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Does Child Marriage Matter for Growth?

by Pritha Mitra, Eric M. Pondi Endengle, Malika Pant, Luiz F. Almeida

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Abstract

Global attention to ending child marriage and its socio-economic consequences is gaining momentum. Ending child marriage is not only critical from a development perspective but it also has important economic implications. This paper is the first to quantify the relationship between child marriage and economic growth. Applying a simultaneous equations model, the analysis shows that eliminating child marriage would significantly improve economic growth—if child marriage were ended today, long-term annual per capita real GDP growth in emerging and developing countries would increase by 1.05 percentage points. The results also provide insights on policy prioritization in developing comprehensive strategies to end child marriage. For example, the strong interdependent relationship between education and child marriage suggests that education policies and the budgets that support them should place greater emphasis on reducing child marriage.

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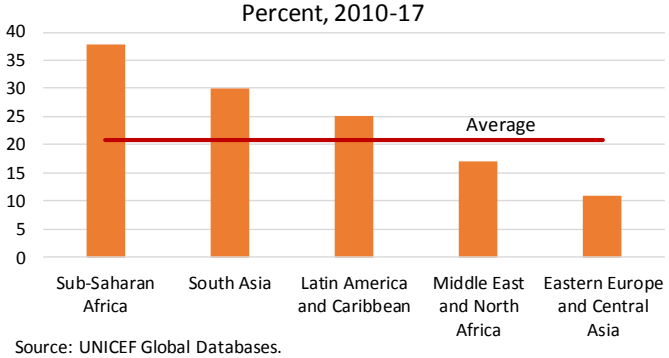
I. INTRODUCTION

Child marriage and its adverse socio-economic consequences are receiving growing international attention. In Emerging and Developing Countries (EMDCs), one fifth of girls are married before the age of 18 (UNICEF Global Database 2018), with the highest presence in Sub-Saharan Africa (Figure 1). Child marriage has been found to substantially increase fertility and population growth and reduce educational attainment resulting in lower earnings and productivity. It also harms the health and nutrition of mothers and their children, is associated with increased family violence and gender inequality, and reduces women's decision-making power (Wodon et al., 2017). In light of its prevalence and importance, ending child marriage is a Sustainable Development Goal for 2030—having a vital impact on poverty-reduction, inequality (e.g., incomes, gender equality), and economic growth.

Figure 1. Child Marriage (Married by 18) 1/
Percent, 2010-17



Source: UNICEF Global Databases.
1/ Percentage of women aged 20 to 24 years who were first married or in union before age 18.

The impact of child marriage on economic growth has yet to be quantified in the literature. So far, studies have found it has substantial links to poverty and inequality. Wodon et al., 2017 find that if child marriage were ended by 2030, a group of 106 EMDCs would save, on average, about $300 billion per year between now and 2030 from reduced population growth and about $75 billion per year from improved child health. Savadogo and Wodon (2017) estimate EMDCs would gain, by 2030, an average of 1 percent of family earnings from improved salaries and productivity. Chaaban and Cunningham (2011) find similarly striking results indicating that allowing girls in EMDCs to complete their education (mainly primary and secondary school) could increase their lifetime earnings by up to 1.5 percent per year. These estimates focus on the impact of child marriage on girls, but it affects boys too. Boys who marry early are more likely to drop out of school and have lower earnings potential. From a broader perspective, the long-term impact of child marriage on growth will reflect the trade-off between increased labor supply—owing to increased fertility rates—against lower productivity—due to weak education and health outcomes resulting from child marriage.

Ending child marriage requires a multi-pronged approach. Factors contributing to child marriage include social and cultural norms as well as low levels of income, education, and health of families and communities (Lloyd, 2005; UNICEF 2005; Santhya et. Al, 2006; Jain and Kurz, 2007; Malhotra et al., 2011; UNFPA 2012; Vogelstein 2013; Klugman et al., 2014; UNICEF 2014 a and b). More generally, child marriage represents a market failure in that families don't factor in the earnings potential of girls when assessing the cost of raising and educating them. Popular strategies to prevent or delay child marriage include empowering girls with information, skills and support networks; educating the community; improving educational quality and access for girls; offering economic incentives to parents; and

enabling the legal and policy framework (Malhotra et al, 2011; Brown, 2012; Kalamar et al., 2016; World Bank, 2018). But any one strategy is not enough. For example, adoption of laws against child marriage have not ended the practice (World Bank, 2017). The World Bank's Sahel Women Empowerment and Demographic regional project as well as African Union, UNFPA, and UNICEF initiatives are beginning to drive broader policy changes. However, comprehensive strategies, including investment in programs and policies, to end child marriage are still lacking.

This paper is the first to quantify the impact of child marriage on economic growth. The analysis finds that reducing child marriage would significantly increase growth, where a 17 percentage point reduction in child marriage would, over the long-term, raise annual per capita growth by 0.66 percentage points. This means if child marriage were ended today, long-term annual per capita growth in EMDCs would increase by 1.05 percentage points. The analysis also provides insights on policy prioritization in developing strategies to end child marriage. For example, the analysis indicates a strong interdependent relationship between education and child marriage—suggesting that education policies should be prioritized when developing comprehensive strategies to end child marriage. The results of the analysis also underline the importance of better health outcomes on increasing education levels and returns to education.

II. MODELING CHILD MARRIAGE AND GROWTH

The literature on economic growth links per capita economic growth to various macroeconomic variables such as initial human capital, government consumption, public investment, or political stability (Barro, 1991). These growth models have been extended to include additional determinants such as social norms (Cole et al., 1992), corruption (Mauro, 1995), income inequality (Berg and Ostry, 2011), and economic diversification (Papageorgiou and Spatafora, 2012).

While it is challenging to establish the optimal specification of a growth model,[2] we can consider that child marriage is likely correlated with some "conventional" growth determinants. Therefore, the identification strategy in this paper is to quantify the correlation between child marriage and growth, through channels that are related to both variables. Since a standard growth model is not able to account for the interdependence between child marriage, health, education, and growth, a simultaneous equations model—which includes a growth equation—is applied.

