions. First, we extend the model to allow for gendered intentions for the number of children and their educational level. We do not assume an a priori asymmetry in gender intentions, unlike other models who relate son intentions to a gender wage gap or low female labor participation and gender differences in education to the time cost for childbearing which only accrue to women [Echevarria and Merlo (1999), Hazan and Zoabi (2015), Guo and Yu (2017), Japaridze (2019), Dao *et al.* (2021)]. Second, following the suggestion of Retherford (1985), we allow for satiated intentions for the number of children and education, because we assume that having more children or education does not necessarily result in more utility, unlike previous studies who assume that the utility parents derive from childrearing follows a logarithmic distribution.

Consider a two-parent collective household model where both parents have their own preferences. Both parents get utility from their own consumption (c), the number of surviving children and their gender mix (n_i), and the gender-specific

[4]For models on the risk and mortality theory, see for example Kalemli-Ozcan (2003) and Canning *et al.* (2013). For models on the cultural diffusion theory, see for example Baudin (2010).

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human capital (h_i) where i refers to boys (b) or girls (g):

$$\begin{aligned} U_{parent} = (1-\delta) \times \ln(c) + \delta \times \{(\zeta n_b - \theta n_b^2) + (\vartheta n_g - \kappa n_g^2) \\ + \lambda[(\mu h_b - \nu h_b^2) + (\rho h_g - \varrho h_g^2)]\}, \end{aligned} \tag{1}$$

where δ is the weight of children in the utility function, ζ, θ, ϑ, κ, μ, ν, ρ, ϱ are the preferences for the number of sons and daughters and their human capital respectively, λ is the preference for human capital and $\delta, \lambda \in [0,1]$ and $\zeta, \theta, \vartheta, \kappa, \mu, \nu, \rho, \varrho \in \mathbb{N}_0^+$. Parents are willing to invest both money and time in childrearing, in competition with alternative uses of time and money. Hence, parents maximize their utility subject to their budget and time constraints:

$$c \leq y - y \times \tau \tag{2}$$

$$\tau = (n_b(\tau^q + \tau^e \times e_b) + n_g(\tau^q + \tau^e \times e_g)), \tag{3}$$

where y is the household's potential income, τ is the fraction of the household's unit-time endowment[5] for raising children with education level (quality) e_i, with τ^q the fraction of the household's unit-time endowment required to raise a child, regardless of quality, and τ^e is the fraction of the household's unit-time endowment required for each unit of education per child. An individual with gender i's level of human capital (h_i) is assumed to be a function of the level of education of gender i (e_i) and the rate of technological progress (t)[6]:

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

For simplicity and in line with our empirical focus on fertility intentions at a certain point in time, we assume that fertility decisions are made at once. Making the maximization process a sequential process to emphasize the role uncertainty plays in parental choice, similar to Namboodiri (1972), Japaridze (2019), and Hazan and Zoabi (2015), would not alter the outcomes of the model. The optimal solution to this problem, obtained by maximizing the utility in equation 1 subject to equations 3 and 4 implies that:

$$n \propto \frac{1}{e_i(t, \zeta, \theta, \vartheta, \kappa, \mu, \nu, \rho, \varrho, \tau^q, \tau^e)}. \tag{5}$$

[5]Some studies assume that the time needed for childrearing can be bought in the market instead of fulfilled by (one of) the parents [de la Croix and Perrin (2018)]. This would not alter the conclusions of the model.

[6]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 t. 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). We assume that the production function for human capital as a function of e_i and t is the same for boys and girls.

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The proof is given in Appendix B. The optimal solution reveals four testable predictions. The first testable prediction of the model is the inverse relationship (i.e., trade-off) between quantity (n) and quality (e) which depends on preferences for quantity and quality and is non-linear. The second testable prediction is that this QQ trade-off can be different for boys or girls. In particular, equation 5 shows that fertility (n) will decrease when the gender education gap (e_g/e_b) improves toward more schooling for boys and/or girls and vice versa. The third testable prediction of this model is that parents may make a different QQ trade-off because we do not assume a unitary household model. The fourth and last testable prediction is that men and women have a different gender bias toward boys and girls when making the QQ trade-off.

In the empirical section of the paper, we investigate these four testable predictions using cross-sectional data from a DCE in rural Ethiopia where the demographic transition is ongoing. Since there is still a high prevalence of unwanted fertility in SSA, we study this QQ trade-off from an intention perspective by estimating intentions for quantity (n) and quality (e) simultaneously in contrast to previous studies who study the existence of a QQ trade-off between quantity (n) and quality (e) using data on fertility outcomes for both variables and unidirectional models.

3. Materials and methods

3.1 Research area and sampling

We use primary survey and DCE data from the Southern Nations, Nationalities, and People's Region in Ethiopia. We collected data in six districts in the Gamo Gofa and Segen People's Zones in this region (Figure 2). This is a predominantly rural area with high ethnic diversity (85 ethnic groups) [Central Statistical Agency (2012)]. The

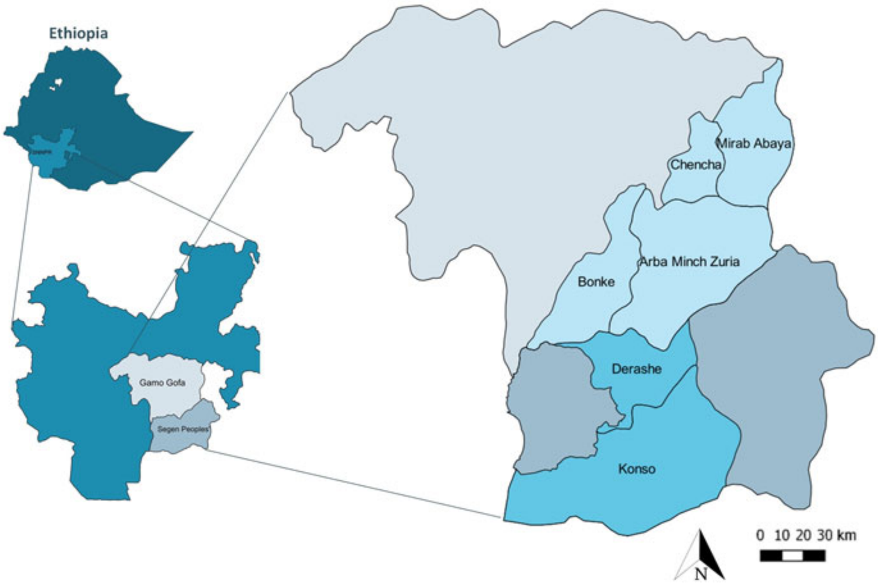

Figure 2. Map of the study area in the Gamo Gofa Zone and Segen People's Zone within the Southern Nations, Nationalities, and People's Region in Ethiopia.

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total fertility rate is 4.9 in the Gamo Gofa Zone and 5.6 in the Segen People's Zone [Central Statistical Agency (2012), Teklu *et al.* (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.

The sample comprises 434 respondents in the age category 18–25 years. The choice of the lower age limit is based on the sensitivity of under-18 marriage—the legal minimum age for marriage in Ethiopia is 18 years [Ethiopian Society of Population Studies (2008)]—and on the ethics of interviewing under-18s. The choice of the upper bound of the age group is based on the median age of first childbirth of 19.5 years in Ethiopia. Our focus minimizes bias due to rationalization for already having a certain number of children [Bongaarts (2011)]. In addition, as fertility intentions have been shown to vary considerably over an individual's lifetime due to high existential uncertainty in SSA [Trinitapoli and Yeatman (2018)], we chose to elicit intentions of parents at the time they make the most crucial decisions. 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 relevant to each category within each selected household.

3.2 Choice experiment design

We investigate (i) latent fertility intentions using a DCE method that allows to analyze trade-offs[7], and (ii) self-expressed fertility intentions through follow-up questions to respondents on the preferred number of children after implementation of the DCE. A DCE is a method to reveal people's latent intentions in the form of a survey. It is based on the characteristic theory of value which states that individuals do not derive utility from a good/service as such, but from the characteristics of this good/service [Lancaster (1966)]. For example, parents do not derive utility from childrearing as such, but from the quantity and quality of children. It is a commonly used method in agricultural economics, health economics, and natural resource economics. In practice, respondents are confronted with several choice cards including two or more mutually exclusive alternatives (i.e., options) that are defined by a set of features (i.e., 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 respondents' utility and analyze potential trade-offs between attributes.

3.2.1 Attributes and attribute levels

Given the focus on the QQ trade-off in fertility intentions, the attributes include the number of children and how they would be raised in terms of education. As we measure intentions which are based on perceived constraints, no constraints are added as attributes. The number of children is represented as the sum of the number

[7]DCE and contingent valuation are both common methods to investigate intentions but the latter does not allow to analyze trade-offs.

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Table 1. Attributes and their levels in the DCE

Variables empirical model	Attributes	Attribute levels	Variables theoretical model
Amount component			
n	Total number of children (*Number of children*)	1, 2, 3, 4, 5, 6, 8, 9, 10, 12	n
Mixture component			
n_1	Number of boys who have not received any schooling (*Boys no schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12	$n_b = n_1 + n_3 + n_5 + n_7$
n_3	Number of boys who have completed primary schooling (*Boys primary schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12	
n_5	Number of boys who have completed high school and preparatory schooling (*Boys secondary schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12	
n_7	Number of boys who have completed university or TVET (*Boys tertiary schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12	
n_2	Number of girls who have not received any schooling (*Girls no schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12	$n_g = n_2 + n_4 + n_6 + n_8$
n_4	Number of girls who have completed primary schooling (*Girls primary schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12	
n_6	Number of girls who have completed high school and preparatory schooling (*Girls secondary schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12	
n_8	Number of girls who have completed university or TVET (*Girls tertiary schooling*)	0, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12	

of boys and girls, and education as 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 schooling 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 (2022)].

