Why Are Underage Girls Married off in The Developing World?

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January 2014

\textit{Abstract:} In this article, we propose a theory of child marriage in which patriarchs time the marriage of their underage daughters. Our theory has two main ingredients to our theory. One is patriarchs’ socioeconomic characteristics, and the other is the intrinsic preference weight men put on having underage brides. Patriarchs’ socioeconomic characteristics are summarized by their level of educational attainment and their wealth. These socioeconomic characteristics determine not only household’s economic stability in the face of competing demands on household resources, but also the outcome of patriarchs’ marriage-timing decision on the well-being of their daughters. Based upon the patriarch’s optimization problem, we build a two-dimensional poverty index comprising his wealth and years of completed schooling as dimensional indicators. We then relate each patriarch’s multi-dimensional poverty score to his incentive to marry off his underage daughter. When parameterized to match 2006 and 2012 for Niger our model predicts that men’s preference for underage brides play a significant role in driving child marriage.

\textbf{JEL:} O12, J12, J13. \textbf{Keywords:} Calibration, child marriage, Men’s preferences for younger brides, Niger.

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1. Introduction

The Millennium Development Goals underscore the need to transform women’s social status as a precondition for long-term economic prosperity. In countries that, to this day, enjoy a high level of prosperity, women have been breaking down barriers to their empowerment and are achieving parity with men in terms of participation in education, the labor market, as well as the social and political life of the countries in which they live. By contrast, in the developing world, girl marriage — an age-old institution tantamount to sexual slavery (Vogelstein, 2013) — continues to stand in the way of women’s empowerment, robbing millions of young girls of their basic human rights. Drawing on numerous reports and case studies documenting child marriage worldwide, development experts and international organizations specializing in children’s issues have reached a consensus that this harmful practice is driven by both supply factors — i.e., why parents marry off their underage daughters — and demand factors — i.e., why men marry underage females, often less than half their age. Yet, there has been no quantitative assessment of the relative importance of these two types of factors to guide effective policy action.

We propose a theory of child marriage in which parents time the marriage of their underage daughters. Our starting point in this article is that child marriage is a parental decision. We build from this standpoint by adding two main ingredients to our theory. One is parents’ individual socioeconomic characteristics, and the other is the intrinsic preference weight men put on having underage brides. Parents’ socioeconomic characteristics are summarized by their level of educational attainment and their wealth.

These socioeconomic characteristics determine not only household’s economic stability in the face of competing demands on household resources (including the high costs of raising children), but also the outcome of parents’ marriage-timing decision on the well-being of their daughters. On the one hand, a household may be short on wealth for a number of reasons, including aggregate economic conditions or crises, or idiosyncratic economic
shocks, such as a bad harvest or illness. Despite its documented harmful effects on the well-being of the underage bride, child marriage can emerge as a viable survival option for poor parents, both in terms of releasing household resources for alternative uses, and, in some cultural environments, adding to household resources through bride prices for example.

On the other hand, only altruistic parents lacking adequate education would be oblivious to the harmful effects this practice has on their daughters’ well-being, and so fail to properly internalize them in their marriage-timing decision. In our model therefore, a parent’s payoff function reflects the fact that lack of education can act as a barrier to his awareness of the harmful effects of child marriage, causing him to overestimate its benefits. We model parents’ individual wealth and years of completed schooling as the two main factors driving the supply of underage brides. Indeed, based upon the parent’s optimization problem, we build a two-dimensional poverty index comprising his wealth and years of completed schooling as dimensional indicators. We then relate each parent’s multi-dimensional poverty score to his incentive to marry off his underage daughter.

We model the demand side of child marriage as an exogenous constraint on the outcome of the parent’s marriage-timing decision. In societies where desired fertility is high, being underage may emerge as a criterion for selecting a bride for a number of reasons. First, pubescent girls may be seen as having longer reproductive lives during which to have many children (Jensen and Thornton 2003). Second, high desired fertility may incline men to control their wives’ sexuality, and from this perspective, underage brides may be seen as more easily controllable by the groom and his family to achieve their desired fertility objectives (Jensen and Thornton 2003). In this context, parents who delay their daughters’ marriage, so as to nurture their development into adulthood in the meantime, may make them less marriageable when older (Jensen and Thornton 2003). Fear of poor marriage prospects for their older daughters, in turn, may put pressure on parents (poor or otherwise)
to marry off their daughters at a younger age. In our model therefore, demand-side factors affect the parent’s payoff from delaying the marriage of his daughter until adulthood. In particular, the higher the preference weight men put on having underage brides, the lower the gain a parent derives from delaying his daughter’s marriage.

We first solve a simplified version of the model to illustrate its analytical features. We show that there are three types of environments in which child marriage can strive: (i) those where multi-faceted parental poverty is its driving force; (ii) those where it is driven by men’s preference for underage brides; and (iii) those where both factors combine to drive its prevalence. We then parameterize a richer version of the model to match 2012 DHS data for Niger — the country with the highest prevalence rate of child marriage in the world.

We conduct two thought experiments. In the first of these experiments, we calibrate the model to the data, so as to assess the quantitative importance of demand- and supply-side factors. The purpose of this exercise is to identify which of the three socio-economic forces mentioned above is responsible for child marriage in Niger, and assess whether the nature of these forces varies across the eight geographic regions comprising Niger, namely Agadez, Diffa, Dosso, Maradi, Niamey (the capital), Tahoua, Tillaberi, and Zinder. To perform this analytical task, we treat each of these eight geographical regions as separate socioeconomic environments, and calibrate the model to each region’s data.

In the second experiment, we identify the region with the lowest level of men’s preference for underage brides, which we interpret as the benchmark. We then compute the level of variation in the incidence of child marriage resulting from the substitution, in all other regions, of their respective preference weight by that of the benchmark region. In other words, we assess by how much in percentage points, the incidence of child marriage varies in each of the seven other regions, if they were given the preference weight of the benchmark region, instead of their own. We find that in some of the regions, this figure is quantitatively
large, highlighting the important role played by demand-side factors.