The steps towards building the simultaneous equations model, as well as the model itself and empirical results are outlined below. Section A presents the theoretical growth equation that will ultimately be included in the simultaneous equations model. Section B analyzes the correlations between child marriage and the explanatory variables from the growth equation

[2] Sala-i-Martin et al., 2004 propose a selection procedure based on statistics tools. Their model emphasizes the importance, for growth, of the relative price of investment, school enrollment, and the initial level of GDP per capita.

in Section A. Section C presents the simultaneous equations model and empirical results from the model.

A. Basic Growth Equation

Growth Equation

A cross-country growth equation is built following Sala-i-Martin et al. (2004). The explanatory variables are chosen based on that paper's application of a Bayesian approach to identify the variables that matter most for growth. The following equation is considered:

$$G_{t,t+T} = \theta_0 + \theta_1 \ln(y_t) + \theta X_t + \varepsilon_t \,,$$

where T is the growth horizon, y_t the per capita real GDP in year t, $G_{t,t+T}$ the growth rate of the per capita real GDP between years t and $t+T$, X_t the vector of the other explanatory variables at t, and ε_t the error term.

The equation aims to explain the per capita GDP growth rate from 1997 to 2017 ($T=20$). This data span offers a compromise between (i) having sufficient years to estimate a credible long-term growth equation, and (ii) the availability of child marriage data (see below). Therefore, the growth equation to be estimated is:

$$G_{1997,2017} = \theta_0 + \theta_1 \ln(y_{1997}) + \theta X_{1997} + \varepsilon_{1997} \quad (1)$$

Data

The per capita GDP growth rate is sourced from the IMF's World Economic Outlook and comprises a cross-sectional sample of 112 countries for which child marriage data is available.[3] The explanatory variables, described in Table 1, were chosen based on the selection process of Sala-i-Martin et al. (2004)—except child marriage. To address the issue of endogeneity, most variables are measured at the start of the sample period, 1997. A human capital index (based on years of schooling and return to education) and life expectancy are used as proxies for education and health, respectively.

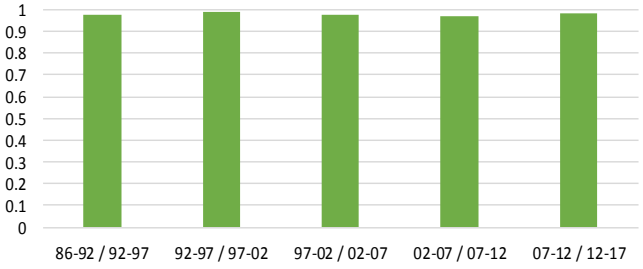
[3] These countries are EMDCs (largely Low-Income Countries). Due to the attrition of data for some countries, the number of observations in the main regressions is reduced to 76 countries.

Table 1: Explanatory variables applied in the basic growth equation

Variable	Description (source)	Mean	Standard deviation	Year of data
Log of per capita GDP	Real GDP per capita in PPP terms (IMF World Economic Outlook)	3.5	0.4	1997
Child marriage	Percentage of women aged 20 to 24 years, married or in union before age 18 (UNICEF Global Database)	26.47	16.74	Average 1986-2017
Human capital index	Based on years of schooling and returns to education (Penn World Table 9)	1.84	0.52	Average 1992-1997
Life expectancy at birth	Total (World Bank World Development Indicators)	60.9	9.6	1997
East Asia dummy	1 for East Asia and 0 otherwise	0.1	0.3	Constant
Share of extractable commodities in total exports	Percent (Updated from Chapter 2, IMF World Economic Outlook, October 2015)	20.7	25.6	2017
Fraction of tropical area	Percent (Gallup et al.)	0.6	0.4	2001
Trade openness	Import+Export in percent of GDP (IMF World Economic Outlook)	69.6	53.2	1997
Relative price of investment	Ratio price level of capital formation - price level of household consumption (Penn World Table 9)	1.4	0.5	1997
Share of government consumption	Percentage of per capita GDP (in PPP terms) related to government consumption	19.8	10.6	1997

Child marriage is defined as the percentage of women aged 20 to 24 years who were first married or in a union before age 18. Each of the countries in the sample has at least one child marriage statistic between 1986 and 2017—several countries have three data points (see Appendix 1). Child marriage is a very stable variable, even over the medium-term, as evidenced by the high correlation of its observations over time (Figure 2).[4] Consequently, for countries with only one data point, that point is used to proxy the 1997 value of child marriage. When more than one data point is available, the average is used as a proxy for the 1997 value.

Figure 2. Child Marriage (Married by 18) 1/ 2/: Correlation Coefficients, 1986-2017



Source: UNICEF Global Databases; IMF staff calculations.
1/ Percentage of women aged 20 to 24 years who were first married or in union before age 18.
2/ The figure presents the correlation coefficients of the average child marriage percentage series. For precision, 86-92 /92-97 represents the correlation coefficient between the average series from 1986 to 1992 and the average series from 1992 to 1997.

[4] Analysis shows that child marriage decreased by 11 percentage points during the past 30 years (UNFPA, 2012 and UNICEF, 2014). However, the stability as presented by the correlation chart refers to the stability of the distribution of child marriage data. Concretely, the decline of child marriage over the medium-term is not important enough to significantly change the distribution of child marriage across countries.

Results

The effect of child marriage on growth is first quantified through the estimation of a basic growth equation. The outcomes from the estimation of equation (1) above are presented in Table 2.

The results from regression 1, Table 2—the estimation of the growth equation with only the initial income level and child marriage as dependent variables—shows that the impact of child marriage on growth is negative and significant. A decrease in child marriage by one standard deviation (16.74 percent) can increase per capita growth by 0.33 percentage points per year.[5] However, the R^2 is only 0.16 indicating that important variables have been omitted, such as other macroeconomic factors affecting growth. This result is also robust to the addition of the square of child marriage as explanatory variable (regression 4, Table 2); given that the square of child marriage is not significantly correlated with growth, the relationship between child marriage and growth can be assumed to be linear.

