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THE BRIDES OF BOKO HARAM: ECONOMIC SHOCKS, MARRIAGE PRACTICES, AND INSURGENCY IN NIGERIA*

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Marriage markets in rural Nigeria are characterised by bride price and polygamy. These customs may diminish marriage prospects for young men, causing them to join militant groups. Using an instrumental variables strategy, I find that marriage inequality increases civil conflict in the Boko Haram insurgency. To generate exogenous shocks to the marriage market, I exploit the fact that young women delay marriage in response to favourable pre-marital economic conditions, which increases marriage inequality primarily in polygamous villages. The same shocks that increase marriage inequality and extremist violence also lead women to marry fewer and richer husbands, generate higher average marriage expenditures, and increase insurgent abductions. The results shed light on the marriage market as an important driver of violent extremism.

As youth populations swell, policymakers in many countries are seeking answers to a long-standing question in social science: why do young men often gravitate towards organised violence? The rational choice view argues that individuals and groups optimally trade off the returns to violence and opportunity costs of fighting. The evidence supports this view: economic shocks that make people better off, such as good rainfall or access to jobs, typically reduce conflict by raising opportunity costs, whereas shocks that increase the value of rebellion—particularly prices of natural resources—tend to increase violence.[1]

The marriage market can play an important role in structuring these incentives. A surplus of unmarried young men with low opportunity costs of violence can destabilise society (Hudson and Den Boer, 2004). By exacerbating marriage market inequality, traditional marriage practices such as bride price—payments from the groom to the bride on marriage—and polygamy—the practice of taking more than one wife[2]—may be at the root of violence in weak states. The idea that these practices may promote violence has recently gained currency in the popular press.[3] Bride price inflation has been blamed for outbreaks of violent cattle-raiding conflict in East Africa; in Nigeria, the Islamist group Boko Haram appeals to young men unable to afford marriage with offers of

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[1] Blair *et al.* (2021) provide a recent meta-analysis of this literature.

[2] While polygamy refers both to the practice of taking many husbands (polyandry) and wives (polygyny), I will use it to mean the latter, given the relative absence of the former in Africa and the Middle East.

[3] *The Economist*, for example, has recently run several stories with headlines such as 'The link between polygamy and war' (December 2017) and 'Why polygamy breeds civil war' (March 2018).

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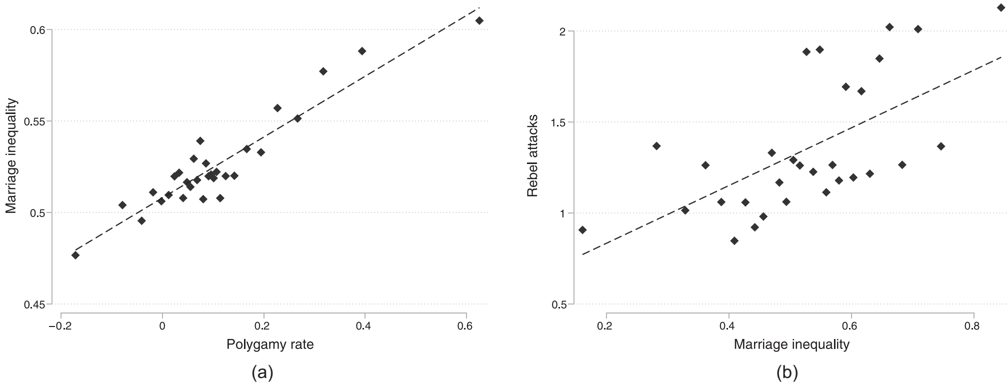

Fig. 1. *Polygamy, Marriage Inequality, and Conflict in Sub-Saharan Africa. The figure shows the binned partial correlation between marriage inequality and polygamy (a), and rebel activity and marriage inequality (b). Marriage inequality is the Gini coefficient of wives among men in a DHS cluster. Rebel attacks is the total number of violent attacks perpetrated by organised rebel groups within 20 km of the DHS cluster in the survey year and subsequent four years. Scatterplots are binned using 30 quantiles of the right-hand side variable. All plots include dummies for first-level subnational region, and DHS survey round, and controls for average wealth index, share of Muslims, average age, a rural indicator, and latitude. Sample is 25,355 villages across 24 sub-Saharan African countries from 1997 to 2016.*

kidnapped brides (Hudson and Matfess, 2017). This suggests a grim logic underlying the use of gender-based violence among militant groups, in particular mass abductions of women and girls:[4] men with limited marriage prospects are easy targets for rebel recruitment with offers of marriage to captured brides.

Data from Demographic and Health Surveys (DHS) on over 25,000 communities across 24 sub-Saharan African countries from 1997 to 2016 (Boyle *et al.*, 2020) suggest that this hypothesis is plausible. The left panel of Figure 1 plots the village-level share of marriage-age men in polygamous unions against the level of marriage inequality—measured as the Gini coefficient of the distribution of brides among men in a village—controlling for a parsimonious set of local characteristics as well as fixed effects for subnational region and survey year. Marriage inequality is strongly increasing in the polygamy rate, consistent with the notion that in these communities, men atop the social hierarchy—typically older and richer—hoard wives at the expense of poorer, younger men. Even more suggestively, the right panel shows a clear positive correlation between marriage inequality and local rebel violence, implying that these marriage market losers may indeed be vulnerable to insurgent recruitment. But the level of violence, cultural norms around polygamy, and marriage market outcomes are jointly determined in equilibrium. To disentangle these forces, I turn to a detailed study of the Boko Haram insurgency in Nigeria.

In this paper, I show that marriage inequality increases the incidence of extremist violence in Nigeria. To guide the empirical exercise, I develop a model of occupational choice and marriage in which men choose between joining insurgent groups or participating in the civilian marriage market. When women experience positive income shocks during their pre-marital adolescence, their families raise the reservation bride price, and women delay marriage. Rising bride prices push poorer men out of the market and women towards richer men, increasing inequality in the

[4] The frequent use of abduction and forced marriages by other terrorist groups, such as ISIS, is well known. In 2014–15 alone, Amnesty International estimates that Boko Haram kidnapped 2,000 girls.

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distribution of brides. This effect is more pronounced under polygamous marriage customs, where women can match with wealthier already-married men, yielding greater option value of waiting. Larger future payoffs under polygamy lead to greater sensitivity of reservation prices to an income shock today. This is because positive income shocks reduce the marginal value of today's dollar, thereby increasing the relative sensitivity of marriage choices to tomorrow's payoff. Violence increases as young men at the margin of civilian life choose insurgency. Given that the marginal reduction in marriage value is greater in polygamous areas, these areas experience more severe outbreaks of violence in response to good pre-marital economic conditions for women. The model implies that the interaction between female income shocks and village-level polygamy norms can be used as an instrument to address the endogeneity of marriage inequality.

To isolate exogenous shifts in the marriage market equilibrium, I first show that good economic conditions in a young woman's pre-marital adolescence increase marriage inequality in polygamous marriage markets and weakly reduce it in monogamous ones. A 1 standard deviation (SD) increase in annual rainfall above its long-run mean in the adolescent period of the average woman differentially increases marriage inequality in polygamous villages by 12.3 Gini points (23.8%), and reduces the marriage rate for men by 14.3 percentage points (30.8%). This differential response is driven by a reallocation of marriage market share towards older men in polygamous villages and younger men in monogamous ones.

These aggregate market effects are driven by decisions at the household level. Consistent with Corno *et al.* (2020), I find that positive income shocks during adolescence increase age of marriage in both polygamous and monogamous communities.[5] In addition, good rainfall shocks significantly reduce a woman's marriage probability over her peak marriageable years, an effect driven mostly by polygamous communities. Taken together, the results imply that plausibly exogenous fluctuations in historical local weather conditions shift families' marriage choices and equilibrium outcomes in the marriage market.[6]

Given that income shocks increase marriage inequality primarily in polygamous markets, I use the interaction between village-level polygamy and rainfall during adolescence as an instrument to identify the causal effect of marriage inequality on violence. In the reduced form, I estimate that a 1 SD increase in rainfall from its long-run mean during the adolescence of the average woman leads to a differential increase of 16.3 Boko Haram-related deaths annually in polygamous villages. In the 2SLS models, a one-point increase in the Gini coefficient of brides increases Boko Haram fatalities by 1.3 annual deaths (22.2%). All estimates control for current and lagged rainfall, ruling out direct effects of current climate conditions on marriage markets and conflict.

I then turn to explore additional mechanisms underlying the main results. Using data on household expenditures, I find that average wedding expenditures—a proxy for bride prices—also increase in response to the adolescent rainfall shock. A 1 SD from the long-run mean of rainfall in the adolescent period of the average woman roughly doubles marriage expenditures in polygamous markets, but has a smaller, insignificant impact in monogamous ones. Therefore, the increase in market concentration observed in the first-stage regressions is likely driven by reservation prices, rather than by other marriage market primitives such as preferences, institutions, sex ratios, or male income. Consistent with this mechanism, I also observe that

[5] To probe the robustness of these results, I conduct placebo tests which reveal that pre-adolescent rainfall shocks are not significantly related to marriage decisions.

[6] In an extension to the model in which families prefer both younger mates and higher bride prices for their daughters, I show that positive shocks can actually reduce marriage inequality under monogamy, reallocating marriage market share from older to younger men. I test and find support for this hypothesis in the data.

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women who experience positive shocks as adolescents marry richer and more polygamous men. I also find that abductions by Boko Haram differentially increase in polygamous areas in response to adolescent rainfall shocks. These abduction raids spill over into neighbouring villages in a declining function of distance, suggesting that Boko Haram responds strategically to marriage market imbalances by increasing abduction of adolescent girls to meet local demand for wives among new recruits.

I provide several additional pieces of evidence supporting the proposed recruitment mechanism. First, using public opinion survey data, I find that in areas where women experienced better rainfall duing adolescence, young Muslim men express greater sympathy for extremist groups, suggestive of greater willingness to join.[7] Next, I show that adolescent rainfall shocks almost exclusively affect the marriage outcomes of young men, the demographic group most at risk of Boko Haram recruitment. Finally, I show that marriage inequality has no effect for internal conflicts in which rebel groups do not employ marriage-based recruitment. Furthermore, while the first stage does not substantially vary across villages, the reduced form conflict effects are significantly larger in Muslim-majority areas and where Boko Haram exercises territorial control. While favourable rainfall during adolescence always increases marriage inequality under polygamy, this translates into increased violence only where such imbalances can be exploited by Boko Haram.

While the problems of rainfall instruments are well known (Sarsons, 2015), the IV uses a female-specific cohort-weighted average of past shocks that should be uncorrelated with current economic conditions, particularly after conditioning on current rainfall. In Online Appendices E and F, I conduct a battery of falsification tests, sensitivity analyses, and robustness tests. Over 1,536 different robustness specifications, 99.5%, 96.2% and 95.8% of the first stage, reduced form, and 2SLS estimates, respectively, are of the correct sign. The main estimates fall in the middle of the distribution of robustness estimates, suggesting that they are not spurious outliers. These tests tend to increase noise while leaving the magnitudes unchanged.