For calibration purposes, we make flexible assumptions about the distribution of socioeconomic characteristics among parents in each region. In particular, we assume that the marginal distributions of both completed years of schooling and wealth among married men in each region are Fréchet. We choose the parameters of the Fréchet marginals so as to match the empirical distributions observed in the data. Furthermore, for each parent, we allow for socioeconomic characteristics (completed years of schooling and individual wealth) to be either dependent or independent draws. As a result, we parameterize the joint distribution of these socioeconomic characteristics by an Ali-Mikhail-Haq copula, and estimate the dependency parameter for each region using the Maximum-Likelihood method. We relate the calibrated joint distribution to the incidence of child marriage in each region. All these flexible assumptions taken together allow for our theory to fail. In other words, these assumptions allow for the possibility that none of the three socioeconomic forces identified by our theory as driving child marriage are rejected by the data.

There are several reports on child marriage (e.g., UNICEF 2001 and 2010, UNFPA 2012, World Bank 2012, Vogelstein 2013), as well as case studies that measure this phenomenon in terms of its effects on demographic trends, fertility, educational attainment, and other considerations (e.g., Jensen and Thornton 2003; Clark 2004; Lloyd and Mensch 2008; Nguyen and Wodon 2012). In particular, Nguyen and Wodon (2012) provide the first systematic attempt at measuring child marriage in the case of Nigeria, although the authors are not explicitly concerned with its driving forces. To the best of our knowledge, child marriage has yet to be analyzed from an economic perspective in developing countries in terms of the quantitative importance of its drivers. We contribute to fill this gap in the literature.

The remainder of this article is structured as followed. Section 2 presents evidence on girl marriage, focusing on Niger— the country with the highest prevalence rate of girl
marriage in the world. Section 3, presents the model and its qualitative properties. Section 4 presents the quantitative analysis, section 5 concludes. Section 6 presents proof of results, as well as tables.

2. Motivating Evidence

Child marriage is illegal in most countries. However, weak enforcement of the law means that this phenomenon remains highly prevalent in South Asia and sub-Saharan Africa. Bangladesh, Burkina-Faso, The Central African Republic, Chad, Guinea, Madagascar, Malawi, Mali, Mozambique, Niger, and Sierra-Leone are the ten developing countries with the highest incidence of child marriage (UNFPA 2012), with Niger being the most affected of all. In this section, we review and discuss the evidence that multi-faceted poverty drives child marriage in developing country. We take advantage of 2006 and 2012 DHS data for Niger to document sub-national regional differences in the incidence of child marriage, and explain their sources.

Niger is a landlocked country located in Western Africa, with a population estimated at 16,899,327. Estimates from the CIA World Factbook (2013) indicate that Niger has the highest fertility rate in the world, at 7.03 children born per woman, as well as the lowest mean age at first birth for women, at 18 years of age. In addition Niger also has the fourteenth highest maternal mortality rate in the world at 590 death/100,000 live births. According to DHS data, in 1998, over three quarters of the women aged 20-24 (77%) were married or in union before age 18, and data shows little to no change since 1998, with prevalence rates of respectively 75% in 2006 and 76% in 2012. Why do so many girls enter a marital relationship in Niger? Whose decision is it? The parents’ or the girl’s? Why is Niamey different?

\[^{4}\text{CIA World Factbook 2013.}\]
2.1. Who Holds The Household’s Decision-Making Power over Child Marriage?

One of the novelty of the 2012 DHS is the inclusion of question asking women aged 20-24 who married before their 18th birthday to reveal who made the decision regarding the timing of their marriage (the patriarch, the mother, another member of the family, or themselves). Figure 1 below, which we built using 2012 DHS for Niger summarizes the answers to this survey question.

The area in dark blue in Figure 1 highlights the proportion of answers that point to the father as the decision-maker; the blue area, the proportion of those that point to the mother, and finally the light blue area, the proportion pointing to the girl herself. In all these eight regions of Niger, the father plays a determining role in the prevalence of child marriage, as he has most of the decision-making power on the timing of his daughters’ marriage. Niamey and Gosso are the two regions where patriarch’s influence is the lowest. Of these two, Niamey has the lowest prevalence rate of child marriage. Incidentally, sub-national regions where parents (and particularly, fathers) make up most of the decision-making role regarding the timing of women’s marriage, such as Maradi, Diffa and Zinder are also
the regions most affected by this harmful practice. So why would parents marry off their underage daughters? What are the main drivers of this phenomenon? In what follows we use casual empirical methods to shed some light into issue.

2.2. How Important Is Poverty?

Niger has the highest prevalence rate of child marriage in the world. According to a newly released 2013 DHS, on average, 76% of Niger’s women aged 20-24 were married before their eighteenth birthday. In this sub-section, we investigate empirically the extent to which this high prevalence rate is driven by poverty.

Observe that women aged 20-24 at the time of the 2012 DHS, were aged 14-18 at the time the 2006 DHS data for Niger were collected. This implies that most of them were married off by their parents around 2006, at a young age. Therefore, to analyze the importance of household poverty as a driver of child marriage, we match 2006 DHS data on household poverty to 2013 DHS data on the prevalence of child marriage among women aged 20-24 in that survey year, because these women were aged 14-18 in 2006.

We look across the 8 sub-national regions comprising Niger, including Agadez, Diffa, Dosso, Maradi, Niamey, Tahoua, Tillaberi, and Zinder. Figure 2 below presents the multidimensional Headcount ratio by region in 2006.
For each region, the multidimensional Headcount ratio denotes the proportion of individuals who are deprived in at least 1/3 of the ten weighted indicators of poverty identified in the survey data. Figure 1 shows that there are considerable variations across sub-national regions, with incidences ranging from a low of 55% in Niamey, to a high of 91% in Diffa. In between these extremes lie Dosso, Tahoua, and Zinder with sensibly similar incidences of poverty at respectively, 81.10%, 82.04%, and 82.49%. On the basis of the Headcount ratio alone, one would expect Niamey to report the lowest prevalence rate and Diffa the highest, if poverty were the driver of child marriage.

Figure 3 below plots the prevalence of poverty by region among married women aged 20-24 in 2012.

Expectedly, Niamey has the lowest prevalence rate at 32.82%. However Diffa— the poorest region on the basis of the Headcount ratio— is not the most affected region, contrary to expectations. Maradi (88.6%) is, followed by Zinder (87.26%). Diffa (82.39%) has the third highest prevalence. These observations suggest a weak, albeit positive, correlation between household poverty and child marriage.