To determine what other variables should be included in the regression, a theoretical growth equation, without child marriage, was estimated. The results from regression 2, Table 2 are consistent with the growth literature (Sala-i-Martin et al., 2004 provides a summary) and have an R^2 of 0.45 indicating a reasonably good fit of the model. Growth per capita between 1997 and 2017 is (i) positively impacted by the human capital index and the East Asia dummy; and (ii) negatively impacted by per capita GDP in 1997, the fraction of tropical area in the country, and the share of government consumption in GDP. These results likely reflect that a more educated population supports higher productivity and growth; extreme growth figures for East Asian countries during 1997-2017 (due to the Asian crisis and a V-shaped recovery as well as rapid economic diversification); wealthier countries are more likely to experience lower long-run growth than poorer countries that have further to catch up; government consumption in EMDCs often crowds out more productive private investment; and most tropical countries are EMDCs.

Notably, the coefficient for life expectancy is not significant. This may be due to its correlation with the human capital index (Pearson correlation coefficient of 0.64), which is accounted for in the simultaneous equations model estimated in Section C. The coefficients for trade openness and the share of extractable commodities in exports, both proxies for economic diversification, are also not significant. The remaining explanatory variables are not significant but are of the correct sign.[6]

For robustness, variations of the theoretical growth equation are provided in Appendix 2. The results are robust to the addition of the terms of trade and credit to the private sector. The effect of the trade openness becomes significant when the human capital index is replaced

[5] For each variable, the impact on growth is estimated by multiplying its regression coefficient by the variable's standard error.

[6] Wealthier countries are assumed to have intense commercial interactions with the rest of the world. This naturally increases their trade openness, measured in this paper as (Imports + Exports) / GDP.

with the secondary school enrollment of girls (instrumented by the human capital index to correct for endogeneity). However, the signs and the significances of the other coefficients remain the same as in regression 2. Note that these robustness-checks are mainly informative, as the theoretical growth equation strictly replicates the model proposed by Sala-i-Martin et al. (2004). A wide range of robustness-checks, including controls for governance and income inequality, are included in the simultaneous equations model in Section C.

Table 2: Growth equation estimation

	(1)	(2)	(3)	(4)
Log of the per capita GDP	-0.80***	-1.26***	-1.27***	-0.79***
	(0.29)	(0.28)	(0.31)	(0.29)
Child marriage	-0.02***		-0.00	-0.03*
	(0.00)		(0.01)	(0.01)
Child marriage squared				0.00
				(0.00)
Human Capital Index		0.76***	0.75***	
		(0.22)	(0.24)	
Life expectancy at birth		0.02	0.02	
		(0.01)	(0.01)	
East Asia dummy		1.04***	1.04***	
		(0.29)	(0.30)	
Share of extractable commodities in total exports		0.00	0.00	
		(0.00)	(0.00)	
Fraction of tropical area		-0.61***	-0.61***	
		(0.16)	(0.19)	
Trade openness		-0.00	-0.00	
		(0.00)	(0.00)	
Relative price of investment		0.01	0.01	
		(0.23)	(0.24)	
Share of government consumption		-0.02*	-0.02*	
		(0.01)	(0.01)	
Constant	4.45***	3.72***	3.79***	4.57***
	(1.23)	(0.76)	(1.16)	(1.23)
Observations	76	76	76	76
P-value	0.02	0.00	0.00	0.02
R2	0.16	0.45	0.45	0.16

Note: (1) is the equation with only child marriage and the initial wealth level as explanatory variables, (2) replicates the Sala-i-Martin et al (2004) theoretical growth equation, (3) is an equation where child marriage is added to the explanatory variables of the theoretical equation, and (4) is the equation with the square of the child marriage.

Regression 3 in Table 2 includes child marriage and the other explanatory variables. The results confirm that the marginal effect of child marriage on growth is negative. However, unlike in regression 1, that effect is not significant—suggesting correlations between child marriage and the other explanatory variables need to be accounted for. The signs, the marginal effects, and the standards errors for the other explanatory variables are consistent with regression 2.[7]

B. Correlations Between Child Marriage and Explanatory Variables in the Basic Growth Equation

To understand the interactions between child marriage and the other explanatory variables in the growth equation from Section A, child marriage is regressed on these variables. Some variables whose correlation with child marriage has been stressed in the literature, are included as controls.

To model the impact of child marriage on growth, the channels through which this impact could take place need to be considered. Wodon et al. (2017) outline five main channels: health, education, fertility, labor force participation, and decision-making.[8] Given the overlap across these channels, they can be consolidated into the channels of health and education, which will be explanatory variables in the child marriage equation.[9] For example, health and fertility are closely linked as are education and labor force participation. Wodon et al. (2017) shows that child marriage reduces earnings and household welfare but its impact on women's labor force participation is marginal—where the latter is more related to girls' education attainment; and that decision-making matters through health (e.g., HIV/AIDS) and education. The application of per capita growth as an explanatory variable also partially accounts for fertility.

Child Marriage Equation

Consider the following equation for child marriage in a given year, *t*:

$$CM_t = \beta_0 + \beta_1 He_{t-h} + \beta_2 Edu_{t-h} + \beta X_t^2 + \varepsilon_t^2$$

Where CM_t is the proportion of child marriage at time *t*, He_{t-h} and Edu_{t-h} represent overall health and education levels, respectively, lagged by h periods relative to *t*, X_t^2 is the vector of other explanatory variables at *t*, and ε_t^2 the error term.

In this equation, child marriage is assumed to depend on lagged values of education and health—where past improvements in the levels of education and health of the family and the community are expected to reduce child marriage. The rest of the explanatory variables are

[7] The application of robust regressions to correct for heteroscedasticity and leverage effects ensures the robustness of the results from regression 2 to regression 3.

[8] These channels imply correlation and not necessarily causality.

[9] Robustness-checks include the labor force participation rate as an explanatory variable.

contemporaneous macroeconomic variables reflecting the idea that current economic conditions affect a family's decision to marry their children early. Endogeneity should not be an issue as current rates of child marriage take several years to affect macroeconomic variables.

To match the equation from Section A, *t* is assumed to be 1997. A lag of 5 years is applied for the education and health variables, allowing the equation to capture the education and health levels when the girls got married (recall the child marriage data is collected on girls aged 20-24 years).