The attributes consist of discrete levels ranging from 0/1 to 12 children. The maximum total number of children is set at 12, a choice guided by the observed

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household size in the study area. Therefore, a constraint is added in the design of the DCE ensuring that the sum of the number of girls and boys distributed over the 4 education levels should not exceed 12. This results in 162,425 possible attribute-level combinations or alternatives.

3.2.2 Mixture-amount modeling

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' intention, 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 n of the total number of children in Table 1, we created a candidate list for the mixture proportions in JMP using an $\{8, n\}$ simplex lattice design for the 8 components in Table 1. This ensured that, in all of the alternatives in our DCE, the sum of the 8 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 variance–covariance 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:

$$\begin{aligned} U_{parent} = {} & \sum_{i=1}^{8} \alpha_i n_i + \sum_{i=1}^{7} \sum_{j=1+i}^{8} \alpha_{ij} n_i n_j \\ & + \sum_{i=1}^{6} \sum_{j=i+1}^{7} \sum_{k=j+1}^{8} \alpha_{ijk} n_i n_j n_k + \beta n + \beta n^2 + \beta n^3 \\ & + \beta n^4 + \beta n^5 + \varepsilon. \end{aligned} \tag{6}$$

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

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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 equation 6 and involving 60 choice sets can be found in Table C.1 in Appendix C.

In our DCE, we did not add an opt-out option because this could lead to a lack of information as 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)]. A second reason is that 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 1 of the 5 blocks. We used visual aids since the adult literacy ratio in Ethiopia is only 39% [Central Statistical Agency & ICF International (2016)]. Appropriate images were examined during focus group discussions in four non-sampled villages in the research area. Figure 3 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.

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." First, oral informed consent was asked after which a cheap talk script was used in which the objective, the method, and the attributes were explained to ensure that respondents consider their personal attitudes, perceived norms, and perceived behavioral control when choosing their preferred option based on their intentions. Confidentiality and anonymity were assured. To reduce measurement error and informational bias, the DCE started with two test cards including one card with a dominant scenario, while the order of the remaining choice cards was randomized between respondents. Subsequently, 12 choice cards from 1 of the 5 blocks were presented. As a robustness check, the DCE ended with two duplicates per respondent.

3.4 Analysis

DCEs are embedded in the random utility theory which states that utility is a latent construct that exists in consumers mind but cannot be observed directly [Thurstone (1927), McFadden (1974), Manski (1977)]. This latent utility depends on the attributes of a good/service and the individual's socio-economic characteristics. Following this framework, the latent utility can be split up into an observable and an unobservable part. Choosing one alternative over others implies that the utility of the chosen alternative exceeds the utility associated with the other alternatives. We observe whether an alternative is chosen or not in terms of a binary dependent variable. Typically, a logit model is used to analyze these binary choices. We use the

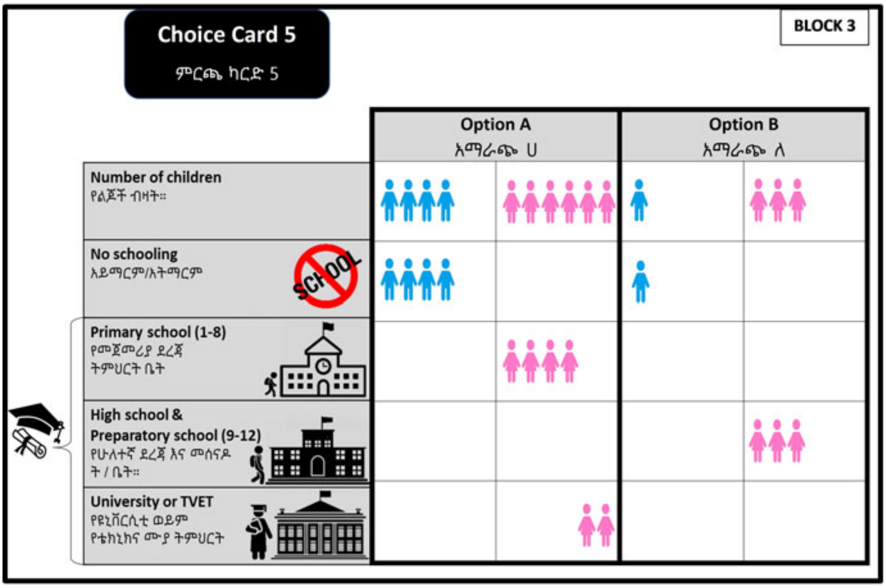

Figure 3. Example of one of the choice cards.

mixed logit model (MXLM),[8] which is the most common discrete choice model and allows for intentions to be heterogeneous among respondents [Revelt and Train (1998)]. The parameter estimates of the MXLM quantify the average respondent's intentions. We estimate different model specifications of the MXLM, using the hierarchical Bayes option[9] in JMP using 10,000 iterations, 5,000 of which were for burn-in. We estimate a first model which is a basic mixture-amount model to investigate the QQ trade-off and the possible bias by the gender of the child. In a second specification, we add the variable *Gender of the parent* as an interaction term to evaluate the existence of a bias by gender of the parent. In both models, we drop one of the linear terms (*Girls no schooling*) to make the choice model estimable, as explained by Goos and Hamidouche (2019).

To select the model with the best fit, we test 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 (2022)]. We select the best mixture-amount model based on the Bayesian information criterion (BIC), as recommended by Schwarz (1978), but

[8]We also considered a conditional logit model which assumes preference homogeneity among respondents. The estimates are in the same range of magnitude. However, the Bayesian Information Criterion (BIC) values indicated that the MXLM fits the data better, indicating that there is preference heterogeneity among the respondents, and hence we only report the results from the MXLM model.

[9]This is equivalent to the maximum likelihood estimation but entails a smaller computational burden and time [Huber and Train (2001)].

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we report also the Akaike information criterion corrected for small sample sizes (AICc). This results in the selection of the following model:

$$E(U_{parent}) = \left(\sum_{i=1}^{7} \gamma_i n_i\right) + n\left(\sum_{i=1}^{8} \gamma_i n_i\right) + n^2\left(\sum_{i=1}^{8} \gamma_i n_i\right). \tag{7}$$

We perform a robustness check to control for attribute non-attendance (i.e., not considering a certain attribute in making a choice) and scale heterogeneity (i.e., making inconsistent choices across the choice cards). A description of the methods and results of the robustness checks can be found in Appendix A. We find that the experiment is robust to both attribute non-attendance and scale heterogeneity.

To evaluate the existence of a QQ trade-off, we perform a joint Wald test[10] for the interaction terms between the quantity and quality attributes. To visualize the QQ trade-off, we calculate the marginal rates of substitution (equation 8) which measures the willingness of individuals to give up one attribute of a good or service in exchange for another such that the utility of the good or service remains constant. In our study, it is calculated as:

$$\partial U = 0 \tag{8}$$

$$MRS_{n,n_i} = \frac{\partial U/\partial n}{\partial U/\partial n_i} = \frac{-dn_i}{dn}, \tag{9}$$

with *MRS* the marginal rate of substitution, U the utility, n_i the number of boys or girls following a certain level of schooling, and n the total number of children (as defined in Table 1). The marginal rates of substution should be interpreted at the highest utility level as respondents are assumed to maximize their utility during the DCE. We visualize the utility indifference curves for no schooling and primary schooling combined, and secondary and tertiary schooling combined. We do this because the QQ trade-off cannot be directly deducted from the primary and secondary schooling variables, 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) due to the mixture-amount design. The choice to combine the levels of education in this way is because secondary and tertiary education are both not compulsory and are therefore only supposed to be attended when there is an expected return from sending children to secondary or tertiary education [Girma and Kedir (2005)].

To analyze the existence of a gender bias for boys or girls in the QQ trade-off, we perform a joint Wald test for the equality of the interaction terms between the quantity and quality attributes of boys versus girls. In addition, we maximize the utility to identify the optimal mixture via the Wolfe reduced-gradient optimization algorithm in JMP. To evaluate the existence of a bias by gender of the parent, we perform a joint Wald test for the equality of the interaction terms between the quantity and quality attributes of men versus women.

[10]For all Wald tests, we used Bonferroni's method for adjusting p-values for multiple testing.

4. Results

4.1 Descriptive statistics

Respondents are on average 21 years old, and men are on average older than women (Table 2). The majority of respondents (64%) are Protestant and 29% have completed secondary school, with more women having completed the first cycle of secondary school than men. 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 four 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%) has 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.

4.2 Heterogeneity in fertility intentions and the QQ trade-off by gender of the child

To analyze fertility intentions, 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 intentions. To facilitate the output interpretation of the non-linear model specification, Figure C2 in Appendix C visualizes the interaction effects between the number of children and the eight educational 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 the percentage *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.

The Wald test for testable prediction 1 indicates that respondents do make a QQ trade-off. To visualize this QQ trade-off, Figure 4 shows that respondents make a QQ trade-off until respondents reach 3.0–5.7 children. For example, Figures 4a and b show that respondents are willing to have fewer children if more children can reach secondary or tertiary education (so fewer children who do not finish any or only primary schooling due to the mixture characteristic of the experiment), or as respondents' willingness to accept a lower level of education for their children in return for more children until the point where 3.0–5.7 children is reached. Beyond this turning point, respondents are only willing to have more (fewer) children, if their children can reach a higher (lower) level of education.