This paper contributes to a large empirical literature on economic shocks and civil conflict. It is well known that welfare-improving economic shocks typically raise opportunity costs of fighting, reducing violence (Humphreys and Weinstein, 2008; Berman *et al*., 2011; Bazzi and Blattman, 2014; Hodler and Raschky, 2014; Blattman and Annan, 2016; Gehring *et al*., 2018; McGuirk and Burke, 2020). Conversely, some positive shocks—such as rising commodity prices—may both improve welfare and increase the value of capturing the state, generating a countervailing ‘rapacity’ effect that increases violence (Angrist and Kugler, 2008; Dube and Vargas, 2013; Nunn and Qian, 2014; McGuirk and Burke, 2020), and may additionally relax insurgent credit constraints (Gong and Sullivan, 2017). Much of the empirical literature on the economics of conflict focuses on adjudicating these two forces. This paper applies a similar opportunity cost-based argument. However, I show that comparative statics of the opportunity cost mechanism can be reversed when the marriage market is accounted for: positive income shocks can exacerbate conflict by increasing marriage inequality when marriage markets exhibit polygamy. This is a novel finding, which points to the importance of traditional cultural practices in determining the effects of economic shocks on violence.

The findings also speak to the literature on marriage markets and crime, where researchers have typically studied the role of sex ratio imbalances (Edlund *et al*., 2013; Cameron *et al*., 2017). I expand this literature by providing more detailed mechanisms underlying the link between marriage market fluctuations and violence, identifying how institutions and outside options

[7] Notably, this relationship is absent for all other demographic groups.

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influence inequality, the value of marriage, and the opportunity costs of violence. I also consider forms of violence beyond criminality and intimate partner violence, suggesting that marriage market causes may underlie a wide range of violence, from crime to religious extremism.

Lastly, the results add to the emerging literature on the welfare consequences of traditional marriage practices. Since Grossbard (1980) and Becker (1981), economists have studied polygamy and bride price as equilibrium outcomes, but only recently has an emerging empirical literature begun to investigate the implications of these practices for outcomes such as child mortality (Arthi and Fenske, 2018), child marriage (Corno and Voena, 2016; Corno *et al.*, 2020), investment in girls' education (Ashraf *et al.*, 2020), and marital quality (Lowes and Nunn, 2018). This is the first paper to rigorously identify the link between polygamy and civil conflict and demonstrate the underlying mechanisms, existing evidence being found only in cross-country regressions (Kanazawa, 2009). More broadly, the results speak to the importance of culture and traditional practices in shaping economic outcomes, conflict, and development, as in recent work by Moscona *et al.* (2020).

The paper proceeds as follows. Section 1 provides background information on traditional marriage practices in Nigeria and the history of the Boko Haram insurgency. Section 2 lays out a model of the marriage market and occupational choice to motivate the empirical analysis. Section 3 describes the data and presents summary statistics. Section 4 details the empirical strategy and provides preliminary tests to validate the instrument. Section 5 provides the primary results and robustness tests, while Section 6 provides results illustrating key mechanisms. Section 7 concludes.

1. Background

1.1. *Marriage Customs in Nigeria*

Marriage markets in Nigeria are characterised by two key institutions: bride price and polygamy. Bride price is a marriage practice that dictates payments from the groom to the family of the bride at the time of marriage, although allocation of property rights over this transfer between bride and her parents varies across societies (Anderson, 2007). Historically, nearly all of the ethnic groups in Nigeria have practised both polygamy and bride price. Data from Murdock (1967), which codes an extensive set of traditional practices across 1,265 pre-modern societies, provide insights about traditional marriage practices across 95 Nigerian ethnic groups observed at varying points between 1870 and 1950. Every ethnic group in this sample practice some form of bride price, while 86% practice direct monetary transfers to the bride's family.[8] At the same time, only two groups in the Nigeria sample, the Chamba and the Jibu, practice strictly monogamous marriage.

Despite the lack of group-level differences in historical marriage institutions, as Fenske (2015) demonstrates using data from DHS, there is substantial within-country variation in rates of polygamous marriage across Africa. In the Nigerian sample, there is variation in polygamous practice both at the household level within communities, and across villages and regions. To capture variation in polygamy as a long-standing norm rather than the polygamy rate itself, which is an equilibrium outcome of the marriage market, I define polygamy as a dummy that indicates whether a village contains any polygamous man. By this measure, polygamy is practised in 61% of villages included in the 2008 and 2013 Nigeria DHS rounds. In Online Appendix F.1,

[8] The remainder also practice bride price in the form of either token or in-kind transfers.

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I show that all results are robust to using different thresholds to define cluster-level polygamy status, as well as using equivalent definitions based on the larger female sample.

There is qualitative evidence that high bride prices and polygamy in Nigeria have led to concentration of brides in the hands of richer, older men (Hudson and Matfess, 2017). Two facts are consistent with this story: (*i*) large gender gaps in age of marriage suggests that men must accumulate significant wealth in order to afford marriage, and (*ii*) a strong within-village correlation between wealth, age and the number of brides,[9] which suggests that polygamy and high bride price concentrate wives among older and richer men. Ethnographically, Cohen (1961) finds that polygamy among the Kanuri in north-east Nigeria[10] engenders a status hierarchy among men based on the number of wives. A concentration of young men at the bottom of this hierarchy may brew social instability.

1.2. *Boko Haram*

Boko Haram is an Islamist terror group espousing Salafi jihad and the violent imposition of an Islamic state in northern Nigeria. It was founded in 2002 by the itinerant preacher Mohammed Yusuf in Maiduguri, the capital of Borno State. Though the group has always espoused violent jihad, it did not begin active operations until 2008. In 2009, Boko Haram announced their presence in a wave of violence that swept through northern Nigeria, killing over 1,000 civilians.

Since 2009, Boko Haram has been engaged in near-constant conflict with the Nigerian military and has preyed on local civilian populations. The insurgency has resulted in a humanitarian emergency, including the death of more than 20,000 people and the displacement of roughly 1.7 million others.[11] At its height, the group controlled significant territory in northern Nigeria and boasted an estimated fighting force of roughly 15,000.[12] The group is known for its extreme brutality, its use of mass abductions and frequent use of women and children as suicide bombers.

Interviews with militants suggest that recruitment is driven by poverty and unemployment in northern Nigeria (Onuoha, 2014). However, marriage may be a potent force in funnelling recruits to Boko Haram. Boko Haram is distinguished from other jihadist groups by its use of mass abductions of schoolgirls,[13] which suggests that controlling large numbers of adolescent girls is strategically important to the group. Boko Haram has explicitly used offers of marriage to attract young men, and bride price emerges as a key concern among young members (Cold-Ravnkilde and Plambech, 2015; Hudson and Matfess, 2017). Recent qualitative evidence shows that young men in northern Nigeria do in fact join Boko Haram for marriage: women are abducted for this purpose, trained as wives, and men are rewarded for their service with affordable, recognised marriages (Hudson and Matfess, 2017). Boko Haram is reported to have paid bride prices to families of abducted girls (Hudson and Matfess, 2017).

2. Model

In this section, I present a model that derives marriage and occupational decisions as a function of exogenous economic conditions and marriage market institutions. In the model, men make bride

[9] These results are presented in Table D1 and discussed in detail in Online Appendix D.1.
[10] The Kanuri homeland makes up the centre of the Boko Haram insurgency.
[11] According to reports from UNOCHA.
[12] According to reports from Amnesty International.
[13] For example, the Chibok girls, or more recently in Dapchi, Yobe State.

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price offers based on their position in the income distribution, and a girl's parents accept or reject these offers based on outside options. The resulting marriage market equilibrium determines the expected value of civilian life, which is traded off by young men against the value of joining insurgents. The key exogenous parameters in the model are the marriage regime—monogamy or polygamy—the distribution of male types, and the girl's contribution to household income. The endogenous variables are the equilibrium bride price, the marriage rate of different male types, and the probability of joining Boko Haram. The model delivers several testable predictions: (*i*) that polygamous marriage markets have greater marriage inequality, (*ii*) that marriage inequality increases in response to positive female income shocks, more so under polygamy, and (*iii*) that positive female income shocks increase Boko Haram activity, more so under polygamy.

2.1. *Set Up*

Consider a very simple marriage market with polygamy, a reformulation of the classic Becker (1974) model with dynamic considerations, as in Corno *et al.* (2020). There are four types of men who differ along two dimensions: they are young or old $\{Y, O\}$ and they are rich or poor $\{R, P\}$. In a monogamous marriage market, only the young participate, while in a polygamous market, the rich old also participate. There are N^F women and N^j men of each type. For simplicity, I assume that the male types have equal population, and that any man can marry up to two women. Men have willingness to pay for marriage as follows: $v^{RO} > v^{RY} > v^{PY}$.[14] This assumption is based on results in Online Appendix D.1 showing that richer, older men have more wives on average, the simplest microfoundation for which is that wives are a normal good. For simplicity, men are allowed a maximum of two wives. Each period every woman meets a randomly drawn man with probability λ, and meets nobody with probability $1 - \lambda$. If a meeting happens, the man of type j makes an offer w^j and gets surplus $v^j - w^j$.

Following the qualitative literature (Erulkar and Bello, 2007; Grossbard, 2015), I assume a girl's parents make decisions about her marriage offers. They have log utility. Girls generate income y^f for their family each period if they remain unmarried. Parents discount the future by a factor β. Given an offer w, they solve the discrete problem

$$\max\{\log(w), \log(y^f) + \beta V_r^{wait}\}.$$

Where V^{wait} is the value of staying in the market until the next period. r is the regime, either monogamous m or polygamous p. Before the marriage market, young men must decide whether to enter civilian life or join a rebel group, which is absorbing. The rebels offer a marriage package worth v^{reb} to all young men. If the man enters the rebel world, he gains the offer of marriage v^{reb} and incurs disutility ξ_i of rebel activity, drawn from distribution Ξ, which is independent of his type. The utility from taking the rebel offer is $v^{reb} - \xi_i$.

2.2. *Marriage Market*

First note that parents will follow a cut-off strategy, accepting w such that $\log(w) > \log(y^f) + \beta V_r^{wait}$ and declining otherwise. The reservation offer $\bar{w}$ will therefore satisfy

$$\bar{w} = y^f \exp(\beta V_r^{wait}).$$

[14] I also assume the poor old have exited the market unmarried. This assumption does not affect the main results, but may affect the age-incidence of marriage inequality.

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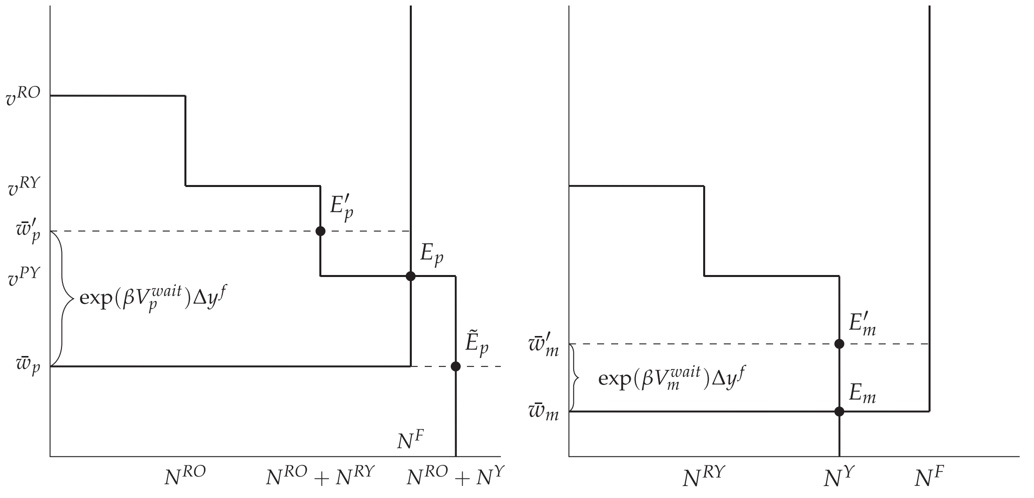

Fig. 2. *Equilibrium in the Marriage Market.*

I assume that the value of waiting in a polygamous market is $V_p^{wait} > V_m^{wait}$. This is because additional high-value men in the market both increase the likelihood of meeting a match next period and, since these men are the rich type, increase the expected offer. Both factors increase the expected value of next-period matches. Together, this yields the first result: that polygamy creates greater reservation bride prices. The market under polygamy and monogamy is illustrated in Figure 2. Demand forms a step function, with the steps indicated by the values of the different types of men. In the monogamous market (panel (b)), only RY and PY types enter the market, while in the polygamous market (panel (b)), demand begins at the higher v^{RO} due to older, richer men re-entering the marriage market. Because of the binary nature of the marriage choice and the homogeneity of female preferences, all women enter the market at the same reservation bride price and so supply is perfectly elastic at $\bar{w}$ until N^F, after which all women have entered the market and it becomes inelastic (as in Becker, 1974).[15] The reservation price under polygamy is higher than under monogamy because of the difference in continuation values.