Therefore, the model estimated is:

$$CM_{1997} = \beta_0 + \beta_1 He_{1992} + \beta_2 Edu_{1992} + \beta X^2_{1997} + \varepsilon^2_{1997} \quad (2)$$

Data

The data is the same as that applied in Section A except the 1992 series are applied for the human capital index and life expectancy.

Results

The results from the estimation of equation (2) are presented in Table 3. Regression 1 indicates that GDP per capita, the East Asia dummy, and lagged human capital are significantly and negatively linked to child marriage, while the fraction of tropical area is significantly and positively correlated with child marriage. These findings support the idea that the education of the child, the family, and the community help reduce child marriage; poorer countries, often located in the tropics, have higher instances of child marriage; and the rapid economic development in East Asia during the 1990s resulted in an exceptional decline in child marriage.

Table 3: Regression of child marriage on explanatory variables from the basic growth equation

	(1)
Log of the per capita GDP	-13.01*
	(7.71)
Human Capital Index (5-year lag)	-11.27***
	(3.58)
Life expectancy at birth (5-year lag)	0.12
	(0.43)
East Asia dummy	-12.55***
	(4.19)
Share of extractable commodities in total exports	-0.01
	(0.07)
Fraction of tropical area	10.81***
	(3.03)
Trade openness	-0.00
	(0.03)
Relative price of investment	-1.95
	(2.34)
Share of government consumption	-0.05
	(0.19)
Constant	85.00***
	(16.15)
Observations	77
P-value	0.00
R2	0.56

These results are robust to changing the lags on the human capital index and life expectancy from 5 to 7 years. They are also robust to the addition of variables such as the terms of trade, credit to private sector, and labor force participation (see Appendix 3). The lack of significance of life expectancy may be due to its correlation with the human capital index.

C. Simultaneous Equation Model for Growth and Child Marriage

Given the interdependence between child marriage, education, and health (as discussed above), a simultaneous equations model is estimated. This model assumes child marriage depends on past levels of health and education and that education depends on past levels of health.

Model

Consider the following *T*-year model, defined between a year *t* and year *t+T (T>0)*:

$$\begin{cases} G_{t,t+T} = \alpha_0 + \alpha_1 He_t + \alpha_2 Edu_t + \alpha_3 CM_t + \alpha_4 ln(y_t) + \alpha X_t^1 + \varepsilon_t^1 & (3) \\ CM_t = \beta_0 + \beta_1 He_{t-h} + \beta_2 Edu_{t-h} + \beta X_t^2 + \varepsilon_t^2 & (4) \\ Edu_{t-h} = \gamma_0 + \gamma_1 He_{t-2h} + \gamma_3 CM_{t-2h} + \varepsilon_{t-h}^3 & (5) \end{cases}$$

Where $G_{t,t+T}$ is the growth rate of the per capita GDP between *t* and *t+T*, *CM* represents the proportion of child marriage, *He* and *Edu* represent overall health and education levels, *y* the real GDP per capita, X^1 *and* X^2 the vectors of other explanatory variables in equations (3) and (4), respectively, ε^i for *i*=1,2,3 are the error terms. *h* is a lag-time horizon, which is chosen to be 5 years.

Estimation of the simultaneous equations model (represented by equations (3)-(5)) through three-stage least squares permits addressing potential endogeneity issues raised by some variables being both explanatory and dependent. The three-stage least squares method is an instrumental variable (IV) method which corrects for potential correlation in the structure of disturbances across equations. Concretely, the three-stage least squares method estimates all coefficients simultaneously and proceeds in three steps: (i) applying a two-by-two IV regression; (ii) estimating a consistent covariance matrix of the errors; and (iii) applying a multivariate GLS-type regression, by using the covariance matrix estimated in the second step.

Given the lack of child marriage data, the stability of near-term child marriage rates, and the stability its distribution over the medium-term, it is assumed that:

$$CM_t = CM_{t-2h} = CM$$

Thus, to explain per capita growth between 1997 and 2017 (presented in Section A) while accounting for some of the factors behind child marriage (presented in Section B), the model can be written as follows:

$$\begin{cases} G_{1997,2017} = \alpha_0 + \alpha_1 He_{1997} + \alpha_2 Edu_{1997} + \alpha_3 CM + \alpha_4 ln(y_{1997}) + \alpha X^1_{1997} + \varepsilon^1_{1997} & (3') \\ CM = \beta_0 + \beta_1 He_{1992} + \beta_2 Edu_{1992} + \beta X^2_{1997} + \varepsilon^2_{1997} & (4') \\ Edu_{1992} = \gamma_0 + \gamma_1 He_{1987} + \gamma_3 CM + \varepsilon^3_t & (5') \end{cases}$$

Data

All variables are the same as those from Sections A and B, including the human capital index and life expectancy applied as proxy variables for education and health, respectively.

The control variables X^1 are the explanatory variables used in the growth equation from Section A (equation 1, Table 2). However, to ensure their exogeneity in the estimation of the simultaneous equations model, prior values (averages from 1992-96) are used as proxies for their 1997 values. Table 4 provides a summary.

The control variables X^2 are the significant variables from the child marriage OLS regression in section B (equation 2, Table 3).

Table 4: Description of the explanatory variables in equations (3') and (4')

Variable	Description in equation (3')	Description in equation (4')
Child mariage	Average from 1986 to 2017	
Log of the per capita GDP	Value in 1997	Value in 1997
Human Capital Index	Value in 1997	Value in 1992
Life expectancy at birth	Value in 1997	Value in 1992
East Asia dummy	Constant	Constant
Share of extractable commodities in total exports	Constant	
Fraction of tropical area	Constant	Constant
Trade openness	Average from 1992 to 1996	
Relative price of investment	Average from 1992 to 1996	
Share of government consumption	Average from 1992 to 1996	
Terms of trade	Average from 1992 to 1996	

Results

Estimation of the simultaneous equations model confirms that child marriage has a significant and negative impact on growth (Table 5). A decrease in child marriage by one standard deviation (16.74 percent) can increase per capita growth by 0.66 percentage points per year. The impact is double that from the growth model in section A (regression 1, Table 2) due to the incorporation of the interdependent relationships between child marriage, education, and health. This implies that if child marriage were ended today, the long-term annual per capita growth in EMDCs would increase by 1.05 percentage points (given the linear relationship between child marriage and growth, as highlighted above). This result is in line with the findings of and help further quantify the increases in per capita growth implied by their results. In particular, Wodon et al. (2017) estimate that from a sample of 106 countries the annual benefit from ending child marriage in 2015 would have been $22 billion in 2015 and would be as much as $566 billion in 2030. This, coupled with the leverage effect from the reduction in population growth, would naturally lead to important increases in per capita growth.