Regarding the existence of a bias by gender of the child, the Wald test for testable prediction 2 indicates that respondents do make a different trade-off for boys and girls. Figure 4 shows that respondents are willing to trade-off a higher share of girls'

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

	Total		Female		Male		
Variable	Mean	St. dev.	Mean	St. dev.	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 (%)	1.40		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		10.60		
Other ethnic group (%)	9.85		9.10		10.59		
Education							
Years of education (*years*)	10.01	3.35	9.75	3.37	10.27	3.33	*
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	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	85.06		86.98		83.02		
Preferred age at first marriage (years)—unmarried	25.12	2.78	23.83	2.27	26.55	5.59	***

Note: The category *other religion* includes Akale, Mekane eyesus, and Hawariyat. The category *other ethnic group* includes Kusume, Wolaita, Gofa, Zavse, Gidicho, and Kore. 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 χ^2 test accounting for the false discovery rate. Significant differences of the mean of the male versus 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

	Total		Female		Male		
Variable	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	
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 χ^2 test accounting for the false discovery rate. Significant differences of the mean of the male versus female subgroups are shown with *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

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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		
Wald test for testable prediction 1 (*p*-value)			0.00		
Wald test for testable prediction 2 (*p*-value)			0.00		

Note: Significant effects of the posterior mean on a 5% level are indicated with *. The posterior SD refers to the posterior standard deviation. Testable prediction 1 is that the quantity (*n*) and quality (*e*) are inversely related. Testable prediction 2 is that this QQ trade-off can be different for boys or girls.

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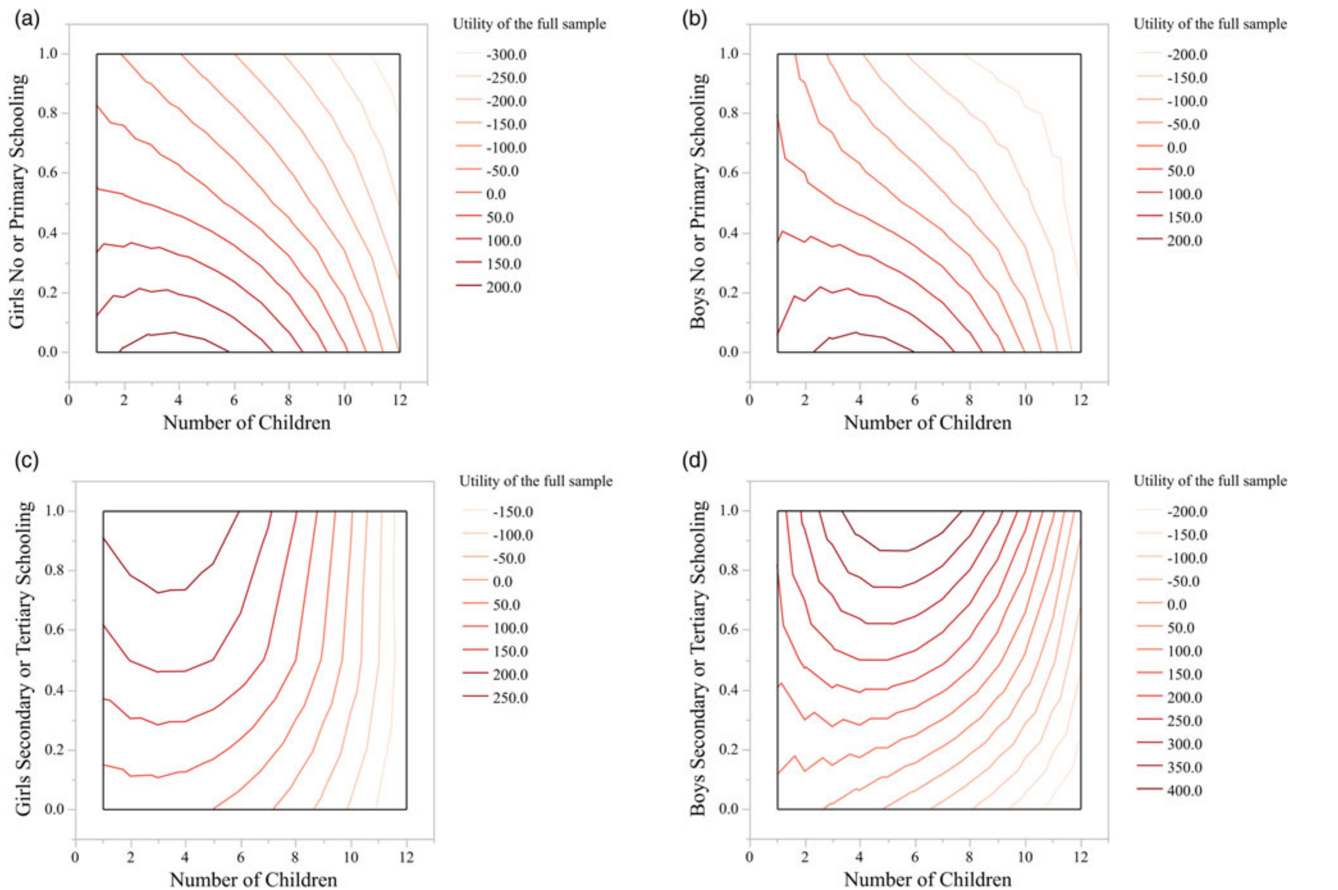

Figure 4. Utility indifference curves of all respondents for the different schooling components (y-axis) and the number of children (x-axis) to visualize the marginal rates of substitution ceteris paribus. The brightest red lines show the highest constant-utility curves. *Note*: all results need to be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

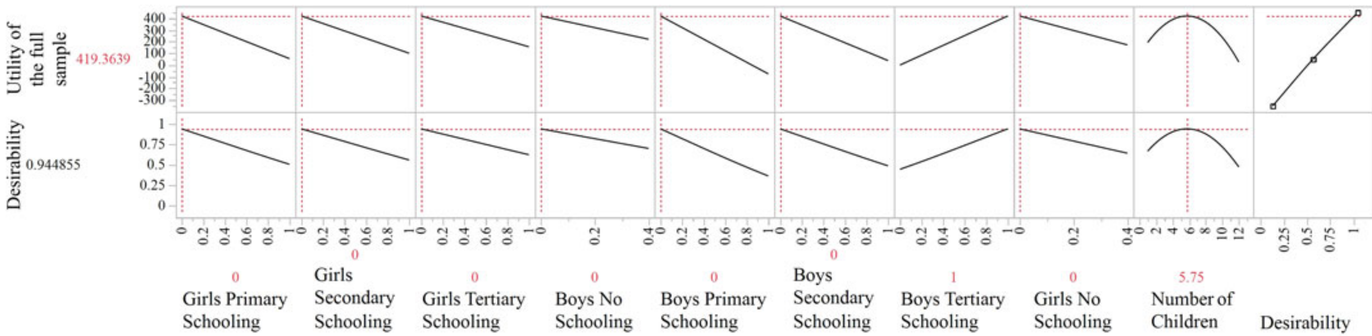

Figure 5. Optimal mixture and amount variable for all respondents. *Note*: all results need to be interpreted with respect to *Girls no schooling*.

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secondary or tertiary education in return for more children compared to boys until the turning point. Figure 5 confirms that respondents have a higher preference for boys, both in terms of quality (as their ideal mixture consists of 100% boys following tertiary education) and quantity (as the percentage of boys over all the educational levels equals 100%). In addition, Figure 5 reveals that the utility-maximizing number of children is situated at 5.75 children.

4.3 Heterogeneity in fertility intentions and the QQ trade-off by gender of the parent

To analyze the heterogeneity in fertility intentions between male and female respondents, the MXLM with the variable *Gender of the parent* as a covariate is estimated (Table 5). Regarding the existence of a bias by gender of the parent, the Wald test shows that there are significant differences in the intentions between male and female respondents. Figures C.2 and C.3 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.

Visualizing the QQ trade-off using the marginal rates of substitution reveals that both male and female respondents make a similar QQ trade-off until respondents reach a certain number of children (ranging from 2.7 to 4.9 for male respondents and 3.8 to 4.8 for female respondents) except that women are less willing to trade-off education for children (shown by the larger marginal rate of substitution) (Figures 6 and 7). Again, beyond this turning point, respondents are only willing to have more (or less) children, if their children can reach a higher (lower) level of education.

The Wald test confirms the existence of a bias for the gender of the child by gender of the parent. Figures 6 and 7 reveal that male respondents are willing to trade-off a larger amount of the quality component for one more child for girls compared to boys, which is not the case for female respondents. Figures 8 and 9 confirm that respondents have a higher intention for boys (as their ideal mixture consists of 100% boys following tertiary education). In addition, it shows that the utility-maximizing number of children is higher for male respondents (5.98 children) than for women (5.62 children).

5. Discussion

Our analysis documents the existence of a QQ trade-off in fertility intentions at a lower quantity of children. 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 willingness to trade-off secondary or tertiary schooling in return for more children. In addition, both men and women have a preference for sons and for tertiary education for boys over education of girls.

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 a certain number of children, between three and six, is reached. Hence, our results imply that stimulating education will have no clear effect on fertility. As a result of the U-shaped utility indifference curves, fertility levels will either rise or fall.