To begin, I compare the properties of the initial equilibria under polygamy and monogamy. Because women marry younger than men on average (see Table 1), I assume that the number of unmarried women is greater than the number of unmarried young men, but less than the total men in a polygamous market, that is, $N^Y < N^F < N^Y + N^{RO}$. The first result is that in polygamous equilibrium E_p, prices are higher than in the monogamous equilibrium at E_m. This is driven by two forces: (*i*) the reservation bride price is higher under polygamy, and (*ii*) the entry of *RO*-type men shifts out demand and drives up the equilibrium price from $\bar{w}_p$ to v^{PY}. The second result is that marriage inequality is higher under polygamy. At E_m, each man married to exactly one woman, and there is perfect equality of brides among men. But at E_p, some PY are unmarried, while all *RO* have two wives. Finally, note that both of these predictions depend in magnitude, but not direction, on elasticity of supply. If supply is perfectly elastic, then the polygamous

[15] Unobserved preference shocks in the female decision equation would generate an upward-sloping supply curve as women enter the market at different reservation prices. This does not affect the model conclusions; polygamy then shifts each individual reservation point and therefore the aggregate supply curve upward.

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Table 1. *Summary Statistics.*

Year	2008			2013		
Cluster	Monogamous	Polygamous	All	Monogamous	Polygamous	All
Cluster-level, N = 1,771						
Bride Gini	0.52	0.48	0.50	0.57	0.51	0.54
	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)
Polygamous	0.00	1.00	0.64	0.00	1.00	0.59
	(0.00)	(0.00)	(0.48)	(0.00)	(0.00)	(0.49)
Boko Haram active	0.14	0.15	0.15	0.11	0.22	0.18
	(0.35)	(0.36)	(0.35)	(0.32)	(0.41)	(0.38)
Boko Haram deaths	1.45	4.22	3.21	4.16	11.98	8.80
	(16.15)	(25.65)	(22.68)	(31.96)	(46.90)	(41.64)
Boko Haram kidnapping	0.03	0.04	0.03	0.01	0.04	0.03
	(0.17)	(0.19)	(0.18)	(0.10)	(0.19)	(0.16)
Wealth Gini	0.15	0.19	0.17	0.09	0.10	0.10
	(0.07)	(0.06)	(0.07)	(0.03)	(0.03)	(0.03)
Wealth index	2.14	1.37	1.65	3.04	2.17	2.53
	(0.81)	(0.82)	(0.90)	(0.75)	(0.80)	(0.89)
Population density in 2005	2,684.97	967.67	1,594.08	2,117.79	1,170.03	1,555.27
	(5,781.97)	(3,142.80)	(4,372.69)	(4,373.13)	(4,069.38)	(4,218.88)
Male, N = 32,427						
Age of marriage	27.33	24.05	24.98	27.20	24.20	25.14
	(6.14)	(5.43)	(5.83)	(5.73)	(5.19)	(5.54)
Unmarried	0.53	0.40	0.44	0.58	0.45	0.50
	(0.50)	(0.49)	(0.50)	(0.49)	(0.50)	(0.50)
One wife	0.47	0.45	0.45	0.42	0.42	0.42
	(0.50)	(0.50)	(0.50)	(0.49)	(0.49)	(0.49)
Two wives	0.00	0.13	0.09	0.00	0.12	0.08
	(0.00)	(0.34)	(0.29)	(0.00)	(0.32)	(0.26)
Three wives	0.00	0.02	0.01	0.00	0.01	0.01
	(0.00)	(0.13)	(0.11)	(0.00)	(0.11)	(0.09)
Four wives	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.06)	(0.05)	(0.00)	(0.05)	(0.04)
Muslim	0.18	0.59	0.45	0.20	0.70	0.52
	(0.39)	(0.49)	(0.50)	(0.40)	(0.46)	(0.50)
Hausa	0.05	0.32	0.23	0.04	0.41	0.27
	(0.21)	(0.47)	(0.42)	(0.21)	(0.49)	(0.45)
Kanuri	0.01	0.03	0.02	0.01	0.02	0.02
	(0.09)	(0.17)	(0.15)	(0.10)	(0.15)	(0.13)
Female, N = 71,851						
Age of marriage	20.15	16.92	17.81	20.21	16.69	17.75
	(5.16)	(4.25)	(4.75)	(5.08)	(4.06)	(4.68)
Polygamous	0.14	0.40	0.33	0.13	0.41	0.33
	(0.35)	(0.49)	(0.47)	(0.34)	(0.49)	(0.47)
Number of co-wives	1.19	1.51	1.42	1.17	1.51	1.42
	(0.59)	(0.74)	(0.72)	(0.54)	(0.72)	(0.69)
Muslim	0.17	0.58	0.45	0.20	0.70	0.52
	(0.38)	(0.49)	(0.50)	(0.40)	(0.46)	(0.50)
Hausa	0.04	0.31	0.22	0.04	0.41	0.28
	(0.21)	(0.46)	(0.42)	(0.20)	(0.49)	(0.45)
Kanuri	0.01	0.03	0.02	0.01	0.02	0.02
	(0.09)	(0.17)	(0.15)	(0.11)	(0.14)	(0.13)

Notes: Table displays variable means with standard deviations in parentheses. Sample is a DHS repeated cross-section at cluster, male, and female level, as indicated. Sample sizes are pooled across DHS rounds and cluster type.

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equilibrium is $\tilde{E}_p$, while the monogamous one is unchanged. Equilibrium polygamous bride prices fall to $\bar{w}_p$, but are always higher than under monogamy by the assumption $V_p^{wait} > V_m^{wait}$. Wives are now affordable to all men, so inequality falls. Still, inequality persists under polygamy because *RO* men have two wives.

The key result is that positive female income shocks increase the reservation price and leading to greater marriage inequality only under polygamy. To see this, note that $\frac{\partial \bar{w}}{\partial y^f} = \exp(\beta V_r^{wait}) = \frac{\bar{w}}{y^f}$. The derivative is proportional to the initial reservation wage, and so greater under polygamy. In Figure 2, this corresponds to an upward shift in the equilibria to E'_p and E'_m, respectively. Under monogamy, the shift in reservation prices is small enough that all men remain married. However, given that $\frac{\partial \bar{w}}{\partial y^f}$ is bigger under polygamy, an equivalent Δy^f increases prices enough to push all of the PY types out of the market. Thus inequality is unchanged in m but rises in p.[16]

2.3. *Occupational Choice*

Now consider the decision of a young man who is considering entering the civilian or militant market under regime r before observing his type. His expected value of civilian life will be

$$
\begin{aligned}
V_r^{civ}(w_r) = {} & \lambda \frac{N^{RY}}{N^Y}\left[(v^{RY} - w_r)1(v^{RY} \geq w_r) + 1(v^{RY} < w_r)\beta V_r^{search,\, RY}\right] \\
& + \lambda \frac{N^{PY}}{N^Y}\left[(v^{PY} - w_r)1(v^{PY} \geq w_r) + 1(v^{PY} < w_r)\beta V_r^{search,\, PY}\right] \\
& + (1-\lambda)\beta V_r^{search}.
\end{aligned}
$$

With probability λ, he meets a match and draws his type.[17] The expectation is taken over the two possible states, rich or poor, comprising the first two terms. In either case, if the equilibrium bride price w_r is below his value v^j, he obtains marriage value $v^j - w_r$; if above, he continues to search conditional on type. With probability $1-\lambda$, he obtains the continuation value. Assuming a stationary equilibrium, as shown in Online Appendix C the value function can be re-written

$$
V_r^{civ}(w_r) = \frac{\lambda}{1-(1-\lambda)\beta}\left[\frac{N^{RY}}{N^Y}(v^{RY} - w_r)1(v^{RY} \geq w_r) + \frac{N^{PY}}{N^Y}(v^{PY} - w_r)1(v^{PY} \geq w_r)\right].
$$

In contrast, his value from joining a militia will be $v^{reb} - \xi_i$. The joining rate ρ_r will be

$$
\rho_r = \Xi\left(v^{reb} - V_r^{civ}(w_r)\right).
$$

The joining rate—and Boko Haram violence—is increasing in y^f for both r

$$
\begin{aligned}
\frac{\partial \rho_r}{\partial y^f} &= \frac{\partial \rho_r}{\partial V_r^{civ}} \frac{\partial V_r^{civ}}{\partial w_r} \frac{\partial w_r}{\partial y^f} \\
&= -\Xi'\left(v^{reb} - V_r^{civ}(w_r)\right) \frac{\partial V_r^{civ}(w_r)}{\partial w_r} \frac{\partial w_r}{\partial y^f} > 0.
\end{aligned}
$$

[16] Note that the relative magnitudes of bride price effects depend on the supply elasticity. If supply is perfectly elastic, then equilibrium prices are pinned down by $\bar{w}$, so price increases will be greater under polygamy. However, when the supply curve slopes up at N^F, then supply constraints may only bind in the polygamous market because of greater male demand. As such, the price increase under polygamy is only $v^{PY} - \bar{w}_p < \bar{w}'_p - \bar{w}_p$, and so may not necessarily exceed $\bar{w}'_m - \bar{w}_m$.

[17] This assumption is purely for notational convenience. It is easy to verify that V^{civ} will be decreasing in w for both types, which is all that is required for the results to hold. We can think of this setup as giving the choice of the 'average' young man in the market.

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Given that $\Xi' > 0$, $\frac{\partial V_r^{civ}(w_r)}{\partial w_r} < 0$, $\frac{\partial w_r}{\partial y^f} > 0$. The final prediction is that $\frac{\partial \rho_p}{\partial y^f} > \frac{\partial \rho_m}{\partial y^f}$. To see this, consider the simplest case of perfectly elastic supply, $w = \bar{w}$. We have already established that the term $\frac{\partial \bar{w}}{\partial y^f}$ is larger under polygamy. Assuming equal group sizes, $\frac{\partial V_p^{civ}(\bar{w}_p)}{\partial \bar{w}_p} = \frac{\partial V_m^{civ}(\bar{w}_m)}{\partial \bar{w}_m}$. Finally, $\Xi'(v^{reb} - V_p^{civ}(\bar{w}_p)) > \Xi'(v^{reb} - V_m^{civ}(\bar{w}_m))$ as long as ρ_r is sufficiently low for both r. This depends on the distribution for ξ. If Ξ is symmetric, then using $V_p^{civ}(\bar{w}_p) < V_m^{civ}(\bar{w}_m)$, we have that $v^{reb} - V_p^{civ}(\bar{w}_p) > v^{reb} - V_m^{civ}(\bar{w}_m)$. As long as $\rho_p \leq 0.5$,[18] the distribution function Ξ' is increasing and the inequality holds. A positive female income shock makes men more likely to join Boko Haram by raising the reservation bride price and reducing the expected value of civilian life under polygamy.