Child marriage, lagged by 10 years, also has an impact on growth through its effect on education 5 years later. A one standard deviation reduction in 10-year lagged child marriage improves the human capital index by 0.35. This then affects child marriage after another 5 years, and ultimately improves per capita growth by 0.36 percentage points. This result highlights the positive intergenerational effects of reducing child marriage.

The impact on growth of a country's initial wealth, as measured by per capita GDP, is similar to that of child marriage. A decrease in the log of per capita GDP by one standard deviation (0.41 percentage points) can increase per capita growth by 0.67 percentage points per year. The share of government consumption in GDP also has a significant and negative impact on growth but smaller in magnitude. A one standard deviation (11.67 percentage points) decline in the share of government consumption can increase per capita growth by 0.23 percentage points per year. The remaining variables in the estimation of the growth equation, including education and health, are not significant.

Education has a substantial indirect impact on growth, through its effect on child marriage. Lagged education has a significant and negative coefficient in the estimation of child marriage (equation 4', Table 5). A one standard deviation improvement in the 5-year lagged human capital index (0.51) reduces child marriage by 13.54 percentage points (or almost one standard deviation of child marriage). This, in turn, increases per capita growth by 0.53 percentage points per year—suggesting that almost 80 percent of the effect of child marriage on growth is accounted for by lagged education.

The impact of health on growth is smaller than that of education and is mainly channeled through the effect of health on education. Lagged health has a significant and positive coefficient in the estimation of education (equation 5', Table 5). A one standard deviation improvement in the 10-year lagged life expectancy at birth (9.28 years) increases the human capital index by 0.19. This feeds through to a reduction in child marriage by 5.20 percentage points, which is about 40 percent of the effect of the human capital index on child marriage. The improvement in child marriage then increases per capita growth by 0.20 percentage points per year. Notably, the effect of 5-year lagged life expectancy on child marriage is significant and positive. This could be interpreted as better survival rates of children resulting in more children being married, absent policy changes to improve the income levels, education, and cultural practices.

The model is robust to changes in a variety of assumptions—including on income inequality and governance. These variations are presented in Appendix 4. The impact of income inequality, proxied by the ratio of rural population and included in the child marriage equation, is not significant, as it is probably correlated to the impacts of the Human Capital Index and the Fraction of tropical area, which are both significant. The proxies for governance (quality of institutions and rule of law), included in the growth equation are also not significant. This is consistent with the findings of Sala-i-Martin et al. (2004), where the proxy for governance, political right, is ranked 23rd in terms of its explanatory power for economic growth. The following alternative specifications also do not materially change the results: increasing the lag-horizon *h* to 7 years; considering child marriage by age 15 (instead of age 18); adding successively credit to the private sector, and labor force participation as regressors in equation 3'; and removing the East Asia dummy in equation 3', which could be viewed as a control for social norms in addition to being a control for the extreme growth figures for East Asian countries during 1997-2017 (due to the Asian crisis and a V-shaped recovery).

The estimation results can also be interpreted under the long-run assumption that all variables have reached an equilibrium level—while this is unlikely scenario in the near-term, it provides another perspective on the results. In this case, a one standard deviation reduction in child marriage (16.74 percentage points) could raise annual per capita growth by 1.02 percentage points. The impact of education would remain the same as described above, with a one standard deviation improvement in the human capital index (0.51) resulting in a 0.53 percentage point increase in annual per capita growth. The effect of health on growth would account for both the positive impact on growth through the education channel as well as the negative impact on growth through increased life expectancy resulting in more child marriage. The net impact on growth would still be positive with a one standard deviation improvement in life expectancy (9.53 years) raising annual per capita growth by 0.04

percentage points. As countries improve their economic situations, their growth rates decline—consistent with theories of economic convergence. A one standard deviation reduction in the log of per capita GDP (0.41 percentage points) results in a 0.72 percentage point increase in annual per capita growth.

Table 5: Simultaneous equations model estimation

		(1)
Growth (t,t+T)		
	Child mariage (t)	-0.04**
	Log of the per capita GDP (t)	-1.63***
	Human Capital Index (t)	0.07
	Life expectancy at birth (t)	0.02
	East Asia dummy	0.42
	Share of extractable commodities in total exports	0.00
	Fraction of tropical area	-0.36
	Trade openness (t)	-0.00
	Relative price of investment (t)	-0.08
	Share of government consumption (t)	-0.02**
	Credit to private sector (t)	
	Constant	7.30***
	Observations	74
	P-value	0.00
Child marriage (t)		
	Log of the per capita GDP (t)	-7.89**
	Human Capital Index (t-h)	-26.80***
	Life expectancy at birth (t-h)	0.46**
	East Asia dummy	-5.60
	Fraction of tropical area	6.18**
	Constant	73.23***
	Observations	74
	P-value	0.00
Human Capital (t-h)		
	Life expectancy at birth (t-2h)	0.02***
	Child mariage (t-2h)	-0.02***
	Constant	1.14**
	Observations	74
	P-value	0.00

There are several avenues for future research in this area. First, the model applied in this paper cannot be used to infer strict causality but micro-analysis, potentially based on randomized experimentations, could provide more insight on causality. The analysis could also be enriched as higher frequency and more granular data become available. In particular, with annual data on child marriage and more regular and comprehensive country coverage of education variables (such as enrollment rates), the model's interpretations could be further developed. Alternatively, a panel analysis could be performed on state-level child marriage data in an emerging market or advanced country (e.g., the annual American Community Survey collects this type of data on child marriage).