However, because the Headcount ratio by itself does not account for the intensity of the deprivations faced by households, the above diagnostic of a weak correlation may not be robust to considerations about the intensity of the deprivation among the poor.
example, despite having less deprived people than Diffa, Maradi—the sub-national region most affected by child marriage—may perhaps host those who are more severely deprived. To correct for this possible bias, we present, in Figure 4 below, scatter plots of respectively the 2006 MPI index and the prevalence rate of child marriage among married women aged 20-24 in 2012.

![Figure 4. MPI 2006 and Prevalence Rates 2012 by Region](image)

The Multidimensional Poverty Index (or MPI) developed by Alkire and Santos (2010) is an index of acute multidimensional poverty, capturing both the incidence (Headcount ratio) and the intensity—i.e., the average share of dimensions in which the poor are deprived—of poverty. The higher the MPI score, the higher the proportion of multidimensionally poor people, and the more intense their deprivation is.

The horizontal axis of Figure 3 represents sub-national regions ranked from 1 to 8, on the basis of their respective MPI scores. Region 1 is Niamey with the lowest MPI at 29%, Agadez is number 2, and number 8 is Diffa, with the highest MPI score at 55.7%. The left-hand-side vertical axis represents the MPI score of each sub-national region extracted from 2006 DHS data for Niger, and the right-hand-side vertical axis, its prevalence rate of child marriage extracted from 2012 DHS data.
Figure 4 reveals a strong, but imperfect, positive correlation between multidimensional poverty and child marriage in Niger, suggesting that poverty indeed play an important role as a driver of child marriage. Sub-national regions 1 and 2 have the lowest MPI score, and are also the regions least affected by child marriage. In contrast, sub-national region 8 (Diffa) is the poorest, but not the most affected by this harmful practice. Regions 6 and 7 (i.e., Zinder and Maradi) are the most affected, causing the correlation between poverty and child marriage to be imperfect. This imperfect correlation suggests that there may be other factors competing against, or combining with, poverty to drive child marriage. Motivated by this evidence, we develop a model of patriarchs’ decision on the timing of their daughters’ marriage, highlighting the socioeconomic forces driving child marriage, and quantitatively assessing their relative importance.

3. The Model

In this section, we develop a decision model of parental timing of daughter’s marriage that incorporates both demand-side factors—parents’ incentives to marry off their underage daughters—and demand factors—men’s taste for underage girls. We aim to assess the quantitative importance of each type of factors in order to inform policy actions.

According to a 2012 DHS for Niger, the timing of women’s marriage is predominantly a father’s decision. Consistent with this evidence, we assume that there are $N$ underage girls, each associated with one household, headed by a patriarch—the household decision maker. Therefore $N$ is also the number of decision-making patriarchs in this environment. Each patriarch’s decision on the timing of his daughter’s marriage is binary. He may either time her marriage at $t_i = 0$, meaning that he marry her off before her 18th birthday; or he may time it at $t_i = 1$, instead, meaning that he delays her marriage until after her 18th birthday, so as to nurture her social, emotional, and cognitive development in the meantime. Marriage-timing is important to all individuals, but, in this model, we
explicitly focus on the marriage-timing decisions involving the $N$ underage girls. Out of these $N$ underage girls, a fraction $m \in [0, 1]$ will be married off before they are old enough to decide for themselves. We interpret $m$ as the level of prevalence of child marriage in environment, and explores its determinants.

3.1. Preferences and Endowments

Because child marriage is a parental decision, it is important to understand the socioeconomic characteristics of parents who marry off their underage daughters, as well as those of the environment underlying its emergence as a mass phenomenon. In the 2012 DHS data for Niger, fathers or patriarchs have the most decision-making power over the timing of women’s marriage. Therefore in this study, the relevant individual socioeconomic characteristics considered are those of men—the patriarchs. Evidence collected from the 2012 DHS data for Niger suggests that men’s level of educational attainments are negatively correlated with the prevalence of child marriage, as is their levels of wealth. Consistent with this empirical evidence, we assume that in each household with an underage girl, the patriarch has completed $s_i$ years of schooling and is endowed with a level of wealth, $\omega_i$. Patriarchs’ completed years of schooling and wealth levels are drawn from a joint distribution $\Psi(s, \omega)$, with support in the reals. For any patriarch $i$ ($i = 1, \ldots, N$), his socioeconomic characteristics, $(s_i, \omega_i)$, may be dependent or independent draws. Henceforth, we denote as patriarch $i$, one with individual socioeconomic characteristics $(s_i, \omega_i)$.

Each patriarch cares about the level of economic stability of his household, $h_i$, as well as the outcome of his marriage-timing decision on the well-being of his daughter, $b_i$. The utility function representing these preferences is given by:

$$u_i := \ln h_i + \gamma b_i,$$ (3.1)
where $\gamma$ denotes the relative utility weight the parent put on his daughter’s socioeconomic outcomes including safety and protection, health, as well as economic well-being. Conceptually, we expect the terms $b_i$ and $h_i$ to capture incentives, forces and constraints that put an underage girl at a risk of becoming a child bride. In other words, we structure $b_i$ and $h_i$ such that their respective levels reflect both demand-side and supply-side factors. The semi-logarithmic parameterization of parental preferences shown in (3.1) is designed to capture some degree of risk-aversion on the part of the patriarch, while allowing for the possibility that the outcome of his marriage-timing decision on his daughter’s well-being is negative (i.e., $b_i \in \mathbb{R}$), in which case the parent will face a disutility. For this reason, we also interpret $\gamma$ as the marginal utility/disutility of the outcome generated by the patriarch’s actions.