The conclusions of the model rest on a number of assumptions. First, the assumption that older and richer men have more willingness to pay is key to generating greater marriage inequality in polygamous places. Second, parents are assumed to have diminishing marginal utility; under linearity, the sensitivity of the reservation price to outside income no longer depends on the regime. Third, only under the assumption that supply constraints are initially non-binding do income shocks unambiguously have greater effects on bride prices in polygamous markets. Fourth, the assumption of regime-dependent continuation values drives the dynamics of reservation bride prices; greater polygamous demand should naturally increase both next-period prices and match probability. Finally, the assumptions of symmetry on the distribution of disutility and a low joining rate are sufficient, but not necessary, for ensuring differential violence effects.

3. Data and Summary Statistics

3.1. *Data Description*

To test the hypotheses about extremist violence, marriage, and female income, I collect community-level data on exposure to Boko Haram, marriage market statistics such as the polygamy rate, mean number of wives, and marriage inequality, individual-level demographic data, and a full rainfall history for each location to construct rainfall shocks.[19]

3.1.1. *Marriage data*

Data on the marriage market comes from repeated cross-sections of men, women and households in the 2008 and 2013 Demographic and Health Surveys (National Population Commission [Nigeria] and ICF, 2008; 2013). I measure marriage-market inequality by calculating the Gini coefficient of wives reported by men aged 15–59, including zero values for unmarried men. I also take demographic data for men and women, including ethnicity, religion, education, migration, age of marriage, year of birth and household wealth. Women are oversampled in the DHS; as such, I obtain a final sample of 32,427 men, 71,851 women, and 1,771 clusters for which all relevant data is available. I define a marriage market as a DHS cluster and use clusters as the unit of analysis for all market-level regressions. In Online Appendix E.6, I show that the results hold at higher levels of aggregation which account for between-village migration for marriage.[20] In all market-level regressions, I collapse variables measured at the individual level to their

[18] This seems reasonable given that the number of Boko Haram fighters is small relative to the population.

[19] More detail is available in Online Appendix B.

[20] However, to the extent that marriage markets are spatially integrated, economic shocks will affect marriage outcomes in clusters in which they did not occur, biasing the results towards zero.

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cluster-level means. Figure A1 in Appendix A maps the geographic distribution of the male polygamy rate across DHS clusters in the 2008 (panel (a)) and 2013 (panel (b)) DHS rounds. Polygamy is common across the Muslim North, Christian South, and the religiously mixed 'Middle Belt' central region.[21]

3.1.2. *Conflict data*

Data on Boko Haram incidents comes from the Armed Conflict Location Event Dataset (ACLED), which identifies events using local and international newspapers (see Raleigh *et al.*, 2010, for a description). I identify 1,826 Boko Haram-involved events between 2008 and 2017, roughly 20% of Nigeria's total number of violent events over this period. I match these events to DHS clusters by assigning to each cluster all of the events that fall within a 20 km radius. For 2008 I retain events occurring from 2008 to 2012, and for 2013 I retain events occurring from 2013 to 2017.[22] I measure conflict as the mean annual number of events or fatalities.[23] Data on Boko Haram territory comes from Political Geography Now (Centanni, 2015), a research service specialising in territorial control in conflict zones. I digitise seven maps covering 2013–15, which include Boko Haram's greatest extent of territory in January 2015.

Figure A2 in Appendix A maps the geographic distribution of mean annual Boko Haram fatalities across DHS clusters for 2008–12 and 2013–17. In the first period (panel (a)), most Boko Haram deaths are clustered in the north-east, primarily in Borno State, highlighted in bold. Maiduguri, the capital of Borno and birthplace of the group, has the highest density of Boko Haram fatalities. Outside the north-east, only Kano, the largest city and commercial capital of northern Nigeria, has a substantial density. However, from 2013 to 2017, attacks both increase in Borno and spill over into neighbouring states. This suggests an expanding reach and increased remote activity over time.

3.1.3. *Rainfall data*

I take monthly precipitation from 1900 to 2014 from the University of Delaware (UDEL) gridded precipitation dataset (Dell *et al.*, 2014, Willmott and Matsuura, 2015). The data are gridded at a spatial resolution of 0.5×0.5 degrees (roughly 50 km at the equator), and are interpolated from weather stations. I match the grids to DHS clusters by distance, obtaining 287 rainfall grids matched to any DHS cluster. Several DHS clusters can be assigned to the same grid-cell, resulting in spatial autocorrelation within cells. I address this by clustering standard errors at the grid-cell level. I use rainfall data to construct individual and cluster-level female rainfall shocks, defined as the deviation of rainfall from its long-run mean experienced during a woman's pre-marital adolescent years, ages 12–16, which I take from the literature (Fenske, 2015; Corno *et al.*, 2020).

Throughout the paper, I control for unobserved ethnic heterogeneity using ethnicity fixed effects derived from the boundaries of ethnic homelands in the Murdock (1967) *Ethnographic Atlas*, digitised by Nunn (2008). This comprehensive map of the homelands of ethnic groups across sub-Saharan Africa has been used extensively in empirical research on African economic history.

[21] To rule out generic measurement error biases specific to the DHS data, in Online Appendix F.2 I replicate all of the main marriage results using data from Nigeria's General Household Survey (GHS).

[22] Results are similar if limited to 2 and 3 year periods. Results available upon request.

[23] I test robustness to conflict data sources in Online Appendix F.8.

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3.2. *Descriptive Statistics*

Summary statistics for the data at cluster and individual level are presented in Table 1. I estimate means and standard deviations by DHS year and marital regime. The top panel considers cluster-level variables—marriage inequality, wealth inequality, Boko Haram activity, population density, and an indicator of whether the cluster contains any polygamous men. Marriage inequality is high across Nigeria, and rising, with an average within-cluster bride Gini of 0.5 in 2008 and 0.54 in 2013. In contrast, average within-village wealth inequality is low and falling, from 0.17 to 0.1. Polygamy is a common institution, with around 60% of villages containing at least one polygamous man. Boko Haram activity is widespread and rising, affecting 15% of clusters in 2008 and 18% in 2013. Average annual fatalities per cluster also rise over time, from 3.2 to 8.8, reflecting an increase both in the level of activity and deadliness over this period.

Monogamous and polygamous areas generally have comparable levels of marriage and wealth inequality, and Boko Haram presence. However, annual Boko Haram deaths—the main outcome of interest—are greater in polygamous villages. Monogamous villages are also more densely populated, consistent with higher levels of average wealth in monogamous villages in both rounds.

There is a large gender gap in age of marriage, with men marrying around age 25 on average, while women marry just before 18, below the minimum legal age of marriage nationally. Roughly 9% of all men are polygamous, implying that polygamists comprise roughly 18% of married men. Among women, polygamy is more common—roughly 33% of married women aged 15–49 are in polygamous unions, and these women have on average 1.4 co-wives. Polygamy rates do not vary substantially over time, suggesting a stable equilibrium.

Both marriage customs and Boko Haram conflict may be correlated with cultural and religious demographics. The predominant ethnic groups in northern Nigeria are the Hausa and the Fulani. However, the Kanuri, though a small minority, occupy Boko Haram's north-eastern stronghold in Borno State. Northern Nigerian ethnic groups tend to be overwhelmingly conservative Muslim, which may in turn correlate with both marriage practices and Boko Haram activity. Table 1 shows that polygamous villages indeed have larger shares of Muslim and Hausa inhabitants, as well as an earlier age of marriage for both men and women.[24]

Figure A3 in Appendix A gives the distributions of marriage inequality, adolescent rainfall shocks, polygamy, and average number of wives. The distribution of village-level shocks ranges from -1 to 0.5; a 1-unit change therefore corresponds to moving from the first to the 90th percentile of the distribution, which is important for interpreting coefficients in the reduced form and first stage. Marriage inequality is fairly symmetrically distributed, while both polygamy rate and mean number of wives have a point mass at zero and one, and long right tails.[25]

Figure A5 in Appendix A plots the equilibrium relationship between polygamy and marriage inequality, controlling for survey round and ethnicity fixed effects, and a large set of control variables. The positive slope is consistent with the model prediction that polygamy pushes up reservation prices, shifting poor men out of the market and women towards richer polygamous

[24] While this earlier age of marriage is arguably inconsistent with the model prediction of higher bride prices and delayed marriage in polygamous markets, it is more likely driven by the fact that polygamous norms are likely to predominate among more conservative ethno-religious groups. In addition, polygamy and child marriage may be associated because polygamy creates societal incentives for younger marriages (Grossbard, 1980).

[25] In Figure A4 plots the density functions for marriage inequality separately by polygamy status. Perhaps unexpectedly, the distribution is shifted slightly to the right in monogamous relative to polygamous villages. However, this relationship reverses after conditioning on cluster-level controls and ethnicity fixed effects, see Figure A5.

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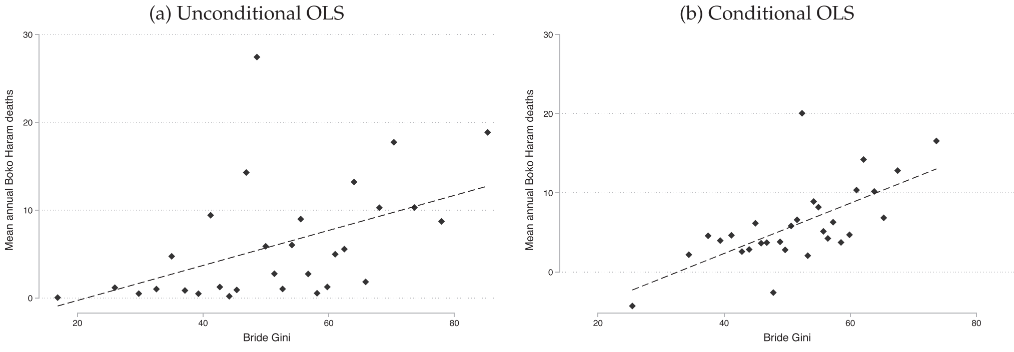

Fig. 3. *Ordinary Least Squares Correlation Between Boko Haram and Marriage Inequality. The figure shows the partial correlation between Boko Haram fatalities and marriage inequality. Scatterplots are binned using 30 quantiles of the bride Gini. Panel A shows the unconditional relationship while Panel B controls for DHS round and ethnic homeland fixed effects, slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa and share Muslim.*

men. These forces exert upward pressure on inequality. Despite this strong correlation, the clear endogeneity of the polygamy rate renders it unsuitable as an instrument for marriage inequality.

Figure 3 plots both the unconditional (panel (a)) and conditional (panel (b)) OLS correlations between marriage inequality and Boko Haram activity. Both slopes are positive, but the correlation strengthens once I condition on ethnicity fixed effects and cluster-level controls. The unconditional relationship has a slope of 0.19, significant only at the 10% level, while the conditional slope estimate is 0.32, significant at the 5% level. While the positive association is robust, it is likely not causal. I introduce my instrumental variables approach in Section 4.