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Table 5. Parameter estimates of the plain MXLM with interaction effects of the dummy variable *Gender of the parent*

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

(*Continued*)

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Table 5. (*Continued.*)

Variable	Posterior mean		Posterior SD	Lower 95% CI	Upper 95% CI
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
Female parent × girls primary schooling	−14.74		37.82	−80.65	69.21
Female parent × girls secondary schooling	56.14		45.58	−37.10	133.06
Female parent × girls tertiary schooling	−106.51	*	41.41	−178.01	−16.79
Female parent × boys no schooling	−238.43	*	74.51	−383.66	−67.46
Female parent × boys primary schooling	−8.46		37.04	−79.21	65.23
Female parent × boys secondary schooling	−21.10		53.65	−179.64	63.59
Female parent × boys tertiary schooling	−90.65	*	47.53	−192.58	−10.65
Female parent × girls no schooling × number of children	−101.74	*	11.05	−124.05	−77.12
Female parent × girls primary schooling × number of children	−0.05		10.15	−19.71	18.24
Female parent × girls secondary schooling × number of children	37.33	*	13.54	16.50	63.37
Female parent × girls tertiary schooling × number of children	91.55	*	11.86	70.63	112.15
Female parent × boys no schooling × number of children	13.53		20.13	−30.24	47.23
Female parent × boys primary schooling × number of children	−15.45		14.43	−44.01	6.13
Female parent × boys secondary schooling × number of children	80.26	*	16.99	53.34	118.32
Female parent × boys tertiary schooling × number of children	119.43	*	14.17	92.26	142.15
Female parent × girls no schooling × number of children^2	8.38	*	1.40	5.57	10.91
Female parent × girls primary schooling × number of children^2	−0.02		0.82	−1.70	1.57
Female parent × girls secondary schooling × number of children^2	−5.02	*	1.01	−6.98	−3.07

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Female parent × girls tertiary schooling × number of children^2	−7.09	*	1.06	−9.25	−5.40
Female parent × boys no schooling × number of children^2	−1.25		1.91	−4.44	2.25
Female parent × boys primary schooling × number of children^2	−2.88		1.84	−6.67	0.14
Female parent × boys secondary schooling × number of children^2	−10.57	*	1.53	−12.98	−7.76
Female parent × boys tertiary schooling × number of children^2	−11.60	*	1.54	−13.91	−8.71
AICc			89.72		
BIC			226.91		
−2LL			47.54		
Wald test for testable prediction 3 (p-value)			0.00		
Wald test for testable prediction 4 for women (p-value)			0.00		
Wald test for testable prediction 4 for men (p-value)			0.00		

Note: Significant effects of the posterior mean on a 5% level are indicated with *. The posterior SD refers to the posterior standard deviation. Testable prediction 3 is that parents make a different QQ trade-off. Testable prediction 4 is that men and women make a different QQ trade-off for boys and girls.

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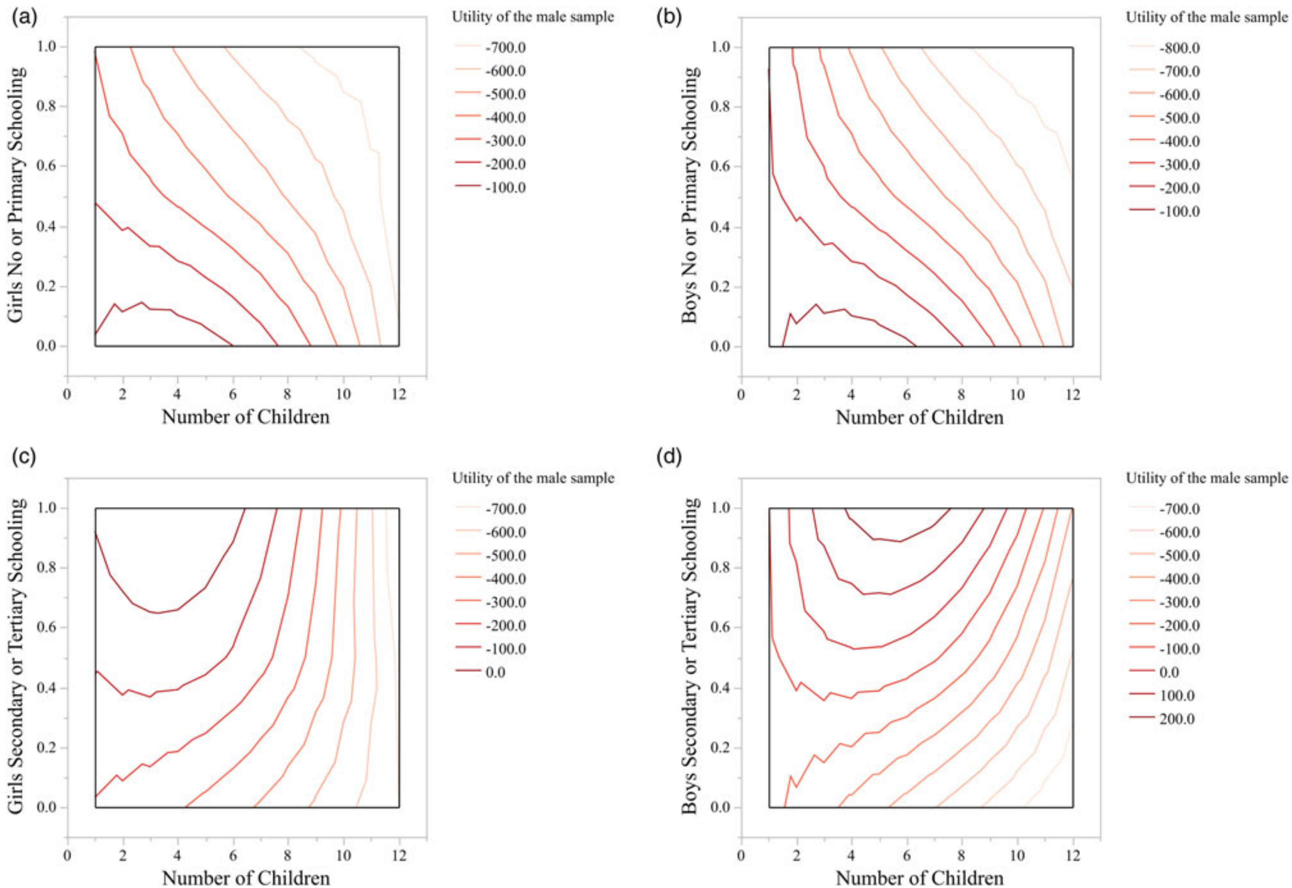

Figure 6. Utility indifference curves of male respondents for the different schooling components (*y*-axis) and the number of children (*x*-axis) to visualize the marginal rates of substitution ceteris paribus. The brightest red lines show the highest constant-utility curves. *Note*: all results need to be interpreted with respect to *Girls no schooling*.

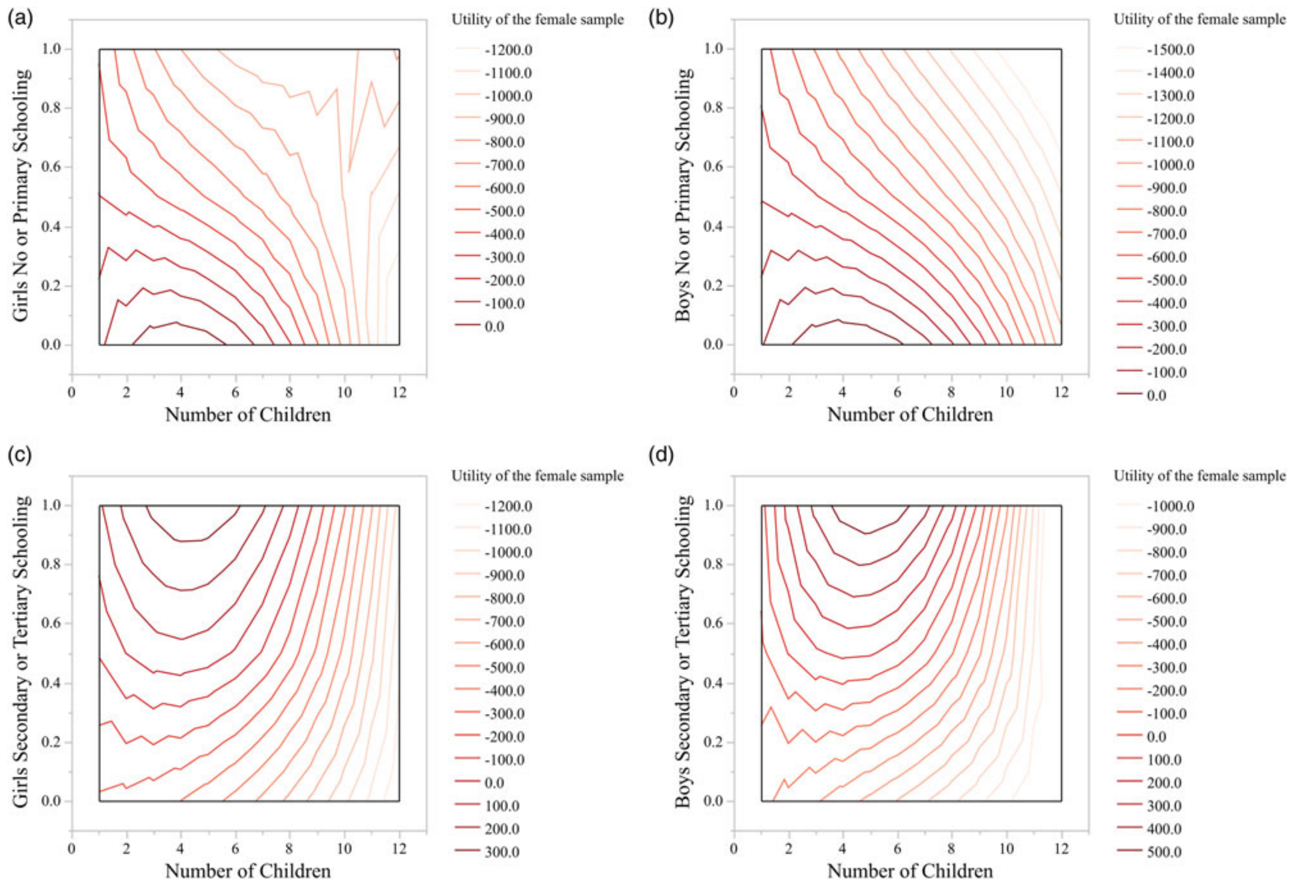

Figure 7. Utility indifference curves of female respondents for the different schooling components (y-axis) and the number of children (x-axis) to visualize the marginal rates of substitution ceteris paribus. The brightest red lines show the highest constant-utility curves. *Note*: all results need to be interpreted with respect to *Girls no schooling*.