3.1.1. Marriage-Timing and Household Economic Stability

Each patriarch $i$ allocates a fixed share $\kappa \in (0, 1)$ of his wealth, $\omega_i$, to expenditures aimed at nurturing his daughter’s development, conditional upon deciding to delay her marriage until adulthood. Therefore $\kappa \omega_i$ denotes the level of parental expenditures on child nurturing, including food, clothing, health care, and education related expenditures, all of which may impact the girl’s well-being both today and in the future. If a patriarch $i$ ($i = 1, \ldots, N$) decides to marry off his underage daughter instead (i.e., he times her marriage at $t_i = 0$), the child bride leaves the family home. From the patriarch’s point of view, this decision brings immediate release of household resources for alternative uses, and may also add to household wealth through, for example, the payment of a bride price, as in sub-Saharan African countries. In other words, the cost $\kappa \omega_i$ of nurturing the child is averted by early marriage, while the household may also receive a bride price measured by $\phi \omega_i$, where $\phi \in (0, 1)$ is a parameter that convert the bride price into a share of household’s initial wealth, $\omega_i$. This specification can be justified by the fact that a parent’s wealth determines
his bargaining power over the groom’s family, which in turn influences the agreed-upon bride price. The higher the bride’s family’s wealth, the higher the patriarch’s bargaining power. Therefore a patriarch $i$ who decides to marry off his underage daughter ends up with total wealth $(1 + \phi) \omega$, which immediately impacts the household’s economic stability, $h_i$. Thus there is a link between the household’s level of economic stability, $h_i$, and the patriarch’s timing of the marriage of his underage daughter, $t_i$:

$$h_i = t_i (1 - \kappa) \omega_i + (1 - t_i) (1 + \phi) \omega_i \equiv H (t_i, \omega_i),$$

(3.2)

all $i$. The level of economic stability of a household in which the patriarch times his daughter’s marriage at $t_i = 0$ is measured by $H (0, \omega_i) = (1 + \phi) \omega_i$, while that of a household where the patriarch time it at $t_i = 1$ instead is measured by $H (1, \omega_i) = (1 - \kappa) \omega_i$.

3.1.2. Marriage-Timing and Daughter’s Outcomes

Next, we turn to the link between the patriarch’s marriage-timing decision, $t_i$, and the outcome of this decision on his daughter’s well-being, $b_i$. Suppose first that patriarch $i$ decides to time the marriage of his underage daughter at $t_i = 1$ (i.e., he delays her marriage so as to nurture her social and emotional development in the meantime). From the patriarch’s standpoint, the outcome of this decision on his daughter’s well-being (for example, in terms of safety, protection, health, social and economic emancipation) depends on his socioeconomic characteristics as well as on exogenous factors beyond his control. On the one hand, household resources invested in nurturing the girl contribute to her social and emotional development, as well as her economic and social well-being, through education, health care, future career prospects and family life. For example, when enrolled in school—an event which depends on the resources available to the household—, a well-nourished girl may be more alert, and thus more able to learn, which in turn will impact positively on her school performances—an important determinant of her social and professional
development. Furthermore, a girl whose needs are well provided may be less tempted to adopt risky behaviors such as sexual debauchery that could lead to out-of-wedlock teenage pregnancy. A poor parent may thus fear that if he does not have sufficient resources to adequately invest in his daughter’s nurturing, she may be at risk of becoming victim to out-of-wedlock teenage pregnancy, which would undermine her socioeconomic outcomes and her future prospects. For this reason, we link the outcome of the patriarch’s decision to nurture his underage daughter to the level of household resources allocated to this end, $\kappa \omega_i$. This feature of the relation between nurturing and the girl’s outcomes suggests that richer parents may have a comparative advantage at delaying the marriage of their underage daughters (Jenson and Thornton, 2003). For poor parents, limited resources thus act as a contrainst to child nurturing and as an incentive to marry her off.

Yet, even for richer parents, delaying their daughters marriage so as to nurture their development into healthy, educated, and responsible adults may yield a poor outcome in an environment where men put a high preference weight on having underage brides. In such an environment, a parent, rich or poor, may fear that delaying his daughter’s marriage may have an adverse effect on her future marriage prospects, making her less marriageable (Jenson and Thornton, 2003). This demand-side factor is captured by the paremeter $\theta$ measuring the strength of men’s preference for underage brides. We therefore assume that a patriarch $i$ who times his daughter’s marriage at $t_i = 1$ (i.e., he delays her marriage) expects this choice to produce a level of outcome measured by $\kappa \omega_i - \theta$. In this analysis, $\theta$ summarizes demand-side factors in child marriage. The higher $\theta$, the poorer the marriage prospects of older women, and the better those of underage girls.

Next, a patriarch $i$ who chooses to marry off his underage daughter (i.e., he times her marriage at $t_i = 0$) permanently transfers her custody to another household which will

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5In many developing countries, men’s preference for underage brides is often expressed through the existence of customary or religious laws that condone the practice; for example, the tradition of requiring that the bride be a virgin at first marriage.
from then on influence her socioeconomic outcomes. A key conceptual innovation of our analysis is that parents’s level of education affects their perception of the outcome on the girl’s well-being of the decision to marry her off as a younger age. It is well-documented that child marriage undermines the child’s emotional and social development, in addition to compromising her reproductive health (e.g., Nour 2006 and 2009, UNFPA 2012, Vogelstein 2013). A parent who is well-educated is more likely to know this and factor it into his assessment of the outcome of his marriage-timing decision, as is the case in developed countries which, today, have all banned this harmful practice. By contrast, an uneducated parent (rich or poor) may either be oblivious to the harmful effects of child marriage, or may easily be swayed by sociocultural factors (custom and tradition) that prevent the internalization of its harmful effects. We capture this supply-side factor by assuming that from the standpoint of patriarch $i$, the outcome of his decision to marry off his underage daughter is measured by $\hat{s} - s_i$, where $\hat{s}$ denotes a cutoff level of completed years of schooling above which the patriarch is able to internalize the harmful effects of child marriage. A patriarch with a level of education $s_i \geq \hat{s}$, fully internalizes the harmful effects of early marriage on the child’s well-being. Therefore he would prefer not to marry her off, and may only do so if the alternative is worse. By contrast, a patriarch whose level of education is such that $s_i < \hat{s}$ does not fully internalize these harmful effects. He would prefer to marry off his underage daughter, and may only reject this option, if the alternative is better.

To sum up, the link between patriarch $i$’s marriage-timing decision, $t_i$, and its outcome on the daughter’s well-being is characterized fully as follows:

$$b_i = (1 - t_i) (\hat{s} - s_i) + (\kappa \omega_i - \theta) t_i \equiv B^i (t_i, s_i, \omega_i, \theta), \quad (3.3)$$

all $i$. In other words, if patriarch $i$ times his daughter’s marriage at $t_i = 0$, the outcome of this decision on her well-being is $B^i (0, s_i, \omega_i, \theta) = \hat{s} - s_i$; it is $B^i (1, s_i, \omega_i, \theta) = \kappa \omega_i - \theta$, if
he times it at \( t_i = 1 \) instead. Again, note that depending on the patriarch’s socioeconomic characteristics, \((s_i, \omega_i)\), these outcomes can be either positive or negative.