4. Empirical Strategy

4.1. *Main Specification*

The model predicts that higher female pre-marital income y^f reduces the marriage rate of poorer men, and this effect is greater under polygamy. This in turn reduces the expected value of civilian life V^{civ} and increases ρ, the recruitment rate. The empirical implication is that marriage inequality and Boko Haram activity should respond more positively to income shocks in polygamous villages. The model lends itself naturally to an IV interpretation; the equation for the marriage market value forms a first stage for the occupational choice equation. The interaction of polygamy status with female income can serve as an instrument for marriage market conditions to estimate the effect of the marriage market on Boko Haram activity. The estimating equation corresponding to the occupational choice equation, for cluster j in survey round r is

$$b_{jr} = \alpha_0 + \varphi g_{jr} + \delta_r + \gamma_s + \xi_g + \boldsymbol{x}'_{jr}\boldsymbol{\beta} + u_{jr}.$$

Where b_{jr} are Boko Haram-related deaths in cluster j in the years between round r and $r+1$. g_{jr} is the Gini coefficient of brides in cluster j among all sampled men aged 15–59. γ_s are state fixed effects and ξ_g are ethnicity area fixed effects. The coefficient of interest is φ, which represents the marginal change in Boko Haram-related fatalities corresponding to a one-point

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increase in the bride Gini. The parameter φ is estimated via 2SLS with the following first stage:

$$g_{jr} = \alpha_1 + \pi_1 p_{jr} s_{jr} + \pi_2 p_{jr} + \pi_3 s_{jr} + \delta_r + \gamma_s + \xi_g + \boldsymbol{x}'_{jr}\boldsymbol{\beta} + \varepsilon_{jr}.$$

Where p_{jr} is a dummy for polygamy status and s_{jr} is the average deviation of rainfall from its long-run mean during the adolescent period of women in cluster j. The coefficient of interest is the interaction term, π_1, capturing the differential effect of rainfall shocks on marriage inequality in polygamous societies relative to monogamous ones. This coefficient serves both as a test of the theoretical model, which predicts $\pi_1 > 0$, and as a source of identification for the IV models. Throughout, I measure p_{jr} as a dummy variable that equals one when any household in village j is polygamous. Note that both p_{jr} and s_{jr} are included in the second stage, along with fixed effects and controls. Only the interaction term is excluded.

All regressions include a vector of cluster-specific controls $\boldsymbol{x}_{jr}$, which include survey round fixed effects, annual rainfall deviation and average monthly temperature in the year of the survey, lagged rainfall deviation, cluster gradient, population density in 2005, average age of men and women, wealth inequality, distance to borders, share Muslim and share Hausa, the dominant ethnic group in Northern Nigeria. Standard errors are clustered at the grid-cell level to account for spatial correlation in shocks across clusters within grids. This should provide conservative variance estimates, since each cluster is matched to a larger rainfall grid.

4.2. *Measurement Assumptions*

The joining rate ρ is unobserved. However, if we assume that the level of violence Boko Haram perpetrates in a given locality is an increasing function of the number of recruits, then we can use observable conflict intensity as our outcome variable. In Subsection 6.4, I interrogate the validity of this assumption in detail. We also do not observe V^{civ}, the value of the civilian marriage market, which links the exogenous features of the marriage market to Boko Haram activity. I use the level of inequality in the distribution of brides and the male unmarried rate, both observable indicators of marriage market tightness.

Following the sizeable literature in development economics starting with Miguel *et al.* (2004), I use rainfall to measure y^f, the economic conditions in which families form their reservation bride prices. In particular, I construct cohort-by-cluster specific rainfall shocks that measure the deviation between the average annual rainfall over a woman's pre-marital adolescence, ages 12–16, and the cluster's long-run average. This is relevant for the parents' reservation price, as it represents the economic environment when their daughter enters the marriage market. Let μ_j be the long-run average rainfall in cluster j, and σ_j be its standard deviation. r_{jt} is the rainfall experienced by cluster j in year t. For woman i in cluster j born in year τ_i (alternatively, belonging to cohort c), the individual rainfall shock is

$$s_{ij} = \frac{\frac{1}{T}\sum_{t=\tau_i+12}^{\tau_i+16} r_{jt} - \mu_j}{\sigma_j}.$$

In terms of cohorts, the cluster-level average, s_j, can be written as

$$s_j = \frac{1}{N_j}\sum_{i=1}^{N_j} s_{ij} = \sum_{c=1}^{C} s_{cj}\omega_{cj}.$$

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The cluster-specific shock s_j represents the mean of individual shocks s_{ij}. Given that all women of cohort c in village j have experienced the same rainfall history, this is equivalent to a within-cluster cohort-weighted average of shocks, where the share of cohort c in cluster j, ω_{cj}, is the weight. Therefore, s_j represents the rainfall deviation experienced by the average female cohort in cluster j in their adolescent period. For each village, I average over all women in the DHS sample aged 15–49.

Standardising the individual-specific shock s_{ij} accounts for both the mean level of rainfall in a cluster as well as its variability. This is germane given the literature on the effects of climate and geography on development (Dell *et al.*, 2014), suggesting that both the long-run level and variability of rainfall are correlated with present-day income. Given that the shock is defined using rainfall data that often occurs decades (depending on the age-structure of the village) before the outbreak of Boko Haram violence, there is little danger of endogenous measurement error at weather stations as a direct result of conflict, as highlighted by Schultz and Mankin (2019). In Subsection 5.5.1 as well as in the Online Appendix, I conduct extensive robustness tests on different definitions of this variable.[26] In Online Appendix E.1 I estimate 'balance test' regressions that show minimal correlation between the interacted IV and numerous spatial, demographic, economic, and agro-climatic covariates.

5. Main Results

Table 2 presents baseline results for the OLS, reduced-form, first-stage, and 2SLS regressions. These specifications include the full set of controls as well as DHS round fixed effects, and are estimated for five outcome variables: probability of Boko Haram activity (1), number of events (2), average annual fatalities (3), $\log(1 + \textit{fatalities})$ (4), and $\log(1 + \textit{events})$ (5).[27] In Online Appendix E.2 (Table E3), I test robustness of these baseline specifications to the inclusion of location fixed effects for Nigerian states and ethnic homelands.

5.1. *OLS Results*

Consistent with Figure 3, the OLS results in Table 2, Panel A, demonstrate a positive association between extremist violence and marriage inequality. This relationships holds across all three conflict outcomes: a one-unit increase in the marriage Gini is associated with a 0.3 percentage point increase in Boko Haram incidence, 0.036 additional events, and 0.356 additional deaths, with only the first outcome significant at conventional levels. Results become even more significant once noise is reduced using the logged dependent variables. Of course, marriage market concentration is likely to be correlated with wealth inequality, cultural factors and a variety of omitted variables affecting conflict, making interpretations of the OLS results difficult. To make progress, we turn to the reduced form and instrumental variables results.

[26] These can be found in Online Appendix F.4, F.5, F.6 and F.12.

[27] Incidence is a dummy variable indicating any Boko Haram activity in the cluster, while number of events is the average annual number of Boko Haram-related events recorded in ACLED. The last two specifications are primarily to account for the skewness of the incidents and fatalities variables, which are zero in nearly 80% of the clusters.

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Table 2. *The Effect of Marriage Inequality on Violence: Baseline Results.*

Dependent variable	Any event (1)	Total events (2)	Total deaths (3)	log(1 + *deaths*) (4)	log(1 + *events*) (5)
Panel A: OLS					
Bride Gini	0.003***	0.036*	0.356*	0.013***	0.006***
	(0.001)	(0.022)	(0.194)	(0.004)	(0.002)
R^2	0.186	0.074	0.091	0.182	0.171
Panel B: Reduced form					
Adolescent rainfall shock × polygamous	0.252***	1.609**	16.341**	0.776***	0.382***
	(0.086)	(0.720)	(7.006)	(0.281)	(0.128)
R^2	0.194	0.063	0.081	0.170	0.158
Panel C: Two-stage least squares					
Bride Gini	0.021***	0.131**	1.331**	0.063**	0.031***
	(0.008)	(0.062)	(0.605)	(0.025)	(0.011)
Mean dependent variable	0.161	0.597	5.992	0.334	0.147
Dependent variable			Bride Gini		
Panel D: First stage					
Adolescent rainfall shock × polygamous	12.281***				
	(2.792)				
Mean dependent variable	51.535				
R^2	0.499				
Kleibergen–Paap F-statistic	19.349				
Observations	1,771	1,771	1,771	1,771	1,771

Notes: Sample pools all clusters over DHS rounds 2008 and 2013. Standard errors, in parentheses, are clustered at the grid-cell level. In Panels A, B, and C, outcome variable is (1) an indicator of any Boko Haram-related events, (2) the number of Boko Haram events, (3) the number of Boko Haram fatalities, (4) the log of 1 plus (3), or (5) the log of 1 plus (2). In Panel D, the outcome variable is the Gini coefficient of wives in the cluster. All regressions include DHS round fixed effects and controls for slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa and share Muslim. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

5.2. *Reduced Form Results*

In the reduced form, we should see that Boko Haram conflict responds to adolescent rainfall shocks in polygamous marriage markets and is relatively unaffected in monogamous ones. I present the reduced form regression results as a binned scatterplot in Figure 4, partialling out the full set of controls from the baseline specification. In panel (a), I run this regression only for clusters in which $p_{jr} = 1$; here we observe a strong correlation between the mean annual Boko Haram deaths and the magnitude of the adolescent rainfall shock. In panel (b), I estimate the same regression in the monogamous sample, and the positive correlation disappears.

I estimate reduced form regressions in Panel B of Table 2. In the baseline specification, I estimate that a 1 SD increase in rainfall above its mean during the average woman's adolescent period corresponds to a differential (by polygamy) increase in conflict probability of 25.2 percentage points, 1.6 additional events, and 16.3 additional annual deaths, all significant at the 5% level. The estimates appear very large, the last being just under three times the sample mean. However, recall that since the deviations are averaged within clusters, a one-unit increase is equivalent to moving from roughly the 1st percentile of shocks to the 90th (see Figure A3 in Appendix A). Moving instead from the 25th to the 75th percentile of the shock increases Boko Haram conflict by 7.2 percentage points (44.9%), 0.46 events (77.3%), or 4.7 deaths (78.3%). Results are similar and even more significant for the logged dependent variables.