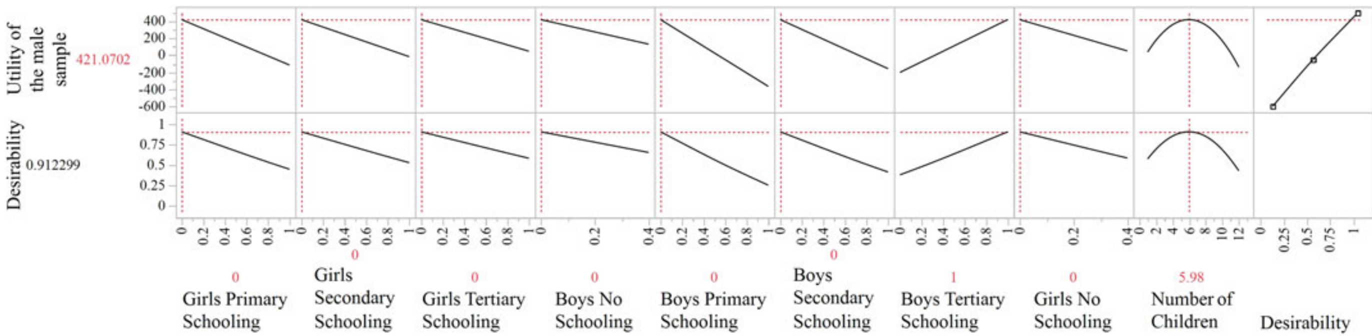

Figure 8. Optimal mixture and amount variable for male respondents. *Note*: all results need to be interpreted with respect to *Girls no schooling*.

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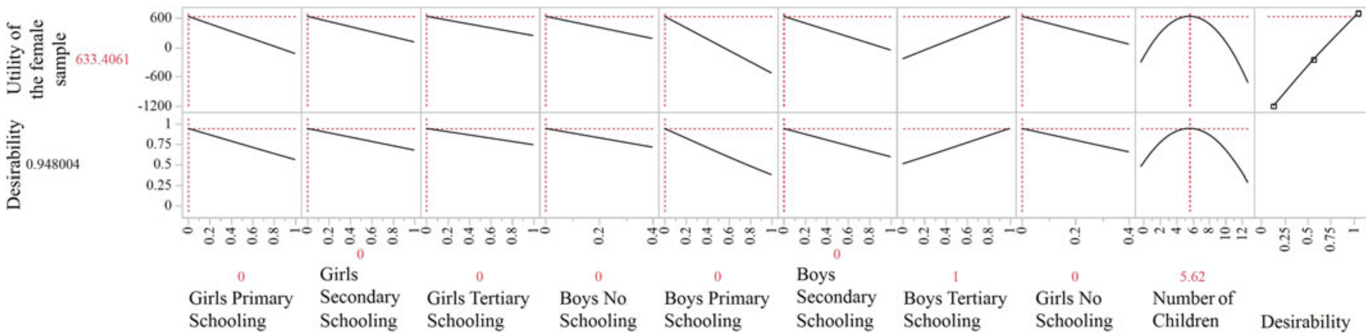

Figure 9. Optimal mixture and amount variable for female respondents. *Note*: all results need to be interpreted with respect to *Girls no schooling*.

These empirical findings document that theoretical models on fertility need further fine-tuning to better capture nuances in fertility intentions and in QQ trade-offs.

The focus of our study on analyzing the QQ trade-off using a DCE by jointly estimating QQ intentions provides additional insights to the current literature on the QQ trade-off. Previous studies focus on actual fertility outcomes rather than fertility intentions 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 SSA, 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 studies on the QQ trade-off shows that estimates are not conclusive and can be non-linear [Clarke (2018)]. We do find a QQ trade-off in fertility intentions and confirm that this trade-off can be non-linear. In addition, our study is the first to reveal that the trade-off only applies when the number of children is less than three to six and entails a twofold gender bias. Concerning the latter, it is important to point to some imbalances between men and women in terms of age (men are 1.65 years older) and marriage (men are 7.59pp more likely to be married). However, studies show mixed evidence about the effect of age and marriage on fertility intention and outcome [Toulemon and Testa (2005), Alemayehu *et al.* (2010), Kodzi *et al.* (2012), Rutaremwa *et al.* (2015), Ibrahim and Arulogun (2019)]. Because of our focus on the gender bias, we only considered the latter background factor in this study.

In addition, 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 total fertility rate of 4.90 in the Gamo Gofa Zone and 5.60 in the Segen People's Zone [Teklu *et al.* (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 the reported gap between the ideal and actual family size in the literature that ranges between one and two children [Bongaarts and Casterline (2013), Günther and Harttgen (2016), Trinitapoli and Yeatman (2018)]. This gap can be explained by (i) an inherent higher family size intention[11] or (ii) by an unmet demand for contraception [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 which is in line with the national unmet demand for contraception of 21% [The World Bank (2022)]. This might result in an inability of women to implement their fertility intentions into fertility outcomes. Yet, fertility intentions in the research area are high as well. Current family planning programs are mainly centered around the availability and awareness on contraception. The effectiveness of family planning policies and programs could improve through a complementary focus on reducing

[11]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.

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 findings result in several policy implications. First, the existence of the U-shaped utility indifference curves shows that a focus on education and fertility is complementary. Policies that stimulate (preferences for) education (e.g., via increased availability, accessibility, and affordability) could be associated with changes in fertility preferences that go in either direction, and thereby could increase or decrease the total fertility rate. This is in line with other studies arguing that free education or education based on a general taxation system can unintentionally result in an increased total fertility rate [de la Croix and Doepke (2004), Azarnert (2008)]. In order for low fertility rates and high schooling rates to go hand in hand and for the demographic transition to accelerate in the study area, policies should be designed to foster preferences for both smaller families and child education. Second, women's ideal family size is lower than men's, implying that stimulating women's reproductive empowerment and women's bargaining power within the household could contribute to a decreased total fertility rate. A recent report by the UNFPA states that women's bargaining power is low in Ethiopia [UNFPA (2021)]: 55% of women lack autonomy in decision-making regarding health care, contraception, and sex, and this decreases with women's education. In addition, empirical evidence in Uganda shows that higher female decision-making power is correlated with fertility intentions that follow women's intentions more closely [Van Hoyweghen *et al.* (2022)]. Third, we observe a gendered preference for more boys 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 *et al.* (2013), Brée and De La Croix (2019)], call for attention to increasing preferences for education, in particular girls' education, to decrease fertility in the long run.

Our research demonstrates the usefulness of the DCE method for analyzing trade-offs in fertility intentions. While DCE results may suffer from several possible sources of bias, including attribute non-attendance, scale heterogeneity, hypothetical bias (i.e., inconsistent behavior because of non-real choices that the respondents must make), informational bias (i.e., influenced behavior due to the provision of information), and social desirability bias, we find that our results are robust to attribute non-attendance and scale heterogeneity. Hypothetical and information bias was mitigated by a cheap talk script, by randomizing the order of the choice cards between respondents, and by screening the data for implausible responses [Loomis (2014)]. Social desirability bias could have influenced our research outcomes, but this is not specific to our method as also direct questions on fertility intentions would suffer such bias. We could have used social desirability scales or rating of item desirability to estimate the degree of social desirability but did not do this to limit the cognitive burden and length of the DCE [Larson (2019), Lopez-Becerra and Alcon (2021)]. Instead, we tried to minimize this bias by hiring local enumerators to implement the DCE and by emphasizing that there are no right or wrong answers during the cheap talk script. In addition, the outcome of the DCE is sensible to the design choices [Hanley *et al.* (2019)]. We optimized the design by consultation of DCE experts and adjustments of the candidate list to avoid unrealistic choice cards. Another 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 disentangle personal attitudes from perceived norms and perceived behavioral control by adding these concepts explicitly as different attributes in a DCE. Further, the effect of parental education could be assessed to see if a higher parental education results in a reinforcing effect through a higher intention for higher education.

6. Conclusion

Different theories exist on the key factors explaining fertility decline. The Beckerian school emphasizes the importance of the demand for human capital as a trigger for fertility decline. They argue that when the demand for human capital increases, parents make a QQ trade-off because of resource constraints. We analyze the existence of this QQ trade-off by analyzing ex ante fertility intentions. In addition, we analyze a possible gender bias in making this QQ trade-off which could be twofold, 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. Our study confirms the existence of a QQ trade-off when the number of children is less than six. Moreover, we find gendered intentions for boys in both the quantity and quality of childrearing, by both men and women, but men intend to trade-off more education in return for an extra child than women do.