### 3.2. Optimization

Each patriarch makes an optimizing decision on the basis of his socioeconomic characteristics, \((s_i, \omega_i)\), and the payoff associated to each of his marriage-timing strategies. Let \( P^i(t_i, s_i, \omega_i, \theta) \) denote the payoff to a patriarch \( i \) for timing his underage daughter’s marriage at \( t_i \), when demand-side factors are summarized by the level of men’s intrinsic preference for underage brides, \( \theta \). From (3.1), substituting in (3.2) and (3.3), yields:

\[
P^i(t_i, s_i, \omega_i, \theta) = \ln H(t_i, \omega_i) + B^i(t_i, s_i, \omega_i, \theta), \quad i = 1, \ldots, N. \tag{3.4}
\]

If a patriarch \( i \) times his underage daughter’s marriage at \( t_i \in \{0, 1\} \), then by optimality, it must be that:

\[
t_i = \arg \max_{t_i \in \{0, 1\}} P^i(t_i, s_i, \omega_i, \theta). \tag{3.5}
\]

A simple cutoff rule in terms of individual socioeconomic characteristics, \((s_i, \omega_i)\), therefore determines the patriarch’s optimal decision. In particular, using (3.2) and (3.3), and assuming that

\[
\gamma = \frac{1}{1 + \kappa}, \tag{3.6}
\]

it follows that patriarch \( i \) is better off delaying his daughter’s marriage (i.e., \( t_i = 1 \)), if and only if

\[
\gamma s_i + (1 - \gamma) \omega_i \geq \theta + \hat{s} - \ln \left( \frac{1 - \kappa}{1 + \phi} \right) \equiv \varphi(\theta). \tag{3.7}
\]

He is better off marrying her off instead if and only if

\[
\gamma s_i + (1 - \gamma) \omega_i < \varphi(\theta).
\]
We use this optimality criterion to analyze how patriarchs sort into those who marry off their underage daughters and those who do not, and explore, both theoretically and quantitatively, the link between this sorting and supply-side/demand/side factors.

3.3. Measuring Multi-Faceted Poverty

Recall that the aim of this study is to explore the drivers of child marriage, and assess the quantitative importance of each. Reports sponsored by international organizations advocating the end of child marriage point to multi-faceted poverty as the determinant of supply-side factors—i.e., why parents marry off their underage daughters. Therefore to assess the role played by multi-faceted poverty, we must first measure it, in order to explore the extent to which it impedes parents’ ability to nurture their underage daughters.

In what follows, we construct a measure of multi-faceted parental poverty in this environment. First, using (3.7), we define a two-dimensional index of parental poverty by

\[ I(s_i, \omega_i) := \gamma s_i + (1 - \gamma) \omega_i, \]  

(3.8)

where \( \gamma \) and \( 1 - \gamma \) are the respective weights applied to each of the two dimensions contributing to parental poverty, namely parent’s completed years of schooling \( s_i \) and wealth \( \omega_i \). The poverty score in (3.8) is a truncated measure reflecting the impact of parental poverty only on the outcomes of the targeted underage girl. In particular, since the household includes members other than the targeted underage girl, the fixed relative share, \( \kappa \), of household wealth allocated to her when nurtured at home is necessarily less than unity, because from the viewpoint of family members household wealth is both a rival and excludable good: access to it by one member reduces the quantity available to other members. Our measure of poverty is therefore constructed to reflect the share of household wealth the underage girl would have been entitled to had she been nurtured at home, instead of married off, hence the substraction from parental wealth of the share \( 1 - \kappa \) allocated to
the rest of the household.

In contrast, the parent's level of educational attainment is a household "public good": access to it by one member does not reduce the quantity available to other members. Therefore there is no need to subtract the share the other household members are entitled to in order to better reflect the impact of this dimension of poverty on the outcomes of the targeted underage girl. This explains why, in our two-dimensional poverty score defined in (3.8), the relative weight applied to the educational attainment indicator, $\gamma = \frac{1}{(1 + \kappa)}$, is bigger than the one applied to the wealth indicator, $1 - \gamma = \frac{\kappa}{(1 + \kappa)}$, for $\kappa \in (0, 1)$.

Second, we define a two-dimensional poverty cutoff, $c^*$, as the weighted sums of the dimensional indicators' cutoff $s^*$ (for the parent's years of schooling) and $\omega^*$ (for parental wealth), respectively:

$$c^* := \gamma s^* + (1 - \gamma) \omega^*. \tag{3.9}$$

For example, in Alkire and Santos (2010), an adult is considered deprived in terms of his level of educational attainment, if he/she has less than five years of schooling. Therefore $s^* = 5$ years of schooling is a good cutoff for this indicator.

On the basis of this two-dimensional poverty measure, patriarch $i$ is said to be poor, if and only if he has socioeconomic characteristics, $(s_i, \omega_i)$, give him a capability score, $I(s_i, \omega_i)$, that lies below the cutoff, $c^*$:

$$I(s_i, \omega_i) < c^*. \tag{3.10}$$

He is not considered to be poor if and only if

$$I(s_i, \omega_i) \geq c^*.$$
3.4. Necessary and Sufficient Conditions Poverty-Driven Child marriage

Is multi-faceted poverty the only drive of child marriage? For poverty to be the only driver of child marriage as a mass phenomenon, there must be a one-to-one correspondence between the set of poor patriarchs and the set of those who are better off marrying off their underage daughters. We offer a systematic assessment of this issue in this subsection.

For this purpose, we explore the qualitative features of the optimization problem faced by patriarchs in this environment. We start with the following assumption.

**Assumption 1.** Patriarchs’ individual characteristics, \((s_i, \omega_i)\), are independently distributed:

\[
\Psi(s, \omega) = F(s) G(\omega).
\]

Assumption 1 allows us to solve a simple version of the model so as to illustrate the relative importance of multi-dimensional poverty. We relax this assumption in the next section.