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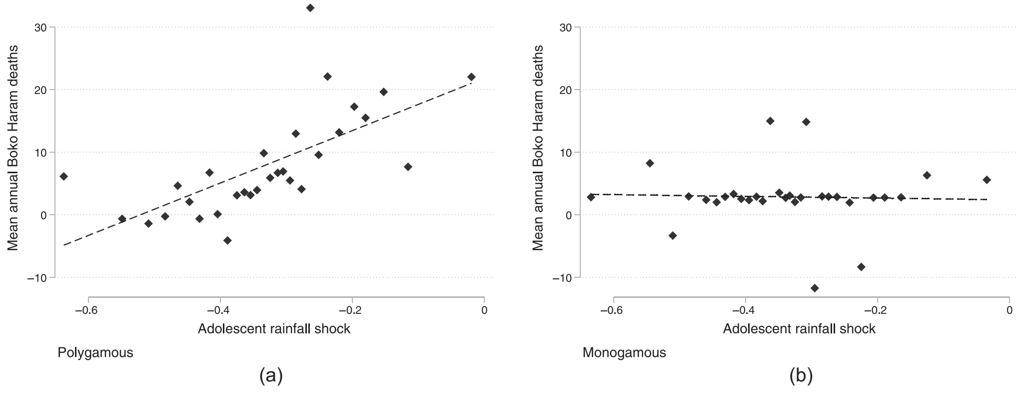

Fig. 4. *Reduced Form: Boko Haram and Rainfall during Adolescence by Polygamy. The figure shows the partial correlation between Boko Haram-related fatalities and the adolescent rainfall shock. Scatter points plot the conditional mean of the outcome for 30 quantile bins of the shock distribution. Panel (a) estimates the relationship on the subsample of polygamous clusters while panel (b) uses monogamous clusters. All plots include DHS round and ethnic homeland fixed effects.*

5.3. *First-Stage Results*

The first-stage relationship estimates the regression of marriage inequality on $s_{jr} \times p_{jr}$, controlling for s_{jr}, p_{jr}, covariates, and fixed effects. These models are of interest in their own right, as they provide a direct test of theory—income realisations in the pre-marital adolescent period should affect marriage decisions by shifting the reservation price, primarily in polygamous regions. This market-level first-stage equation forms the basis of the IV strategy.[28]

To begin, I replicate the graphical analysis of the reduced form, plotting the binned relationship between the Gini coefficient of brides against the mean adolescent rainfall shock in Figure 5. All variables are residualised for the full set of baseline controls and DHS round dummies. As before, panel (a) shows the relationship in polygamous areas, which is positive and significant; in monogamous areas (panel (b)), the slope is negative.

By raising reservation prices, supply-side income shocks should reduce marriage rates among poorer men and, given the correlation between income and brides (see Online Appendix D.1), increase marriage inequality. Either the unmarried rate or inequality can be used as an endogenous variable in IV estimation, and in practice they are highly correlated ($R^2 = 0.87$). In the main results of Table 2, Panel D, I use the Gini coefficient of brides. However, in Online Appendix E.3, I measure marriage inequality using the coefficient of variation in brides, the male unmarried rate, or the market share of young men, finding similar results. In the baseline specification of Table 2, Panel D, a 1-unit differential increase in the adolescent rainfall shock in polygamous areas is associated with a 12.3-point increase in the marriage Gini, a 23.4% increase on the mean.[29] In Online Appendix E.3, I show similar effect sizes across a variety of inequality measures.

[28] In Subsection 6.1, I estimate individual-level regressions using age of marriage, child marriage, and marriage hazard as dependent variables to demonstrate that this aggregate effect is driven by a micro-level marriage response.

[29] For ease of interpretation, the Gini ranging from 0 to 1 is multiplied by 100. While this effect size appears large, note the distribution in Figure A3(b) in Appendix A, which shows that a one-unit increase covers most of the range. Moving from the 25th to the 75th percentile of the adolescent rainfall shock increases marriage inequality by 3.5 points, or 6.8%.

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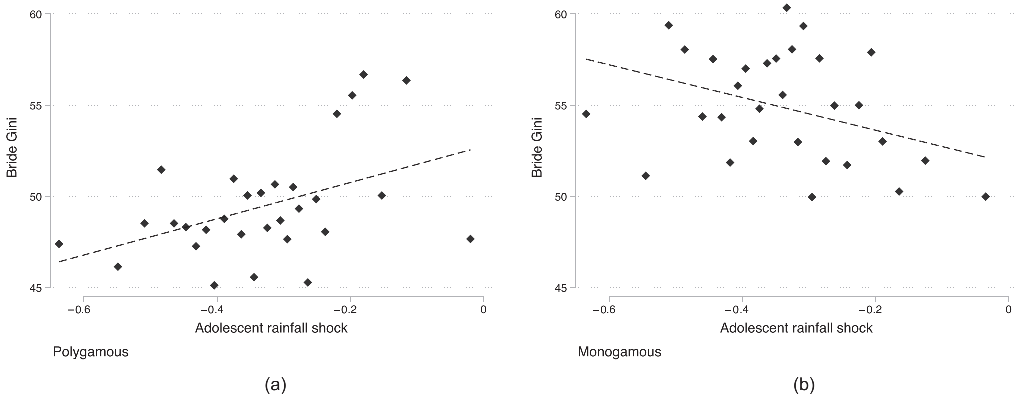

Fig. 5. *First Stage: Bride Gini and Rainfall during Adolescence by Polygamy. Figure shows the partial correlation between bride Gini and the adolescent rainfall shock. Scatter points plot the conditional mean of the outcome for 30 quantile bins of the adolescent rainfall distribution. Panel (a) estimates the relationship on the subsample of polygamous clusters while panel (b) uses monogamous clusters. All plots include DHS round and ethnic homeland fixed effects.*

Figure 5 reveals that in monogamous areas, marriage inequality actually falls in response to the adolescent rainfall shock. In Online Appendix D.2, I extend the model to allow parents to have preferences over both the age and bride price of their daughter's spouse, so that families may react to positive income shocks by demanding spouses who are not only richer but also potentially younger. In monogamous areas, unmarried older men are negatively selected, and so younger men are chosen, reducing marriage inequality. In polygamous areas, rich older men may re-enter the market and so bride price offers are increasing in age; richer men are chosen, increasing marriage inequality.

5.4. *IV Results*

Table 2, Panel C, presents the baseline IV results, with additional specifications in Online Appendix Table E3. As before, the baseline model includes DHS round dummies and a full set of controls. For all IV results, I report the Kleibergen and Paap (2006) F-statistic of the first-stage regression, which accounts for clustering of error terms within rainfall-grid units. Column (1)–(3) indicate that a one-point increase in the bride Gini results in a 2.1 percentage point increase in conflict incidence (10% of the sample mean), an additional 0.13 events (18.9% of the sample mean), and 1.33 additional fatalities (22.2% of the sample mean). All estimates are significant at 5%. In the baseline specification of Table 2, the first stage F is 19.3, above the Stock–Yogo threshold of 16.38 for a 10% maximal 2SLS size Stock and Yogo (2005). The IV estimate for total deaths (column (3)) is 3.7 times larger than the OLS, the latter of which is significant only at the 10% level.

Two key findings emerge from Table 2 and Table E3 in the Online Appendix. First, the IV effect is robustly large and significant: it ranges from an 8.9 to 23.0% increase in Boko Haram-related deaths relative to the sample mean, a large effect, but not implausibly so. Secondly, the IV results are between 2 and 3 times larger than OLS across the specifications. This divergence in OLS and IV estimates is unlikely to be driven by a weak instruments bias. In Online Appendix Table E3

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we observe substantial variation in the strength of the first-stage F-statistic (from 9.6 to 33.2) depending on the specification. However, the IV estimate does not appear to vary predictably with the strength of the instrument.

This discrepancy is more likely to be driven by omitted regional characteristics that bias the OLS estimates downward. The geographical distribution of polygamy in Figure A1 in the Appendix reveals that the polygamy rate is actually relatively low in Nigeria's north-east and high in other parts of the country. As the north-east is both poorer and more Muslim—in addition to many other differences—we might see a downward bias in the cross-sectional correlation. Online Appendix Figure E1 shows that areas with higher marriage inequality are in fact richer, less northern, and less Muslim, all factors that are likely to correlate negatively with Boko Haram activity. This selection pattern would also explain why, in Table E3 of the Online Appendix, the OLS estimate increases when we include controls and fixed effects in columns (2)–(5), relative to (1). It is also consistent with the fact that the OLS estimate falls to zero when we restrict to southern states, and rises to 0.49 when we restrict to northern states (see Online Appendix F.3).

The difference may also be driven by misreporting in the marriage data or differences between local and global and average treatment effects. If misreporting is noise and the IV estimate is the true parameter, then a random measurement error story requires a very low signal-to-noise ratio to explain a threefold difference. While there is evidence of misreporting of age (Lyons-Amos and Stones, 2017) and marital and reproductive activity (Neal and Hosegood, 2015) in DHS data, the magnitude seems implausible.[30] Still, OLS and IV estimates may diverge if there are heterogeneous treatment effects for the sub-population affected by the instrument (Angrist and Imbens, 1994; Angrist and Pischke, 2009). In our context, markets that have always been highly unequal may be less conflict-prone than those in which inequality is a state induced by transitory shocks. The subsample tests of Online Appendix Table F3 are suggestive of substantial heterogeneity: northern, rural, poor villages account for the average effects observed in Table 2.

In Online Appendix E.4, I formalise this discussion using a Bayesian estimation procedure developed by DiTraglia and Garcia-Jimeno (2021). This procedure allows the researcher to estimate whether pre-specified beliefs on the sign of endogeneity and the extent of measurement error are consistent with a valid instrument and a causal effect of a given size. I consider whether the beliefs expressed informally above—negative selection in OLS and modest measurement error in marriage inequality—are consistent with the effect size estimated in Table 2 and an exogenous instrument. The results—presented in Online Appendix Table E5 and Figure E2—generally support instrument validity and suggest that these beliefs are mutually compatible.

5.5. *Threats to Identification*

The exclusion restriction assumes that the interaction between the adolescent rainfall shock and polygamy only affects conflict through the marriage market. In this section, I address additional

[30] If survey respondents intuit that polygamy is perceived as socially undesirable by surveyors, they may under-report second or third wives, leading to an underestimate of marriage inequality in areas where it should be high, reducing the slope of the OLS relationship. Evidence suggests that populations may respond to surveyor identity in ways suggesting 'demand effects' (Cilliers *et al.*, 2015). Online Appendix Table E4 provides a test of this hypothesis by using the male unmarried rate—which will suffer less from such bias—as the endogenous variable. Here, the relative magnitudes of the OLS and IV estimate are similar to the main estimates.

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identification threats arising from endogeneity in either the adolescent rainfall shock or the polygamy dummy which might lead to a violation of the exclusion restriction.

5.5.1. *Endogeneity of shocks*

Current rainfall: The exclusion restriction is violated if adolescent shocks simply capture recent rainfall, which may directly affect conflict (Burke *et al.*, 2015; Von Uexkull *et al.*, 2016; Harari and Ferrara, 2018) differentially by polygamy status. This concern is only valid if adolescent shocks are constructed using rainfall around the time of the DHS survey. To rule this out, I calculate the individual-level difference between the most recent year of the adolescent rainfall shock and the survey year, and plot the distribution of the cluster-level mean differences. Figure A6(a) in Appendix A shows that the identifying variation occurs on average 13 years before the survey year and ranges from -22 to -7, so that substantial autocorrelation would be required for current rainfall to be driving the effect. As an additional robustness check, in Table A1, in Appendix A, I control directly for the current and one-period lagged rainfall deviation and their interaction with polygamy; the results hold.[31]

Persistence: Adolescent rainfall shocks in the past may have persistent income effects (Maccini and Yang, 2009), directly affecting conflict through non-marriage channels. To rule this out, I construct rainfall shocks over successive four-year windows that begin 8 years before birth until 17 years after birth. For each 'placebo' shock, I estimate the first stage and the reduced form regressions. If only adolescent shocks matter—rather than all shocks having similar persistent effects—then the coefficient of the true adolescent rainfall shock should be in the right tail of the distribution of estimates obtained from these placebo tests.[32] The time path of coefficients should also show an increase over time until the adolescent period. Figure A7 in Appendix A shows that these qualitative patterns emerge for both Boko Haram activity (panel (a)) and marriage inequality (panel (b)) outcomes.