Hence, our study shows that preferences for education are inversely related to family size preferences 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, strategies are needed that foster both preferences for child education and for smaller families, as our results show that higher preferences for education can positively or negatively associate with fertility intentions. The revealed gender bias to the disadvantage of girls can possibly impede a further decline in fertility rates. Therefore, a focus on increasing preferences for girls' education is particularly important in light of accelerating the demographic transition in SSA.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/dem.2022.28.

Conflict of interest. None.

References

Ajzen, I. and J. Klobas (2013) Fertility intentions: an approach based on the theory of planned behavior. *Demographic Research* 29(8), 203–232. https://doi.org/10.4054/DemRes.2013.29.8.

Alemayehu, T., J. Haider and D. Habte (2010) Determinants of adolescent fertility in Ethiopia. *Ethiopian Journal of Health Development* 24(1), 30–38. https://doi.org/10.4314/ejhd.v24i1.62942.

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

Ananat, E. O., J. Gruber, P. B. Levine and D. Staiger (2009) Abortion and selection. *Review of Economics and Statistics* 91(1), 124–136. https://doi.org/10.1162/rest.91.1.124.

Ananat, E. O. and D. M. Hungerman (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), 37–51. https://doi.org/10.1162/REST_a_00230.

Angrist, J., V. Lavy and A. Schlosser (2010) Multiple experiments for the causal link between the quantity and quality of children. *Journal of Labor Economics* 28(4), 773–824. https://doi.org/10.1086/653830.

Atake, E.-H. and P. Gnakou Ali (2019) Women's empowerment and fertility preferences in high fertility countries in Sub-Saharan Africa. *BMC Women's Health* 19(1), 305. https://doi.org/10.1186/s12905-019-0747-9.

Azarnert, L. V. (2008) Free education, fertility and human capital accumulation. *Journal of Population Economics* 23(2), 449–468. https://doi.org/10.1007/S00148-008-0205-8.

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

Baudin, T. (2010) A role for cultural transmission in fertility transitions. *Macroeconomic Dynamics* 14(4), 454–481. https://doi.org/10.1017/S1365100509090403.

Becker, G. S. (1960) An economic analysis of fertility. In *Demographic and Economic Change in Developed Countries*, pp. 209–240. Colombia, USA: Columbia University Press.

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

Becker, S. O., F. Cinnirella and L. Woessmann (2013) Does women's education affect fertility? Evidence from pre-demographic transition Prussia. *European Review of Economic History* 17, 24–44. https://doi.org/10.1093/ereh/hes017.

Becker, N. G. and H. G. Lewis (1973) On the interaction between the quantity and quality of children. *Journal of Political Economy* 81(2, Part 2), 279–288. https://doi.org/10.1086/260166.

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

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

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

Berlie, A. and Y. Alamerew (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), 1–12.

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

Blake, J. (1968) Are babies consumer durables? *Population Studies* 22(1), 5–25. https://doi.org/10.1080/00324728.1968.10405523.

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), 209–216. https://doi.org/10.1363/3720911.

Bongaarts, J. (2016) Development: Slow down population growth. *Nature* 530(7591), 409–412. http://dx.doi.org/10.1038/530409a.

Bongaarts, J. and J. Casterline (2013) Fertility transition: is sub-Saharan Africa different? *Population and Development Review* 38, 153–168. https://doi.org/10.1111/j.1728-4457.2013.00557.x.

Bougma, M., T. K. LeGrand and J. F. Kobiané (2015) Fertility limitation and child schooling in Ouagadougou: selective fertility or resource dilution? *Studies in Family Planning* 46(2), 177–199. https://doi.org/10.1111/j.1728-4465.2015.00023.x.

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

Buyinza, F. and E. Hisali (2014) Microeffects of women's education on contraceptive use and fertility: the case of Uganda. *Journal of International Development* 26(6), 763–778. https://doi.org/10.1002/jid.2915.

Canning, D., I. Günther, S. Linnemayr and D. Bloom (2013) Fertility choice, mortality expectations, and interdependent preferences – an empirical analysis. *European Economic Review* 63, 273–289. https://doi.org/10.1016/J.EUROECOREV.2013.07.005.

Central Statistical Agency (2012) *Census 2007 Report*. Addis Ababa, Ethiopia: Central Statistical Agency.
Central Statistical Agency & ICF International (2016) *Ethiopia Demographic and Health Survey 2016*. Addis Ababa, Ethiopia, and Rockville, Maryland, USA: Central Statistical Agency & ICF International.
Chao, F., P. Gerland, A. R. Cook and L. Alkema (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), 9303–9311. https://doi.org/10.1073/pnas.1812593116.
Cinnirella, F. (2019) Marital fertility and investment in children's education. in Diebolt, C., Rijpma, A., Carmichael, S., Dilli, S. and Störmer, C. (eds.), *Cliometrics of the Family. Studies in Economic History*, vol. 1, 1 ed. Basel, Switzerland: Springer, Cham. https://doi.org/10.1007/978-3-319-99480-2_3.
Clarke, D. (2018) Children and their parents: a review of fertility and causality. *Journal of Economic Surveys* 32(2), 518–540. https://doi.org/10.1111/joes.12202.
Cleland, J., K. Machiyama and J. B. Casterline (2019) Fertility preferences and subsequent childbearing in Africa and Asia: a synthesis of evidence from longitudinal studies in 28 populations. *Population Studies* 74(1), 1–21. https://doi.org/10.1080/00324728.2019.1672880.
Colleran, H. and K. Snopkowski (2018) Variation in wealth and educational drivers of fertility decline across 45 countries. *Population Ecology* 60, 155–169. https://doi.org/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* 356, 260–264. https://doi.org/10.1126/science.aal2011.
Dao, N. T., J. D. Avila and A. Greulich (2021) The education gender gap and the demographic transition in developing countries. *Journal of Population Economics* 34(2), 431–474. https://doi.org/10.1007/s00148-020-00787-1.
de la Croix, D. and M. Doepke (2004) Public versus private education when differential fertility matters. *Journal of Development Economics* 73(2), 607–629. https://doi.org/10.1016/J.JDEVECO.2003.05.005.
de la Croix, D. and F. Perrin (2018) How far can economic incentives explain the French fertility and education transition? *European Economic Review* 108, 221–245. https://doi.org/10.1016/J.EUROECOREV.2018.07.001.
Doepke, M. (2015) Gary Becker on the quantity and quality of children. *Journal of Demographic Economics* 81, 55–66. https://doi.org/10.1017/dem.2014.8.
Echevarria, C. and A. Merlo (1999) Gender differences in education in a dynamic household bargaining model. *International Economic Review* 40(2), 265–286. https://doi.org/10.1111/1468-2354.00015.
Eliason, S., F. Baiden, D. A. Tuoyire and K. Awusabo-Asare (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), 187. https://doi.org/10.1186/s12978-018-0616-2.
Eloundou-Enyegue, P. M. and S. C. Giroux (2012) Fertility transitions and schooling: From micro- to macro-level associations. *Demography* 49(4), 1407–1432. https://doi.org/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, Ethiopia.
Farina, P., E. Gurmu, A. Hasen and D. Maffioli (2001) *Fertility and Family Change in Ethiopia*. Addis Ababa, Ethiopia & Rome, Italy: Central Statistical Authority and Institute for Population Research.
Field, E., V. Molitor, A. Schoonbroodt and M. Tertilt (2016) Gender gaps in completed fertility. *Journal of Demographic Economics* 82(2), 167–206. https://doi.org/doi:10.1017/dem.2016.5.
Fishbein, M. and I. Ajzen (2011) *Predicting and changing behavior: the reasoned action approach*, vol. 1, 1 ed. New York, USA: Taylor and Francis, 538 pp. https://doi.org/10.4324/9780203838020.
Fitzsimons, E. and B. Malde (2014) Empirically probing the quantity-quality model. *Journal of Population Economics* 27(1), 33–68. https://doi.org/10.1007/s00148-013-0474-8.
Flato, M. (2018) The differential mortality of undesired infants in sub-Saharan Africa. *Demography* 55(1), 271–294. https://doi.org/10.1007/s13524-017-0638-3.
Fuse, K. (2010) Variations in attitudinal gender preferences for children across 50 less-developed countries. *Demographic Research* 23(36), 1031–1048. https://doi.org/10.4054/DemRes.2010.23.36.
Galor, O. (2012) The demographic transition: causes and consequences. *Cliometrica* 6(1), 1–28. https://doi.org/10.1007/s11698-011-0062-7.
Girma, S. and A. Kedir (2005) Heterogeneity in returns to schooling: Econometric evidence from Ethiopia. *The Journal of Development Studies* 41(8), 1405–1416. https://doi.org/10.1080/00220380500187026.
Goos, P. and H. Hamidouche (2019) Choice models with mixtures: An application to a cocktail experiment. *Food Quality and Preference* 77, 135–146. https://doi.org/10.1016/j.foodqual.2019.04.006.

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

Guo, K. and J. Yu (2017) Gender gap, capital accumulation and the demographic transition. *Economics of Transition* 25(3), 553–572. https://doi.org/10.1111/ECOT.12126.

Hanley, N., J. F. Shogren and B. White (2019) *Introduction to Environmental Economics* (3rd ed.). Oxford, UK: Oxford University Press. Retrieved from https://global.oup.com/academic/product/introduction-to-environmental-economics-9780198737230.

Hazan, M. and H. Zoabi (2015) Sons or daughters? Sex preferences and the reversal of the gender educational gap. *Journal of Demographic Economics* 81(2), 179–201. https://doi.org/10.1017/dem.2014.12.

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

Hin, S., A. Gauthier, J. Goldstein and C. Bühler (2011) Fertility preferences: what measuring second choices teaches us. *Vienna Yearbook of Population Research* 9, 131–156. Retrieved from http://www.jstor.org/stable/41342808.