First, pick a patriarch \(i\) at random from the population of \(N\) patriarchs. Then, the probability that his ability to nurture his underage daughter is hampered by multi-faceted poverty is given by \(\Pr [\text{I}(s_i, \omega_i) < c^*]\). In other words, \(\Pr [\text{I}(s_i, \omega_i) < c^*]\) is the probability that patriarch \(i\) is multi-dimensionally poor. Using (3.8), rearranging, yields a reformulation of this probability as follows:

\[
\Pr [s_i < c^* \gamma^{-1} - \lambda \omega_i] = \int_{\omega} \int_{0}^{c^* \gamma^{-1} - \lambda \omega} \psi(s, u) dsdu, \tag{3.11}
\]

where \(\psi(s, \omega)\) is the joint probability density function of the random variables \(s\) and \(\omega\), and \(\lambda := (1 - \gamma) / \gamma\). By the law of large numbers, the probability in (3.11) is also the fraction of patriarchs who are poor. Denote this fraction as \(\pi \in [0, 1]\). One can interpret \(\pi\) as a multi-dimensional headcount index. Then, using (3.11) in combination with Assumption
1, yields:

$$
\pi = \int_{\omega} F \left( e^* \gamma^{-1} - \lambda \omega \right) G(\omega) \, d\omega
$$

(3.12)

where

$$
F \left( e^* \gamma^{-1} - \lambda \omega \right) := \int_{s}^{e^* \gamma^{-1} - \lambda \omega} f(s) \, ds
$$

denotes the marginal distribution of patriarchs’ completed years of schooling evaluated at the random variable $e^* \gamma^{-1} - \lambda \omega$.

Second, observe that it is optimal for patriarch $i$ to marry off his underage daughter (instead of nurturing her development), if and only if his socioeconomic characteristics, $(s_i, \omega_i)$, satisfy

$$
I(s_i, \omega_i) < \varphi(\theta).
$$

(3.13)

Therefore, the probability that a patriarch $i$ picked at random from the population of $N$ patriarchs is better off marrying off his underage daughter (i.e., $0 = \arg \max_t P^i(t_i, s_i, \omega_i)$) is given by $\Pr[I(s_i, \omega_i) < \varphi(\theta)]$, which, rearranging, yields

$$
\Pr[s_i < \xi(\theta) - \lambda \omega_i] = \int_{\omega} \int_{s}^{\omega} \psi(s, u) \, dsdu,
$$

(3.14)

where

$$
\xi(\theta) := \frac{1}{\gamma} \varphi(\theta).
$$

(3.15)

We then apply the law of large numbers to interpret this probability as the share of patriarchs who marry off their underage daughters, $m$. Then making use of Assumption 1, we obtain this share as follows:

$$
m = \Pr[s_i < \xi(\theta) - \lambda \omega_i] = \int_{\omega} F(\xi(\theta) - \lambda \omega) G(\omega) \, d\omega
$$

(3.16)
where

\[
F (\xi (\theta) - \lambda \omega) := \int_{\Omega}^{\xi (\theta) - \lambda \omega} f (s) \, ds
\]

denotes the marginal distribution of patriarchs’ number of completed years of schooling evaluated at the random variable \( \xi (\theta) - \lambda \omega \).

Finally, using (3.12) and (3.16), we can express the gap between the share of patriarchs who marry off their underage daughters, \( m \), and the share of those who are multidimensionally poor, \( \pi \), as follows:

\[
m - \pi = \int_{\Omega}^{\omega} \left[ F (\xi (\theta) - \lambda \omega) - F (c^* \gamma^{-1} - \lambda \omega) \right] G (\omega) \, d\omega.
\]

When \( m - \pi = 0 \), the set of poor patriarchs and the set of those who marry off their underage daughters are identical, implying that poverty is the only driver of child marriage. Since both \( F \) and \( G \) are increasing functions, this equality is satisfied if and only if \( \xi (\theta) = c^* \gamma^{-1} \).

We have just established the following result:

**Proposition 1.** Under Assumption 1, multi-faceted parental poverty is a necessary and sufficient condition for the emergence of child marriage if and only if

\[
\varphi (\theta) = c^*.
\]  

(3.17)

Proposition 1 states a necessary and sufficient condition for supply-side factors (parental poverty, in particular) to drive the prevalence of child marriage. When

\[
\varphi (\theta) < c^*,
\]  

(3.18)

the set of patriarchs who marry off their underage daughters is smaller than the set of those who are poor. In that case, poverty is necessary, but not alone sufficient for child
marriage to emerge as a mass phenomenon. By contrast, when

$$\varphi(\theta) > c^*, \quad (3.19)$$

multi-faceted poverty becomes only sufficient, but not necessary for child marriage to emerge. An interesting question thus is: can there be child marriage without poverty? In other words, does $m > 0$ necessarily implies that $\pi > 0$? We make the following additional assumption to provide more insight into this issue.

**Assumption 2.** Let $s$ and $\omega$ be drawn from independent uniform distributions:

$$F(s) = \frac{s - s}{\bar{s} - s}, \quad G(\omega) = \frac{\omega - \omega}{\bar{\omega} - \omega},$$

where $0 \leq s < \bar{s} < \infty$ and $0 \leq \omega < \bar{\omega} < \infty$.

We relax this assumption in the next section. From (3.12) and (3.16), making use of Assumption 2 and setting $s = \omega = 0$, without loss of generality leads to

$$\pi = \frac{\bar{\omega}}{2\bar{s}} \left[ c^* \gamma^{-1} - \frac{2\lambda}{3} \bar{\omega} \right], \quad (3.20)$$

$$m = \frac{\bar{\omega}}{2\bar{s}} \left[ \xi(\theta) - \frac{2\lambda}{3} \bar{\omega} \right]. \quad (3.21)$$

Hence the following result.

**Proposition 2.** Let Assumptions 1 and 2 hold simultaneously; and suppose condition (3.19) also holds. Then, $m > 0$ and $\pi = 0$, if and only if:

$$c^* \leq \frac{2\lambda \gamma}{3} \bar{\omega} < \varphi(\theta),$$
Which of conditions (3.17), (3.18), and (3.19) is representative of the real world is clearly an empirical question. Condition (3.17) is that parents’s fear of the effects their poverty will have on their daughter’s well-being (as measured by $c^*$) be stronger than their fear of the effects that being less marriageable as result of delayed participation will have on their daughter’s well being (as measured by $\varphi(\theta)$). Condition (3.17) indeed suggests that due to a relatively low level of men preference for underage brides, parents in this environment become more wary of the negative effects their multi-faceted poverty has on their ability to nurture their underage daughter than they are of the effects of delaying her marriage. Under this condition, the set of parents who are multidimensionally poor is at least as large as the set of those who are better off marrying off their underage daughters (i.e., $m - \pi \leq 0$). , $m$, to be less or equal to the share of those who are multi-dimensionally poor, $\pi$. In environments where a condition like (3.17) fails to materialize, the share of patriarchs who marry off their underage daughters becomes larger than the share of those who are poor: $m > \pi$.