III. CONCLUSIONS

Child marriage is prevalent across many emerging and developing countries and has serious socio-economic consequences. Its adverse impact on population growth, health, education, and earnings—and more broadly, poverty-reduction and income inequality—have been thoroughly examined. However, little work has been done to examine its overall impact on economic growth.

While ending child marriage is an important development goal in itself, this paper investigates the relationship between child marriage and economic growth. A simultaneous equations model is applied to account for the interdependent relationships between child marriage, education, and health and the multiple channels through which they impact economic growth.

The analysis finds that reducing child marriage could significantly improve economic growth. For example, over the long-term, a reduction in child marriage by one standard deviation (16.74 percentage points) could increase annual per capita real GDP growth by 0.66 percentage points. This means that if child marriage were ended today, the long-term annual per capita growth in EMDCs would increase by 1.05 percentage points.

While there is always some margin of error around these types of cross-country econometric estimates, the results of this analysis support the existence of a strong relationship between child marriage and economic growth. These findings further strengthen the case for EMDC policymakers to allocate more effort and resources towards ending child marriage.

As countries develop comprehensive strategies towards ending child marriage, the results of this analysis can also provide insights on policy prioritization in developing strategies to end child marriage. In particular:

- The strong interdependent relationship between education and child marriage suggests that education policies should be prioritized when developing comprehensive strategies to end child marriage. For example, this analysis finds that almost 80 percent of the effect of child marriage on growth is accounted for by past education. Through this channel, an improvement in the human capital index (reflecting years of schooling and returns to education) by one standard deviation (0.51) could raise per capita growth by 0.53 percentage points per year.

- Improving education, both the quality and the number of years of schooling, will also require stepping up complementary policies such as social assistance to poor and marginalized children as well as addressing high rates of school dropout for girls due to pregnancy—in some countries, official policies expel pregnant girls from school.

- Healthcare policies also have an important role, though indirect, in ending child marriage as underlined by the importance of better health outcomes on increasing levels of and returns to education.

- Stepped-up outreach and education to governments and affected communities (especially parents) on the costs of child marriage will also be critical to ending child marriage.

APPENDIX 1: AVAILABILITY OF CHILD MARRIAGE DATA

Country	Years data are available
Afghanistan	2013, 2015
Albania	2008
Algeria	2013
Angola	2015
Armenia	2000, 2005, 2010, 2016
Azerbaijan	2006
Bangladesh	1994, 1997, 2000, 2004, 2007, 2011, 2013, 2014
Barbados	2012
Belarus	2012
Belize	2011
Benin	1996, 2001, 2006, 2012, 2014
Bhutan	2010
Bolivia	1989, 1994, 1998, 2003, 2008
Bosnia and Herzegovina	2012
Brazil	2006
Burkina Faso	1993, 1999, 2003, 2010
Burundi	1987, 2010, 2016
Cabo Verde	2005
Cambodia	2000, 2005, 2010, 2014
Cameroon	1991, 1998, 2004, 2011, 2014
Central African Republic	2010
Chad	1997, 2004, 2010, 2014
Colombia	1986, 1990, 1995, 2000, 2005, 2010, 2015
Comoros	1996, 2012
Congo, Democratic Republic of the	2007, 2013
Congo, Republic of	2005, 2009, 2011, 2015
Costa Rica	2011
Côte d'Ivoire	1994, 1998, 2005, 2012
Djibouti	2006
Dominican Republic	1986, 1991, 1996, 1999, 2002, 2007, 2013, 2014
Ecuador	2004
Egypt	1988, 1992, 1995, 2000, 2003, 2005, 2008, 2014
El Salvador	2008, 2014
Equatorial Guinea	2011
Eritrea	1995, 2002, 2010
Eswatini	2014
Ethiopia	2000, 2005, 2011, 2016
Gabon	2000, 2012
Gambia, The	2013
Georgia	2010
Ghana	1988, 1993, 1998, 2003, 2008, 2014
Guatemala	1987, 1995, 1999, 2009, 2015
Guinea	1999, 2005, 2012, 2016
Guinea-Bissau	2010, 2014
Guyana	2005, 2009, 2014
Haiti	1994, 2000, 2006, 2012, 2016
Honduras	2005, 2011
India	1993, 1999, 2006, 2015, 2016
Indonesia	1987, 1991, 1994, 1997, 2003, 2007, 2012, 2013
Iran	2010
Iraq	2011
Jamaica	2011
Jordan	1990, 1997, 2002, 2007, 2009, 2012
Kazakhstan	2011, 2015
Kenya	1989, 1993, 1998, 2003, 2008, 2014
Kiribati	2009
Kyrgyz Republic	1997, 2012
Lao P.D.R.	2012
Lebanon	2009
Lesotho	2004, 2009, 2014
Liberia	1986, 2007, 2013

APPENDIX 1: AVAILABILITY OF CHILD MARRIAGE DATA (CONTINUED)