Definition of shocks: Finally, in Online Appendix F.4 and F.5 I consider numerous additional permutations to the definition of adolescent rainfall shocks, including using state-level cohort weights, widening the age range to 18, consistent with Nigerian marriage laws, using the 4-year window before individual age of marriage, and excluding more recent cohorts. The results of these robustness tests are summarised in Figure F3; they generally do not affect the results.

5.5.2. *Endogeneity of polygamy*

Polygamy is more prevalent in areas with larger Muslim and Hausa population shares.[33] If, for example, good rainfall during adolescence leads to increased investment in girls' education, and this effect varies by religion or ethnicity, this could have direct effects on both marriage markets and conflict in ways that are unrelated to the explanations proposed here. Throughout the paper, I include the levels of these demographic variables in the main set of controls $\boldsymbol{x}_{jr}$. As an additional test, I re-estimate the reduced-form and first-stage equations with the interaction term $s_{jr} \times d_{jr}$, where d_{jr} is a given demographic population share in village j at DHS round r.

The results are presented in Table A2 in Appendix A, with the reduced form in Panel A, the 2SLS in Panel B, and the first stage in Panel C. All specifications include controls and ethnic

[31] While the 2SLS coefficient magnitudes are not greatly affected, greater noise reduces the significance of first stage enough to fail the Stock–Yogo 10% size test in some specifications. I therefore report weak-IV robust Anderson–Rubin p-values.

[32] However, it may not necessarily be the largest; similarly sized effects may be obtained by shocks around adolescence but in different windows, given that 12–16 was an arbitrary choice.

[33] This is true in both in bivariate and conditional correlations. Results available upon request.

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homeland fixed effects. Columns (1) re-prints the main results for reference. In column (2), including the interaction with Kanuri share has no effect on the first stage, reduced form, or 2SLS results. Column (4) adds the interaction with Muslim share, which weakens the reduced form and 2SLS moderately, though they still remain significant at 5%. Including the Hausa share in column (3) attenuates the first stage, reduced form, and 2SLS substantially. Still, all estimates remain significant at 5% when we consider the weak-IV robust AR p-value. Finally, in column (5) I include all of the demographic interaction terms simultaneously. The results are similar in magnitude to those of column (3), though the reduced form and 2SLS estimates are substantially noisier.

To further probe the role of religion in driving the results, in Online Appendix E.5 I split the sample at the Muslim-majority threshold and re-estimate the main results on subsamples. I find that while the first-stage effects are essentially identical in Muslim-majority and -minority villages, the conflict effects are entirely concentrated in Muslim-majority villages. This suggests that religion is a moderator rather than a confounder. In particular, the marriage market mechanisms underlying the first-stage relationship are universal. However, these marriage market stresses only generate conflict in areas where they can be readily exploited by an existing organised militant group, i.e., in Muslim-majority areas, given Boko Haram's Islamist origins.

5.5.3. *Additional robustness tests*

In the Online Appendix, I explore the robustness of results to covariate balance (Section E.1), tribe and state fixed effects (Section E.2), measures of marriage inequality (Section E.3), Bayesian IV diagnostics (Section E.4) and the marriage market size assumption (Section E.6). I further test robustness to different measures of polygamy (Section F.1), household data sources (Section F.2), sample restrictions (Section F.3), differential population structure effects (Section F.4), definitions of the adolescent rainfall shock (Section F.5), differential climate change effects (Section F.6), controls for land, labour, and agro-climatic characteristics (Section F.7), conflict data sources (Section F.8), male age of marriage effects (Section F.9), migration (Section F.10), demand-side effects (Section F.11), cohort-specific effects (Section F.12), methods of inference (Section F.13), windsorisation (Section F.16) and dynamic panel analysis (Section F.17). None of these tests materially affect the results.

Marriage market size: The empirical analysis defines marriage markets as DHS clusters. Of course, migration for marriage may lead to spatial market integration. To the extent that young men can search outside their home villages, shocks in a given village will propagate to neighbours, as men facing higher bride prices exit the village. These spillovers should moderate the local impact of supply shocks on bride prices, likely leading to an underestimate of the true reduced form and first-stage effects. In Online Appendix E.6, I show that female migration for marriage is indeed relatively common in our setting: roughly 30% of married women in the sample migrated for marriage. To eliminate any bias this may introduce, I replicate the results at higher levels of aggregation, using both (*i*) a k-means geographic distance-based clustering algorithm, and (*ii*) municipality-level marriage markets, which typically contain multiple villages. Neither of these aggregations materially affects the results. In addition, I show that the results hold when limiting the sample to markets with low rates of migration for marriage.

Specification curve: Figure A8 in Appendix A unifies 1,536 robustness tests in a specification curve. These specifications represent all possible combinations of three different endogenous

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variables,[34] four different shocks,[35] four definitions of cluster-level polygamy,[36] four different demographic control specifications,[37] with and without controls for current and lagged rainfall, and four different combinations of fixed effects.[38] All regressions include survey year dummies and the full set of cluster-level control variables, and normalise the endogenous variable and the instrument so that magnitudes are comparable. Figure A8(a) gives the reduced form, (b) the first-stage, and (c) the 2SLS results.[39]

The correct sign appears in 99.5% of the first-stage estimates, 96.3% of the reduced form estimates, and 95.8% of the 2SLS estimates. While some of the reduced form and 2SLS robustness estimates are not conventionally significant, the specification curves reveal that this is likely due to estimation noise, rather than the absence of a robust effect. Figure A9 in Appendix A plots histograms of these coefficients and their associated t-statistics, demonstrating that the baseline estimates are not outliers, and typically fall in the middle of the coefficient estimate distribution. In contrast, they fall closer to the right tail in the distribution of t-statistics. Therefore, the baseline estimates are broadly representative in size, but more precisely estimated than the robustness tests.

5.6. *Non-Boko Haram Violence and Territorial Control*

5.6.1. *Non-Islamist violence*

The pattern of non-Islamist violence in Nigeria provides an additional falsification test to support the proposed mechanism. Other armed groups, such as ethnic militias or criminal organisations, lack the organisation, scale, and control of territory required to exploit marriage market incentives. Organisation and scale are necessary to carry out raids to capture brides for recruits. Administrative control of territory facilitates the formalisation marriages so that fighters may live with captive brides in areas governed by the armed group. During the period of study, only Boko Haram satisfies these criteria. We should therefore expect only Boko Haram violence to respond to marriage market shocks. Table A3 in Appendix A shows that non-Boko Haram violence does not respond to the marriage market conditions induced by adolescent rainfall shocks and cultural institutions. Using either non-Boko Haram attacks in columns (1)–(3) or non-Boko Haram fatalities in columns (4)–(6), there is no significant effect of the interaction between rainfall during adolescence and polygamy. These null results are not sensitive to specification, and are precisely estimated relative to the main results.

5.6.2. *Territorial control*

Another implication of this argument is that while the effect of adolescent rainfall shocks on marriage markets should not depend on who governs, the effect on violence should be greatest in Boko Haram's territorial strongholds, where the group is able to credibly enforce marriage contracts. I test this hypothesis by augmenting the reduced-form and first-stage specifications with the triple-interaction term $p_{jr} \times s_{jr} \times dist_j$, where $dist_j$ indicates the distance in kilometres between cluster j and the border of Boko Haram territory at its largest extent, with $dist_j = 0$ indicating that the cluster falls within the territorial boundaries. The sample of clusters is small,

[34] Bride Gini, bride coefficient of variation, and male unmarried rate.

[35] Ages 12–16, ages 12–18, ages 12–16 with state-level cohort weights, and ages 12–16 excluding five most recent cohorts.

[36] Any polygamous man, more than 5% polygamy, the male polygamy rate, and the female polygamy rate.

[37] No demographics, and shocks interacted with Hausa, Muslim and Kanuri share.

[38] None, ethnicity, state, and both sets of fixed effects.

[39] I only display the 2SLS coefficients for the 1,119 specifications with a significant first stage.

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and therefore I am underpowered to detect interaction effects. Figure A10 in Appendix A plots the linear marginal effect of the instrument over the distance from Boko Haram territory for both the first-stage (panel (a)) and reduced form (panel (b)) regressions.[40] The effect of the instrument on marriage inequality does not vary substantially by distance to Boko Haram territory, and is positive in all but the furthest villages. In contrast, the effect of the instrument on conflict is substantially larger in or near Boko Haram territory and falls to zero thereafter. This suggests that while shocks generate similar marriage market effects everywhere in Nigeria, these incentives can only be exploited where insurgents have territorial control.[41]

6. Mechanisms

In this section, I provide evidence in support of several model predictions about the mechanisms driving the results of Section 5. I first show that the aggregate, market-level first-stage relationship is driven by changes in individual marriage choices: in response to positive adolescent shocks, women reduce their marriage hazard, marry later on average, and marry richer and more polygamous men. I then show that average marriage expenditures—a proxy for bride prices—rise significantly in polygamous communities in response to good adolescent rainfall shocks. Next, I provide several pieces of evidence supporting the recruitment mechanism. Finally, I show that adolescent rainfall shocks increase abductions in polygamous markets, since the supply of captured brides must expand to meet demand from new recruits.

6.1. *Individual-Level Marriage Results*

I test for an underlying supply response in the DHS female sample by regressing the reported age of first marriage on the average annual (standardised) deviation of rainfall from its long-run mean in the years when a woman is aged 12–16. I also consider child marriage as an outcome by regressing an indicator for marriage on the adolescent rainfall shock in the sample of women aged 18 or less. The estimating equation for woman i in grid-cell j in cohort c is

$$y_{ijc} = \alpha + \sigma s_{ijc} + \xi_j + \psi_c + \delta_r + \boldsymbol{x}'_{ijc}\boldsymbol{\beta} + u_{ijc}.$$

Where y_{ijc} is the marriage outcome of interest and the controls $\boldsymbol{x}_{ijc}$ include a quadratic polynomial in age, dummies for Muslim and Hausa, and current rainfall deviation. For the age of marriage analysis, I estimate this model using both OLS as well as a two-step Heckman (1979) selection estimator to account for selection into marriage.[42] Table 3 contains estimates for these individual-level specifications. Panel A presents results for OLS, while Panel B presents the selection models. In the individual-level data, the parameter of interest σ is identified by rainfall variation across locations for a given cohort, and rainfall variation across cohorts for a given location, allowing fixed effects for both rainfall grid ξ_j and cohort ψ_c.

The results of Table 3 show that the marriage response to economic shocks operates at the individual level. In the OLS specification of column (4), a 1 SD increase in average annual rainfall over the adolescent period above the long-run mean is associated with 0.584 years delayed marriage. This estimate is stable once we account for local heterogeneity, with state

[40] Both outcome variables are standardised to compare relative effect sizes.

[41] The corresponding estimates are in Table A4 in Appendix A.

[42] Selection variables are age, age-squared, years of education, year of birth, and indicators for rural, Muslim, Hausa, and Kanuri.