Consider two geographic regions, $A$ and $B$. Suppose these two regions report different levels of prevalence of child marriage: $m^A \neq m^B$. A question of interest is the following: what explains the observed differences between $A$ and $B$ in the level of prevalence of child marriage? In other words, when are the statements $m^A > m^B$ and $\pi^A > \pi^B$ simultaneously true? To address this issue, we first assume that $c^*$ is the common poverty cutoff for both regionss. This assumption implies that $\gamma = 1/(1 + \kappa)$ is identical in both countries. Therefore the only sources of differences between the two regions are (i) the boundaries of distributions, $s^j$ and $\omega^j$, and (ii) the level of men’s preference for underage brides, $\theta^j$, reflecting socio-cultural factors. The following proposition states our main results, which we prove in the Appendix section:
Proposition 3. Let Assumptions 1 and 2 hold and suppose

\[ m^A > m^B. \]

The following statements are all true:

(i) If \( \pi^A > \pi^B \), then

\[ \varphi (\theta^B) \leq c^* \leq \varphi (\theta^A); \quad (3.22) \]

(ii) But if \( \pi^A < \pi^B \), then

\[ \varphi (\theta^B) < c^* < \varphi (\theta^A). \quad (3.23) \]

Proposition 1-(i) states that if a region (say, \( A \)) reports a higher level of prevalence of child marriage than another (say, \( B \)), and if \( A \) is poorer than \( B \), then it must be that if men’s level of preference for underage since by construction the function \( \varphi \) is strictly increasing, condition (3.22) implies that \( \theta^A \leq \theta^B \), i.e., the level of men’s preference for underage brides is at most as high in \( A \) as it is in \( B \). Condition (3.23), by contrast, states that brides is at most as high in the former as it is in the later. Proposition 1-(i) can thus be interpreted as suggesting that cross-country differences in poverty levels are not, by themselves, a sufficient explanation of cross-country differences in the prevalence rate of child marriage. This is because without condition (3.22), the inequality \( \pi^A > \pi^B \) will not be an implication of the inequality \( m^A > m^B \).

The obvious question then is: if poverty is not sufficient, is it necessary for a country to report a high prevalence rate of child marriage? In other words, if for two countries \( A \) and \( B \) we are given the inequality \( \pi^A > \pi^B \), does it necessarily follows that \( m^A > m^B \) is also true? Proposition 1-(ii) provides an answer to this question. It states that if a country (say, \( A \)) is poorer than another (say, \( B \)), it may nevertheless report a lower level of prevalence
of child marriage if a condition like (3.23) is satisfied. Proposition 1-(ii) is consistent with empirical evidence on the pattern of prevalence of child marriage, as presented in section 2 above.

To sum up, Proposition 1 suggests that poverty, by itself, is neither necessary nor sufficient for child marriage to prevail. It also suggests that eliminating factors likely to combine with poverty to drive the prevalence of child marriage can reduce the incidence of child marriage. In the next section, we take this prediction to the data and assess the quantitative importance of a reduction in the level of men’s preference for underage girls.

4. Quantitative Analysis

In this section, we relax Assumption 1 in order to present a richer version of our model in which parental wealth ($\omega$) and completed years of schooling ($s$) are allowed to be dependent draws. Relaxing this assumption is also useful because it provides our model with greater flexibility in matching the data, for example by trading the more restrictive uniform distribution for marginals by a more flexible distribution. We use this richer version of model to assess the quantitative importance of theory, as this has to do with the role played by men’s intrinsic preference for underage brides. To carry out this exercise requires that we match our model to the data.

We calibrate the parameters of the model to 2012 DHS data for Niger. The choice of Niger is natural because, based upon recent estimates, it is the country with the highest prevalence rate of child marriage in the world. The 2012 DHS data divides Niger in eight regions including Agadez, Diffa, Dosso, Maradi, Niamey (the capital), Tahoua, Tillaberi, and Zinder.

Our calibration strategy is to treat each of these eight regions as a separate environment denoted as $j = 1, 2, \ldots, 8$. For each region $j$, an important calibration target is the observed rate of prevalence of child marriage among married women aged 20-24. We adopt
the international convention of 18 years of age as the legal minimum age for first marriage. Therefore of all married women aged 20-24, those who were married off before their eighteenth birthday are considered as underage brides. For each of the eight regions, we calibrate the degree of men’s preference bias for underage brides, \( \theta^j \), the parameters of the marginal distributions of the random variables, as well as those of their joint distribution.

### 4.1. Parameterization of the Joint Distribution of Parental Characteristics

We assume that in each region \( j (j = 1, \ldots, 8) \) a parent’s number of completed years of schooling, \( s \), and his wealth, \( \omega \), are drawn from a joint distribution parameterized by:

\[
\Psi^j (s, \omega) = C \left[ F^j (s), G^j (\omega) \right],
\]

\( j = 1, \ldots, 8 \), where \( F^j \) and \( G^j \) are the marginal cumulative distribution functions of respectively parents’ number of completed years of schooling and wealth in region \( j \), and the function \( C \left[ F^j (s), G^j (\omega) \right] \) is an Ali-Mikhail-Haqq (AMH) copula defined by

\[
C \left[ F^j, G^j \right] := \frac{F^j G^j}{1 - \rho^j (1 - F^j) (1 - G^j)}
\]

all \( j \), where \( F^j := F^j (s) \) and \( G^j := G^j (\omega) \) are marginal distributions of respectively \( s \), and \( \omega \), and \( \rho^j \in [-1, 1] \) is the AMH copula parameter which controls the degree of dependence of the draws for the two random variables \( s \) and \( \omega \). In particular, when \( \rho^j = 0 \), the draws of two random variables are independent: \( \Psi^j (s, \omega) = F^j (s) G^j (\omega) \). As long as \( \rho^j \neq 0 \), the two random variables will be said to be correlated in region \( j \), implying that \( \Psi^j (s, \omega) \neq F^j (s) G^j (\omega) \). Henceforth we refer to \( \rho^j \) simply as the dependence parameter.