Hinde, A. (1998) *Demographic Methods* (1st ed.). London, UK: Taylor & Francis Ltd.

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

Ibrahim, F. M. and O. S. Arulogun (2019) Posterity and population growth: fertility intention among a cohort of Nigerian adolescents. *Journal of Population Research* 37, 25–52. https://doi.org/10.1007/s12546-019-09230-z.

Ito, T. and S. Tanaka (2017) Abolishing user fees, fertility choice, and educational attainment. *Journal of Development Economics* 130, 33–44. https://doi.org/10.1016/j.jdeveco.2017.09.006.

Japaridze, I. (2019) Female labor force participation and fertility differentials. *Journal of Demographic Economics* 85(2), 123–164. https://doi.org/10.1017/DEM.2019.1.

Kalemli-Ozcan, S. (2003) A stochastic model of mortality, fertility, and human capital investment. *Journal of Development Economics* 70(1), 103–118. https://doi.org/10.1016/S0304-3878(02)00089-5.

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

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

Khuri, A. I. (2006) *Response Surface Methodology and Related Topics*. Toh Tuck Link, Singapore: World Scientific Publishing Co. Retrieved from https://doi.org/10.1142/5915.

Kodzi, I. A., D. R. Johnson and J. B. Casterline (2010) Examining the predictive value of fertility preferences among Ghanaian women. *Demographic Research* 22, 965–984. https://doi.org/10.4054/DEMRES.2010.22.30.

Kodzi, I. A., D. R. Johnson and J. B. Casterline (2012) To have or not to have another child: life cycle, health and cost considerations of Ghanaian women. *Social Science and Medicine* 74(7), 966–972. https://doi.org/10.1016/j.socscimed.2011.12.035.

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

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

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

Kumar, S. and A. Kugler (2011) *Testing the Children Quantity-Quality Trade-Off in India. IDEAS Working Paper Series from RePEc.* (*No. 42487*). Harvard, USA: Harvard University.

Lancaster, K. J. (1966) A new approach to consumer theory. *Journal of Policital Economy* 74(2), 132–157. Retrieved from: https://www.jstor.org/stable/1828835.

Larson, R. B. (2019) Controlling social desirability bias. *International Journal of Market Research* 61(5), 534–547. https://doi.org/10.1177/1470785318805305.

Liefbroer, A. C. (2011) On the usefulness of the theory of planned behaviour for fertility research. *Vienna Yearbook of Population Research* 9, 55–62. https://doi.org/10.1553/populationyearbook2011s55.

Loomis, J. B. (2014) Strategies for overcoming hypothetical bias in stated preference surveys. *Journal of Agricultural and Resource Economics* 39(1), 34–46. Retrieved from: http://www.jstor.org/stable/44131313.

Lopez-Becerra, E. I. and F. Alcon (2021) Social desirability bias in the environmental economic valuation: an inferred valuation approach. *Ecological Economics* 184(106988). https://doi.org/10.1016/J.ECOLECON.2021.106988.

Machiyama, K. (2015) Measuring fertility. Retrieved from the International Union for the Scientific Study of Population website http://papp.iussp.org/sessions/papp104_s06/PAPP104_s06_010_010.html.

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

Manski, C. F. (1977) The structure of random utility models. *Theory and Decision* 8(3), 229–254.

Marteleto, L. J. and L. R. de Souza (2012) The changing impact of family size on adolescents' schooling: assessing the exogenous variation in fertility using twins in Brazil. *Demography* 49(4), 1453–1477. https://doi.org/10.1007/s13524-012-0118-8.

McFadden, D. (1974) Conditional logit analysis of qualitative choice behavior. In P. Zarembka (ed.), *Frontiers in Econometrics* (1st ed., pp. 105–142). New York, USA: Wiley.

Mekonnen, W. and A. Worku (2011) Determinants of fertility in rural Ethiopia: the case of Butajira demographic surveillance system (DSS). *Public Health* 11(1), 782. https://doi.org/10.1186/1471-2458-11-782.

Miller, A. R. (2009) Motherhood delay and the human capital of the next generation. *American Economic Review* 99(2), 154–158. https://doi.org/10.1257/aer.99.2.154.

Miller, W., L. Severy and D. Pasta (2004) A framework for modelling fertility motivation in couples. *Population Studies* 58(2), 193–205. https://doi.org/10.1080/0032472042000213712.

Millimet, D. L. and L. Wang (2011) Is the quantity-quality trade-off a trade-off for all, none, or some? *Economic Development and Cultural Change* 60(1), 155–195. https://doi.org/10.1086/661216.

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

Namboodiri, N. K. (1972) Some observations on the economic framework for fertility analysis. *Population Studies* 26(2), 185–206. https://doi.org/10.1080/00324728.1972.10405545.

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

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

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

Pradhan, U. K., K. Lal, S. Dash and K. N. Singh (2017) Design and analysis of mixture experiments with process variable. *Communications in Statistics – Theory and Methods* 46(1), 259–270. https://doi.org/10.1080/03610926.2014.990104.

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

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

Retherford, R. D. (1985) A theory of marital fertility transition. *Population Studies* 39(2), 249–268. https://doi.org/10.1080/0032472031000141476.

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

Rose, J. M. and M. C. J. Bliemer (2009) Constructing efficient stated choice experimental designs. *Transport Reviews* 29(5), 587–617. https://doi.org/10.1080/01441640902827623.

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

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

Rutaremwa, G., J. Galande, H. L. Nviiri, E. Akiror and T. Jhamba (2015) The contribution of contraception, marriage and postpartum insusceptibility to fertility levels in Uganda: an application of the aggregate fertility model. *Fertility Research and Practice* 1(16), 1–8. https://doi.org/10.1186/s40738-015-0009-y.

Sahn, D. E., D. C. Stifel, D. E. Sahn and D. C. Stifel (2010) Parental preferences for nutrition of boys and girls: evidence from Africa. *The Journal of Development Studies* 39(1), 21–45. https://doi.org/10.1080/00220380412331322651.

SAS Institute Inc. (2013) *SAS 9.4*. Cary, USA: SAS Institute Inc.

SAS Institute Inc. (2018) *JMP Pro 14*. Cary, USA: SAS Institute Inc.

Sawhill, I. V. (1977) Economic perspectives on the family. *Daedalus* 106(2), 115–125. Retrieved from https://www.jstor.org/stable/20024479.

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

Schwarz, G. (1978) Estimating the dimension of a model. *Ann. Statist.* 6(2), 461–464. https://doi.org/10.1214/aos/1176344136.

Shapiro, D. and M. Tenikue (2017) Women's education, infant and child mortality, and fertility decline in urban and rural Sub-Saharan Africa. *Demographic Research* 37(21), 670–699. https://doi.org/10.4054/DemRes.2017.37.21.

Shenk, M. K., M. C. Towner, H. C. Kress and N. Alam (2013) A model comparison approach shows stronger support for economic models of fertility decline. *Proceedings of the National Academy of Sciences* 110(20), 8045–8050. https://doi.org/10.1073/pnas.1217029110.

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

Teklu, H., A. Sebhatu and T. Gebreselassie (2013) *Components of Fertility Change in Ethiopia: Further Analysis of the 2000, 2005, and 2011 Demographic and Health Surveys*. Addis Ababa, Ethiopia and Calverton, USA: MoFED, UNICEF and ICF International .

Temel, T. (2013) Family size, human capital and growth: structural path analysis of Rwanda. *Journal of Economic Development* 38(4), 39–73. https://doi.org/10.35866/caujed.2013.38.4.002.

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

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

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

Toulemon, L. and M. R. Testa (2005) Fertility intentions and actual fertility: a complex relationship. *Population and Societies* 415(4), 1–4.

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

UNFPA (2021). *State of World Population* 2021. New York, USA. Retrieved from: https://www.unfpa.org/sites/default/files/pub-pdf/SoWP2021_Report_-_EN_web.3.21_0.pdf.

Van Hoyweghen, K., G. Van den Broeck and M. Maertens (2022) Rural development in Sub-Saharan Africa: Essays on food supply chains, labour markets and fertility [Doctoral dissertation, KU Leuven]. Lirias.

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

Vogl, T. S. (2016) Differential fertility, human capital, and development. *The Review of Economic Studies* 83(1), 365–401. https://doi.org/10.1093/restud/rdv026.

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

The World Bank (2022) DataBank World Bank. Retrieved September 7, 2022, from: https://data.worldbank.org/indicator/.

Yeatman, S., J. Trinitapoli and S. Garver (2020) The enduring case for fertility desires. *Demography* 57(6), 2047–2056. https://doi.org/10.1007/S13524-020-00921-4.

Zakharenko, R. (2021) Dead men tell no tales: the role of cultural transmission in demographic change. *Journal of Demographic Economics* 87(4), 511–536. https://doi.org/10.1017/dem.2021.10.

Zhong, H. (2017) The effect of sibling size on children's health and education: is there a quantity-quality trade-off? *The Journal of Development Studies* 53(8), 1194–1206. https://doi.org/10.1080/00220388.2016.1214720.

Zijlstra, T., P. Goos and A. Verhetsel (2019) A mixture-amount stated preference study on the mobility budget. *Transportation Research Part A – Policy* 126, 230–246. https://doi.org/10.1016/j.tra.2019.06.009.

Appendix A: robustness checks

A.1 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 an MXLM with dummy variables for the most ignored attributes to investigate whether these respondents have different intentions. 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 built up the non-attendance pattern. We then compared the EAAlogit model with a conditional logit model because both models assume preference homogeneity. We estimated the conditional logit model via the Firth penalized-likelihood estimation procedure in JMP.