Country	Years data are available
Macedonia, FYR	2011
Madagascar	1992, 1997, 2004, 2008, 2013
Malawi	1992, 2000, 2004, 2010, 2014, 2015
Maldives	2009
Mali	1987, 1996, 2001, 2006, 2010, 2012, 2015
Marshall Islands	2007
Mauritania	2000, 2015
Mexico	2009, 2015
Moldova	2005, 2012
Mongolia	2010, 2013
Montenegro, Rep. of	2013
Morocco	1987, 1992, 2003
Mozambique	1997, 2003, 2009, 2011, 2015
Myanmar	2016
Namibia	1992, 2000, 2006, 2013
Nepal	1996, 2001, 2006, 2011, 2016
Nicaragua	1998, 2001, 2012
Niger	1992, 1998, 2006, 2012
Nigeria	1990, 2003, 2008, 2013, 2017
Pakistan	1991, 2006, 2012
Panama	2013
Papua New Guinea	2006
Paraguay	2016
Peru	1986, 1992, 1996, 2000, 2004, 2007, 2009, 2010, 2011, 2012, 2014
Philippines	1993, 1998, 2003, 2008, 2013, 2017
Qatar	2012
Rwanda	1992, 2000, 2005, 2010, 2015
Samoa	2014
São Tomé and Príncipe	2008, 2009, 2014
Senegal	1986, 1993, 1997, 2005, 2010, 2012, 2014, 2015, 2016, 2017
Serbia	2014
Sierra Leone	2008, 2013
Solomon Islands	2015
Somalia	2006
South Africa	2003
South Sudan	2010
Sri Lanka	2006-07
St. Lucia	2012
Sudan	2010, 2014
Suriname	2010
Syria	2006
Tajikistan	2012
Tanzania	1992, 1996, 1999, 2003, 2004, 2007, 2010, 2012, 2015
Thailand	2012, 2015
Timor-Leste	2009-10
Togo	1988, 1998, 2013
Tonga	2012
Trinidad and Tobago	2011
Tunisia	2012
Turkey	1993, 1998, 2003
Turkmenistan	2000, 2006, 2016
Tuvalu	2007
Uganda	1988, 1995, 2000, 2004, 2006, 2011, 2016
Ukraine	2007, 2012
Uruguay	2013
Uzbekistan	2006
Vanuatu	2013
Vietnam	1997, 2002, 2005, 2014
Yemen	1991, 1997, 2013
Zambia	1992, 1996, 2002, 2007, 2013
Zimbabwe	1988, 1994, 1999, 2005, 2010, 2014, 2015

Source: UNICEF Global Databases.

APPENDIX 2: ROBUSTNESS CHECKS FOR ESTIMATION OF THE BASIC GROWTH EQUATION

	(1)	(2)	(3)	(4)
Log of the per capita GDP	-1.26***	-1.54***	-1.28***	-1.24***
	(0.28)	(0.41)	(0.29)	(0.33)
Human Capital Index	0.76***		0.87***	0.79***
	(0.22)		(0.24)	(0.26)
Female school enrollment, secondary		0.01**		
		(0.00)		
Life expectancy at birth	0.02	0.03	0.02	0.02
	(0.01)	(0.02)	(0.01)	(0.02)
East Asia dummy	1.04***	1.26***	1.02***	1.05***
	(0.29)	(0.24)	(0.29)	(0.30)
Share of extractable commodities in total exports	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Fraction of tropical area	-0.61***	-0.39**	-0.51***	-0.61***
	(0.16)	(0.16)	(0.19)	(0.18)
Trade openness	-0.00	-0.01**	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Relative price of investment	0.01	0.33*	0.03	0.01
	(0.23)	(0.17)	(0.23)	(0.25)
Share of government consumption	-0.02*	-0.01	-0.02*	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)
Terms of trade			-0.01	
			(0.01)	
Credit to private sector				0.00
				(0.00)
Constant	3.72***	4.04***	4.57***	3.66***
	(0.76)	(1.13)	(1.09)	(0.82)
Observations	76	54	76	72
P-value	0.00	0.00	0.00	0.00
R2	0.45	0.48	0.46	0.44

Notes: (1) Sala-i-Martin et al. (2004) growth model; (2) IV regression; (3) Addition of the terms of trade; (4) Addition of credit to the private sector. The results from the IV regression show that trade openness and the price of investment have a significant effect on growth. The sign associated with the price of investment is consistent with the literature, since countries with higher demands for investment (in comparison to consumption) have higher growth. The sign associated with trade openness is puzzling, as it contradicts the literature. This can be explained by selection bias—in terms of a small sample size (the sample size for the IV regression is only 54)—related to the variable "second school enrollment".

APPENDIX 3: ROBUSTNESS CHECKS FOR REGRESSIONS OF CHILD MARRIAGE ON EXPLANATORY VARIABLES FROM BASIC GROWTH EQUATIONS

	(1)	(2)	(3)	(4)	(5)
Log of the per capita GDP	-13.01*	-10.58	-13.04*	-12.30	-13.00*
	(7.71)	(7.78)	(7.79)	(8.31)	(7.77)
Human Capital Index (5-year lag)	-11.27***		-11.11***	-12.52***	-11.32***
	(3.58)		(4.04)	(3.85)	(3.82)
Life expectancy at birth (5-year lag)	0.12		0.12	0.17	0.13
	(0.43)		(0.44)	(0.45)	(0.44)
Human Capital Index (7-year lag)		-10.34***			
		(3.70)			
Life expectancy at birth (7-year lag)		-0.04			
		(0.47)			
East Asia dummy	-12.55***	-11.98***	-12.59***	-12.43***	-12.60***
	(4.19)	(3.98)	(4.27)	(4.45)	(4.21)
Share of extractable commodities in total exports	-0.01	-0.02	-0.01	-0.03	-0.01
	(0.07)	(0.07)	(0.08)	(0.08)	(0.08)
Fraction of tropical area	10.81***	10.22***	10.95***	11.32***	10.78***
	(3.03)	(2.96)	(3.64)	(3.24)	(3.03)
Trade openness	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Relative price of investment	-1.95	-1.85	-1.94	-1.82	-1.94
	(2.34)	(2.35)	(2.33)	(2.49)	(2.38)
Share of government consumption	-0.05	-0.04	-0.05	-0.00	-0.05
	(0.19)	(0.20)	(0.20)	(0.19)	(0.12)
Terms of trade			-0.01		
			(0.14)		
Credit to private sector				0.00**	
				(0.00)	
Labor force participation					0.01
					(0.13)
Constant	85.00***	84.76***	86.19***	80.87***	84.42***
	(16.15)	(16.15)	(23.8)	(17.57)	(18.66)
Observations	77	77	77	73	77
P-value	0.00	0.00	0.00	0.00	0.00
R2	0.56	0.56	0.56	0.56	0.56

Notes: (1) Baseline model; (2) Model with 7-year lag on education and health; (3) Model with terms of trade; (4) Model with the credit to private sector; (5) Model with the labor force participation rate (as percent of the population aged 15+)