The choice of the AMH copula is useful because, it maximizes our model’s flexibility, for example, by allowing for non-linear dependence between the draws of the two random variables, \( s \) and \( \omega \). It also allows for dependence to be rejected by the data (\( \rho^j = 0 \)).
**Assumption 2.** Each random variable’s marginal distribution is *Fréchet*:

\[
F^j(s) := e^{-s^{-\alpha^j_s}} \quad G^j(\omega) = e^{-\omega^{-\alpha^j_\omega}}
\]

all \( j \), where \( \alpha^j_s, \alpha^j_\omega > 0 \) denote the shape parameter respectively of the Fréchet distribution of completed years schooling and of wealth in region \( j \).

From (3.12) and (3.16), substituting in (4.2), making use of Assumption 2, we can express both the incidence of multi-dimensional poverty, \( \pi^j \), and level of prevalence of child marriage, \( m^j \), in region \( j \) as follows

\[
\pi^j = \int_0^\infty \frac{e^{-\zeta^j(\theta_j, \omega)}}{1 - \rho_j \left( 1 - e^{-\left( e^{\gamma^{-1} - \lambda \omega}\right)^{-\alpha^j_s}} \right) \left( 1 - e^{-\omega^{-\alpha^j_\omega}} \right)} \, d\omega \quad (4.3)
\]

\[
m^j = \int_0^\infty \frac{e^{-\chi^j(\theta_j, \omega)}}{1 - \rho_j \left( 1 - e^{-\left[ \zeta^{(\theta^j)} - \lambda \omega \right]^{-\alpha^j_s}} \right) \left( 1 - e^{-\omega^{-\alpha^j_\omega}} \right)} \, d\omega, \quad (4.4)
\]

all \( j \), where

\[
\zeta^j(\theta_j, \omega) : = \left( e^{\gamma^{-1} - \lambda \omega} \right)^{-\alpha^j_s} + \omega^{-\alpha^j_\omega} \quad (4.5)
\]

\[
\chi^j(\theta^j, \omega) : = \left( \zeta^{(\theta^j)} - \lambda \omega \right)^{-\alpha^j_s} + \omega^{-\alpha^j_\omega}. \quad (4.6)
\]

**4.2. Calibration of Shape Parameters for the *Fréchet* Marginals**

The *Fréchet* we chose for our marginals have shape parameters \( \alpha^j_s \) and \( \alpha^j_\omega \) respectively, with their respective scale parameters normalized to one, and location parameters set at zero. Our study is not the first to make use of *Fréchet* distributions for marginals. Previous studies include Lagakos et Waugh (2013). In terms of interpretation, since a *Fréchet* is an extreme value distribution, in our model, patriarch \( i \)'s wealth draw, \( \omega_i \), can be interpreted
as the maximum level of wealth he can draw from a large range of possible asset-holdings including land, poultry, sheep, cattle, real estate, etc. Likewise, his draw of years of completed schooling can be construed in a Fréchet as the maximum years of schooling he can complete from a range of possible schooling options including general education, and a large menu of vocational training programs.

Recall that for a Fréchet distribution, the shape parameter controls the dispersion of the distribution. The lower $\alpha_s^j$ and $\alpha_\omega^j$, the higher are the variations in years of schooling and wealth levels among parents in region $j$. Dispersion is generally reflected in all the moments of a distribution, including its mean. Therefore, to calibrate the shape parameter of the Fréchet distribution of completed years of schooling, $\alpha_s^j$, we target the average number of years of completed schooling among married men in each region $j$, as observed in the DHS data. Likewise, to calibrate $\alpha_\omega^j$, we target the average wealth index score among married men, as observed in the 2012 DHS data. Since the mean of Fréchet is a Gamma function, $\alpha_s^j$ and $\alpha_\omega^j$ are solutions respectively to:

$$\Gamma \left( 1 - \frac{1}{\alpha_s^j} \right) = s_a^j$$

$$\Gamma \left( 1 - \frac{1}{\alpha_\omega^j} \right) = \omega_a^j$$

all $j = 1, \ldots, 8$.

For each region $j$, the estimated value of each shape parameter is plugged back into (4.3) and (4.4).

4.3. Calibration of the Dependence Parameter, $\rho_j$

For each region $j$, the value of $\rho_j$ reported on Table 2 is plugged back into (??).
4.4. Calibration of the Remaining Parameters

The remaining parameters of our model includes the share of patriarch’s wealth allocated to nurturing the underage girl, $\kappa$, the threshold education level above which the patriarch faces a disutility from marrying off his underage daughter, the cutoff education level below which a parent is considered deprived in terms of education, $\bar{s}$, and the corresponding cutoff level for wealth, $\bar{\omega}$.

5. Concluding Remarks

In this article, we propose a theory of child marriage in which patriarchs time the marriage of their underage daughters. Our theory has two main ingredients to our theory. One is patriarchs’ socioeconomic characteristics, and the other is the intrinsic preference weight men put on having underage brides. Patriarchs’ socioeconomic characteristics are summarized by their level of educational attainment and their wealth. These socioeconomic characteristics determine not only household’s economic stability in the face of competing demands on household resources, but also the outcome of patriarchs’ marriage-timing decision on the well-being of their daughters. Based upon the patriarch’s optimization problem, we build a two-dimensional poverty index comprising his wealth and years of completed schooling as dimensional indicators. We then relate each patriarch’s multi-dimensional poverty score to his incentive to marry off his underage daughter. In this version of our article, we only solved a simplified model and illustrate its analytical features. We show that there are three types of environments in which child marriage can strive: (i) those where multi-faceted parental poverty is its driving force; (ii) those where it is driven by men’s preference for underage brides; and (iii) those where both factors combine to drive its prevalence.

In future work, we will parameterize a richer version of the model to match 2006 and
2012 DHS data for Niger — the country with the highest prevalence rate of child marriage in the world. We will conduct two thought experiments. In the first of these experiments, we will calibrate the model to the data, so as to assess the quantitative importance of demand- and supply-side factors. The purpose of this exercise is to identify which of the three socio-economic forces mentioned above is responsible for child marriage in Niger, and assess whether the nature of these forces varies across the eight sub-national regions comprising Niger, namely Agadez, Diffa, Dosso, Maradi, Niamey (the capital), Tahoua, Tillaberi, and Zinder.

References