With regard to *serial stated ANA*, Table A.1 shows that 84% of the respondents stated that they 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% versus 27% respectively). Therefore, we analyzed these two possibly ignored attributes via an MXLM with the addition of dummy variables for these two attributes (Table A.3). 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 intentions (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 intention for girls going to primary, secondary, and tertiary education and boys going to tertiary education. They also have a lower intention for the number of children. Respondents who indicated that they had ignored the attribute *No schooling* have a higher intention for the number of girls going to tertiary education and boys to secondary education. Moreover, they have a lower intention 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 of the children and education level (Table A.2). Twenty-six percent of the respondents explicitly took the education level into account and 23% of the choices were 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" conditional logit model (Table A.3). 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

Table A.1. Results of serial stated ANA

	Ignored			Least important			
Attributes	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 on the pairwise χ^2 test accounting for the false discovery rate. Significant differences of the mean of the male versus female subgroups are shown with *$p < 0.1$, *$p < 0.05$, ***$p < 0.01$.

Table A.2. 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 on the pairwise χ^2 test accounting for the false discovery rate. Significant differences of the mean of the male versus female subgroups are shown with $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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" conditional logit model.

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.

A.2 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 an MXLM with dummy variables for the respondents who gave different answers on the duplicates, to investigate a discrepancy in intentions. 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 A.4 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 A.4). 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 minimize 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.

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Table A.3. Parameter estimates of the “standard” MXLM and the “standard” conditional logit model for comparison with the models to account for ANA

	MXLM				Serial stated ANA				Serial stated ANA				Conditional logit model				Inferred ANA via EAAlogit			
Variable	Posterior mean		Lower CI 95%	Upper CI 95%	Mean		Lower CI 95%	Upper CI 95%	Mean		Lower CI 95%	Upper CI 95%	Mean		Lower CI 95%	Upper CI 95%	Mean		Lower CI 95%	Upper CI 95%
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 × Gender of the children					27.17	*	11.56	42.79												
Girls secondary schooling × Gender of the children					12.11	*	0.36	21.95												
Girls tertiary schooling × Gender of the children					59.55	*	43.68	74.50												
Boys no schooling × Gender of the children					9.53		−14.36	32.61												
Boys primary schooling × Gender of the children					10.48		−5.81	25.00												
Boys secondary schooling × Gender of the children					7.73		−14.18	22.91												
Boys tertiary schooling × Gender of the children					90.51	*	73.93	111.81												
Number of children × Gender of the children					−3.26	*	−5.16	−1.83												

(*Continued*)

Table A.3. (*Continued.*)

Variable	MXLM				Serial stated ANA				Serial stated ANA				Conditional logit model				Inferred ANA via EAAlogit			
	Posterior mean		Lower CI 95%	Upper CI 95%	Mean		Lower CI 95%	Upper CI 95%	Mean		Lower CI 95%	Upper CI 95%	Mean		Lower CI 95%	Upper CI 95%	Mean		Lower CI 95%	Upper CI 95%
Girls primary schooling × No schooling									−3.68		−10.42	3.77								
Girls secondary schooling × No schooling									5.14		−1.64	11.73								
Girls tertiary schooling × No schooling									17.05	*	8.05	26.91								
Boys no schooling × No schooling									−1.67		−14.05	11.16								
Boys primary schooling × No schooling									−6.81		−16.33	1.54								
Boys secondary schooling × No schooling									8.96	*	0.62	19.60								
Boys tertiary schooling × No schooling									0.66		−9.29	9.92								
Number of children × No schooling									−1.17	*	−1.87	−0.57								
γ (Girls tertiary schooling)																	1.44	*	0.72	2.16
γ (Boys tertiary schooling)																	1.31	*	0.91	1.70
γ (Number of children)																	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 models that account for ANA include interaction effects of the dummy variables *Gender of the children* 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 built up. This is the reason that only three gamma coefficients are shown in the output.

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Table A.4. Parameter estimates of the "standard" MXLM for comparison with the models to account for scale heterogeneity

	MXLM				MXLM with interaction of duplicates				Scaled MXLM			
Variable	Posterior Mean		Lower CI 95%	Upper CI 95%	Mean		Lower CI 95%	Upper CI 95%	Mean		Lower CI 95%	Upper CI 95%
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 × Duplicate					−0.40		−2.39	1.60				
Girls secondary schooling × Duplicate					0.92		−0.87	2.71				
Girls tertiary schooling × Duplicate					3.81	*	1.45	6.18				
Boys no schooling × Duplicate					4.42	*	1.56	7.28				
Boys primary schooling × Duplicate					0.05		−2.17	2.26				
					0.23		−1.94	2.41				

(*Continued*)

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Table A.4. (*Continued.*)

	MXLM			MXLM with interaction of duplicates			Scaled MXLM		
Variable	Posterior Mean	Lower CI 95%	Upper CI 95%	Mean	Lower CI 95%	Upper CI 95%	Mean	Lower CI 95%	Upper CI 95%
Boys secondary schooling × Duplicate									
Boys tertiary schooling × Duplicate				4.86 *	1.72	8.00			
Number of children × 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 τ is the scale parameter.

Appendix B: solution of the theoretical model

The maximization problem to be solved is:

$$\{e_b,\ e_g,\ n\} = argmax\{(1-\delta) \times ln(c) + \delta \times [(\zeta n_b - \theta n_b^2) + (\vartheta n_g - \kappa n_g^2) + \lambda[(\mu h_b - \nu h_b^2) + (\rho h_g - \varrho h_g^2)]]\}. \tag{B.1}$$

Subject to:

$$c \le y - y \times \tau. \tag{B.2}$$

The solution proceeds in two steps. First, solve for n. From equation B.2:

$$c = y - y \times \tau. \tag{B.3}$$

Substitution in equation B.1 gives:

$$\begin{aligned} U_{parent} = &(1-\delta) \times \ln(y - y \times \tau) \\ &+ \delta \times [(\zeta n_b - \theta n_b^2) + (\vartheta n_g - \kappa n_g^2) \\ &+ \lambda[(\mu h_b - \nu h_b^2) + (\rho h_g - \varrho h_g^2)]]. \end{aligned} \tag{B.4}$$

The first-order condition for n_b is:

$$\begin{aligned} &2\delta\theta(\tau^q + \tau^e e_b)n_b^2 + (-2\delta\theta - \delta\zeta(\tau^q + \tau^e e_b) + 2\delta\theta(\tau^q + \tau^e e_g)n_g)n_b \\ &+ \delta\zeta - \delta\zeta(\tau^q + \tau^e e_g)n_g - (1-\delta)(\tau^q + \tau^e e_b) = 0\ . \end{aligned} \tag{B.5}$$

The first-order condition for n_g is:

$$\begin{aligned} &2\delta\kappa(\tau^q + \tau^e e_g)n_g^2 + (-2\delta\kappa - \delta\vartheta(\tau^q + \tau^e e_g) + 2\delta\kappa(\tau^q + \tau^e e_b)n_b)n_g \\ &+ \delta\vartheta - \delta\vartheta(\tau^q + \tau^e e_b)n_b - (1-\delta)(\tau^q + \tau^e e_g) = 0\ . \end{aligned} \tag{B.6}$$

Solving this equation results in:

$$\begin{aligned} D_b = &(-2\delta\theta - \delta\zeta(\tau^q + \tau^e e_b) + 2\delta\theta(\tau^q + \tau^e e_g)n_g)^2 - 8 \times \delta\theta(\tau^q + \tau^e e_b) \\ &\times (\delta\zeta - \delta\zeta(\tau^q + \tau^e e_g)n_g - (1-\delta)(\tau^q + \tau^e e_b)) \end{aligned} \tag{B.7}$$

$$n_b = \frac{-(-2\delta\theta - \delta\zeta(\tau^q + \tau^e e_b) + 2\delta\theta(\tau^q + \tau^e e_g)n_g) \pm \sqrt{D}}{4\delta\theta(\tau^q + \tau^e e_b)} \tag{B.8}$$

$$\begin{aligned} D_g = &(-2\delta\kappa - \delta\vartheta(\tau^q + \tau^e e_g) + 2\delta\kappa(\tau^q + \tau^e e_b)n_b)^2 - 8 \times \delta\kappa(\tau^q + \tau^e e_g) \\ &\times (\delta\vartheta - \delta\vartheta(\tau^q + \tau^e e_b)n_b - (1-\delta)(\tau^q + \tau^e e_g)) \end{aligned} \tag{B.9}$$

$$n_g = \frac{-(-2\delta\kappa - \delta\vartheta(\tau^q + \tau^e e_g) + 2\delta\kappa(\tau^q + \tau^e e_b)n_b) \pm \sqrt{D}}{4\delta\kappa(\tau^q + \tau^e e_g)} \tag{B.10}$$

where using mathematical simulations for γ, δ, $\zeta \in [0,1]$ and $\alpha, \beta \in \mathbb{N}_0^+$ holds that:

$$n_i \propto \frac{1}{e_i(t,\ \zeta,\ \theta,\ \vartheta,\ \kappa,\ \mu,\ \nu,\ \rho,\ \varrho,\ \tau^q,\ \tau^e)}. \tag{B.11}$$

Hence, a first testable prediction of the model is the inverse relationship (i.e., trade-off) between quantity (n) and quality (e) which depends on preferences for quantity and quality and is non-linear. A second testable prediction is that this QQ trade-off differs for boys or girls. A third testable prediction of this model is that parents may make a different QQ trade-off because we assume collective household model. A final testable prediction is that men and women make a different QQ trade-off for boys and girls.

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