APPENDIX 4: ROBUSTNESS CHECKS FOR ESTIMATION OF THE SIMULTANEOUS EQUATIONS MODEL

		(1)	(2)	(3)	(4)	(5)
Growth (t,t+T)						
	Child mariage (t)	-0.04**	-0.06**	-0.11**	-0.03**	-0.06***
	Log of the per capita GDP (t)	-1.63***	-1.77***	-1.72***	-1.56***	-1.85***
	Human Capital Index (t)	0.07	-2.86	-0.20	0.18	-0.24
	Life expectancy at birth (t)	0.02	0.02	0.03*	0.02	0.03*
	East Asia dummy	0.42	0.20	0.42	0.46	
	Share of extractable commodities in exports	0.00	0.00	0.00	0.00	0.00
	Fraction of tropical area	-0.36	-0.20	-0.43	-0.39	-0.21
	Trade openness (t)	-0.00	-0.00	-0.00	-0.00	-0.00
	Relative price of investment (t)	-0.08	-0.11	-0.10	-0.08	-0.11
	Share of government consumption (t)	-0.02**	-0.02*	-0.02**	-0.02*	-0.02**
	Credit to private sector (t)				0.00	
	Constant	7.30***	8.95***	7.50***	6.70***	8.78***
	Observations	74	74	74	71	74
	P-value	0.00	0.00	0.00	0.00	0.00
Child marriage (t)						
	Log of the per capita GDP (t)	-7.89**	-7.44**	-1.32	-8.35**	-8.37**
	Human Capital Index (t-h)	-26.80***	-27.65***	-13.30***	-26.73***	-26.95***
	Life expectancy at birth (t-h)	0.46**	0.47**	0.17*	0.48**	0.49**
	East Asia dummy	-5.60	-6.39	-1.19	-6.08	-7.06*
	Fraction of tropical area	6.18**	6.11**	1.10	6.81**	6.49**
	Constant	73.23***	71.09***	24.91	72.86***	72.81***
	Observations	74	74	74	71	74
	P-value	0.00	0.00	0.00	0.00	0.00
Human Capital (t-h)						
	Life expectancy at birth (t-2h)	0.02***	0.02***	0.01*	0.02***	0.02***
	Child mariage (t-2h)	-0.02***	-0.02***	-0.06***	-0.02***	-0.02***
	Constant	1.14**	0.99*	1.30**	1.05**	1.07*
	Observations	74	74	74	71	74
	P-value	0.00	0.00	0.00	0.00	0.00

Notes: (1) Baseline model; (2) Model with 7-year lag on education and health in child marriage equation and 14-year lag of health and child marriage in human capital equation; (3) Model with child marriage defined as marriage before age 15 (instead of age 18); (4) Model with credit to the private sector; (5) Model without East Asia dummy in growth equation in order to assess the counterfactual for social norm effects. Although the results are highly robust, there are small differences in those associated with marriage before age 15. In the child marriage equation, the effect of initial wealth on marriage before age 15 is not significant, unlike for marriage before 18. Also, the marginal effect of the human capital index is smaller than in the baseline case. This can be explained by the fact that the fundamentals of child marriage by age 18 are slightly different from those of child marriage by age 15. In some countries, sexual majority is reached at age 16 and, conditionally to the consent of parents, marriage at ages 16 or 17 are legal. Removing the control variable for social norms in the first equation, marginally increases the long-run effect of health on growth.

APPENDIX 4: ROBUSTNESS CHECKS FOR ESTIMATION OF THE SIMULTANEOUS EQUATIONS MODEL (CONTINUED)

		(1)	(6)	(7)	(8)	(9)
Growth (t,t+T)						
	Child mariage (t)	-0.04**	-0.04***	-0.04**	-0.05***	-0.04**
	Log of the per capita GDP (t)	-1.63***	-1.63***	-1.66***	-1.87***	-1.76***
	Human Capital Index (t)	0.07	0.07	0.02	-0.15	0.02
	Life expectancy at birth (t)	0.02	0.02	0.02	0.02	0.02
	East Asia dummy	0.42	0.42	0.40	0.24	0.39
	Share of extractable commodities in exports	0.00	0.00	0.00	0.01	0.00
	Fraction of tropical area	-0.36	-0.37	-0.34	-0.23	-0.34
	Trade openness (t)	-0.00	-0.00	-0.00	-0.00	-0.00
	Relative price of investment (t)	-0.08	-0.09	-0.09	-0.09	-0.09
	Share of government consumption (t)	-0.02**	-0.02**	-0.02**	-0.02**	-0.02**
	Rule of law (t)				1.13	
	Government effectiveness (t)					0.77
	Constant	7.30***	7.33***	7.53***	8.3***	7.69***
	Observations	74	74	74	74	74
	P-value	0.00	0.00	0.00	0.00	0.00
Child marriage (t)						
	Log of the per capita GDP (t)	-7.89**	-7.76**	-10.09**	-8.12**	-7.96**
	Human Capital Index (t-h)	-26.80***	-26.94***	-27.22***	-26.84***	-26.84***
	Life expectancy at birth (t-h)	0.46**	0.47**	0.47**	0.47**	0.46**
	East Asia dummy	-5.60	-5.71	-5.16	-5.68	-5.62
	Fraction of tropical area	6.18**	6.09**	6.45**	6.29**	6.21**
	Labor force participation rate (t-h)		0.03			
	Urbanization (t-h)			-0.06		
	Constant	73.23***	70.48***	84.32***	73.19**	73.18***
	Observations	74	74	74	74	74
	P-value	0.00	0.00	0.00	0.00	0.00
Human Capital (t-h)						
	Life expectancy at birth (t-2h)	0.02***	0.02***	0.02***	0.02***	0.02***
	Child mariage (t-2h)	-0.02***	-0.02***	-0.02***	-0.02***	-0.02***
	Constant	1.14**	1.13**	1.11**	1.12**	1.13**
	Observations	74	74	74	74	74
	P-value	0.00	0.00	0.00	0.00	0.00

Notes: (1) Baseline model. (6) Model with labor force participation in the child marriage equation. (7) Model with the percentage of rural population in the child marriage equation (in 1997, the rural population in the sample was 57 percent in average). (8) – (9) Models controlling for the quality of institutions by adding successively rule of law and government effectiveness in the growth equation. Both variables are scores from the Worldwide Governance Indicators database and are normalized so that 0 and 1 respectively correspond to the worse and the best governance situations.

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