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Table 3. *The Effect of Rainfall During Adolescence on Marriage Supply.*

Outcome	Age of marriage				Child marriage			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: OLS								
Adolescent rainfall shock	1.049***	1.350***	0.628***	0.584***	−0.072**	−0.072**	−0.047	−0.044
	(0.113)	(0.144)	(0.078)	(0.079)	(0.029)	(0.030)	(0.030)	(0.033)
Mean dependent variable	17.779				0.211			
Observations	54,136	54,136	54,136	54,136	8,850	8,850	8,850	8,850
R^2	0.223	0.229	0.301	0.313	0.252	0.254	0.372	0.489
Panel B: Heckman selection								
Adolescent rainfall shock	1.333***	1.704***	0.977***	0.921***				
	(0.106)	(0.126)	(0.089)	(0.095)				
λ	3.204***	3.286***	2.058***	1.834***				
	(0.304)	(0.290)	(0.162)	(0.181)				
Observations	54,136	54,136	54,136	54,136				
R^2	0.243	0.250	0.309	0.319				
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DHS Round FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Grid-cell FE	No	No	No	Yes	No	No	No	Yes
State FE	No	No	Yes	No	No	No	Yes	No

Notes: Standard errors, in parentheses, are clustered at the grid-cell level. Outcome variable is either age of marriage, or a marriage indicator, indicated in the table header. Independent variable is average annual rainfall deviation in the years between age 12 and 16. Sample is a repeated cross-section of individual women between ages 15 and 49 for DHS rounds 2008 and 2013. Fixed effects are for DHS round, cohort, state, and/or grid-cell, as indicated. Controls are current rainfall deviation, a quadratic in age, and dummies for Muslim and Hausa. Age of marriage includes the entire sample of ever-married women. For child marriage, the sample includes only women below age 18. Panel A gives results for OLS, while Panel B gives results for the two-step Heckman estimator which predicts marriage with the selection variables age, age-squared, education level, year of birth, rural, Muslim, Hausa, and Kanuri. λ is the inverse Mills ratio. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

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(3) and grid-cell (4) fixed effects producing similar estimates.[43] Selection-corrected estimates in Panel B are substantially larger at 0.921, implying a downward bias induced by sample selection. The coefficient on λ, the inverse Mills ratio, is always positive and significant, rejecting the null of no selection. The result for child marriage in columns (5)–(8) are qualitatively similar, though not always significant.

In Figure A11 in Appendix A, I plot the placebo estimates of $\hat{\sigma}$ using pre-and-post adolescent shocks s^{τ}_{ijc}. The time path of coefficients (Panel B) is inconsistent with persistent spurious income effects. Rainfall shocks prior to birth and in the very early years of childhood have essentially no effect on the marriage decision, with estimated coefficients all near zero for $\tau < 4$. After age four, the importance of shocks increases dramatically as parents likely begin to consider marriage for their daughters. By $\tau = 7$, a 1 SD shock increases age of marriage by about 0.54 years, rising to a peak of 0.69 slightly before our chosen period, at $\tau = 10$.[44]

The age of marriage estimates in Table 3 understate the overall marriage market effects of shocks because they only capture the choices of women who eventually marry. What matters for aggregate supply is how rainfall shocks affect the likelihood of marriage for the average woman. To obtain these magnitudes, I estimate the annual hazard into marriage as a function of rainfall, as in Corno *et al.* (2020). I form an individual-level panel which contains for a woman i in calendar year t the annual rainfall in grid j, her age a, cohort c, and marital status dummy m. Each woman is retained in the data from age 10 until she exits the sample via marriage or until age 45. To test the effect of above-average rainfall on the hazard rate into marriage over the life cycle, I estimate the following regression

$$m_{i,j,a,c,t} = \alpha + \eta_0 s_{j,c} + \sum_{k=11}^{45} s_{j,a,c}\eta_k 1(a_{i,t} = k) + \zeta_a + \gamma_j + \delta_c + \mu_{i,j,a,c,t}.$$

The specification allows the effect of rainfall shocks $s_{j,a,c}$ to vary with age in order to estimate life cycle marriage effects.[45] The regression also contains fixed effects for location, cohort and age. I estimate the model separately by polygamy status to test the prediction that the probability of marriage falls as income rises, and that these effects are more pronounced in polygamous areas. Furthermore, as argued throughout the paper, these effects should be largest in the adolescent period when parents form bride price expectations and make marriage market choices.

Figure 6 plots the effect of recent rainfall shocks on cumulative marriage hazard at each age, defined as the sum of the η_k coefficients (Aalen, 1978), for monogamous (panel (a)) and polygamous (panel (b)) areas, relative to the effect at age 10. The vertical line indicates age 16, the putative age of entry into the marriage market. In polygamous areas, good rainfall reduces the likelihood of marriage substantially. As expected, rainfall matters most during adolescence—the effect emerges just before age 16 and grows throughout the early years of marriage market participation, flattening after age 25.[46] In monogamous areas, the cumulative hazard effect is not statistically different from zero at any age. Quantitatively, a 1 SD increase in rainfall in a

[43] The estimate is nearly doubled in size when we omit geographic fixed effects entirely in (1) and (2), suggesting that geographic heterogeneity biases the coefficient upwards. This seems reasonable if locations more likely to experience positive rainfall shocks are different, but the timing of those rainfall shocks across cohorts within a location is random.

[44] This suggests I could improve the power of the first stage by shifting the adolescent rainfall shock period by two years. However, I use a pre-specified, arbitrary threshold taken from prior literature to allay concerns about p-hacking.

[45] I define the shocks $s_{j,a,c}$ as average rainfall deviations at age a and the four preceding years.

[46] Given that these coefficients plot the cumulative hazard, this implies that annual hazard reductions in response to rainfall after age 25 approach zero.

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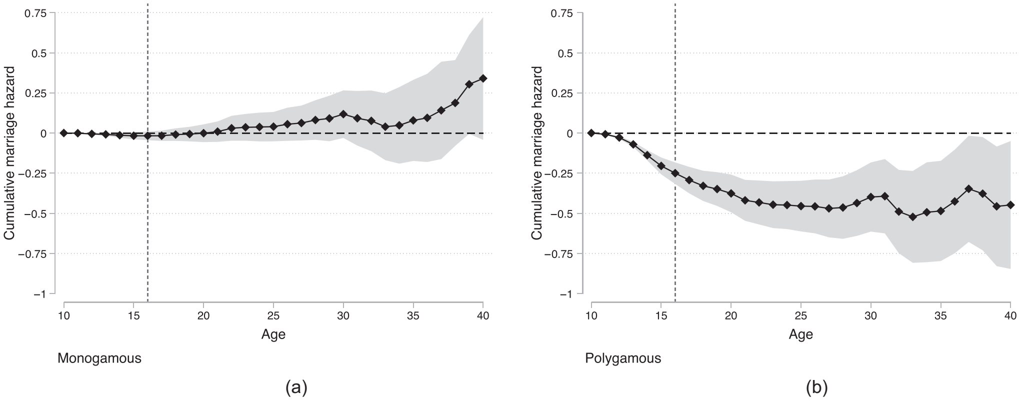

Fig. 6. *Rainfall Shocks and Cumulative Marriage Hazard by Age and Polygamy. The figure shows cumulative coefficients from an individual-level hazard regression of a marriage exit dummy on the mean annual rainfall deviation in the four years prior, interacted with age dummies, controlling for grid-cell and cohort fixed effects in a sample of women aged 10–45. Confidence bands of 95% are calculated using standard errors clustered at the grid-cell level. Subsamples are indicated in subfigure notes. Vertical line indicates age 16.*

polygamous village leads to a 0.37-event reduction in the cumulative marriage hazard by age 20, or a 29.9% decline relative to the cumulative hazard in polygamous communities. In probabilities, this corresponds to a 10.7 percentage points reduction in the probability that a woman is married by age 20.[47]

6.2. *Match Quality*

Increasing marriage concentration implies that in times of plenty, women should match with richer men who can afford rising bride prices, and who are also more likely to be polygamous.[48] This prediction is not entirely obvious; an alternative hypothesis holds that if women incur disutility from older polygamous spouses, a better bargaining position might reduce the selection into polygamous households, reducing marriage market concentration.[49]

To test this, I use the individual-level cross-sectional specification of Subsection 6.1, regressing husband type on the rainfall deviation during adolescence, individual-level controls, and cohort and grid-cell fixed effects. I measure husband type using the husband's wealth index as the dependent variable.[50] In order to test whether women select into polygamous marriages as a result of the shock, I use an indicator for whether the husband was already married at the time of marriage as the dependent variable. For the wealth index outcome, I split the sample into the polygamous and monogamous clusters.

The results of Table 4 confirm that women who experience good adolescent shocks marry richer men, driving market-level inequality. Columns (1)–(4) estimate spouse wealth, while columns

[47] For a more detailed explanation of interpreting the magnitudes of the hazard estimates, see Online Appendix D.3.
[48] This follows from the fact that richer men have a greater propensity towards polygamy, see in Online Appendix Table D1.
[49] The extension to the model in Online Appendix D.2 formally models this hypothesis.
[50] Strictly speaking, the variable available in the DHS data is post-marital household wealth. However, the results hold in the sample of households where women do not work, ruling out that effects are driven by the female contribution to household wealth. These are available upon request.

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Table 4. *Husband Type and Rainfall during Adolescence by Polygamy.*

Outcome	Husband's wealth				Polygamous	
Cluster type	Polygamous		Monogamous		Full sample	
	(1)	(2)	(3)	(4)	(5)	(6)
Adolescent rainfall shock	0.083***	0.039***	0.005	−0.000	0.012*	0.017**
	(0.025)	(0.014)	(0.039)	(0.019)	(0.006)	(0.007)
Mean dependent variable	2.132		3.140		0.233	
Observations	37,333	37,333	13,560	13,560	50,893	50,893
R^2	0.350	0.504	0.370	0.531	0.042	0.058
Controls	Yes	Yes	Yes	Yes	Yes	Yes
DHS Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
Grid-cell FE	No	Yes	No	Yes	No	Yes
State FE	Yes	No	Yes	No	Yes	No

Notes: Standard errors, in parentheses, are clustered at the grid-cell level. Outcome variable is either household wealth after marriage or an indicator for a polygamous husband at the time of marriage. Sample is all married women ages 15–49. Adolescent rainfall shock is the mean annual rainfall deviation from the long-run average between the ages of 12 and 16. Controls are current rainfall deviation, a quadratic in age, and dummies for Muslim and Hausa. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

(5)–(8) estimate the likelihood of matching with a polygamous husband. Women who experienced a 1 SD positive rainfall deviation have a husband roughly 0.04–0.08 points richer on the 5-point wealth scale, both significant (columns 1–2). The effect vanishes in monogamous areas, consistent with the results throughout this paper that have shown negligible inequality effects of the shock in these villages. In the full sample, women who experience a 1SD adolescent shock are 1.2–1.7 percentage points more likely to marry into a polygamous household, a 7.3% increase on the mean.

6.3. *Marriage Expenditures*

To test whether adolescent rainfall shocks affect bride prices, I use data on marriage ceremony expenditures from Nigeria's General Household Survey (GHS) (Nigeria National Bureau of Statistics, 2010; 2013; 2016), a nationally representative panel with three waves from 2010 to 2015.[51] These expenditures are only observed for households that have contributed to some marriage in the 12 months prior to the survey, and are likely to capture bride prices only imperfectly.[52] Unless the measurement error induced by including non-price marriage expenditures is systematically correlated with the variation of interest, it should not bias the results.

I test whether wedding payments increase in positive adolescent income shocks by regressing the log of the amount paid at the household level on the cluster-level mean adolescent rainfall shock (constructed identically as in the DHS data), year and state indicators, and controls. I estimate this model on the polygamous and monogamous subsamples, using the same criteria to define the presence of a polygamy norm as throughout the paper. All specifications pool all available observations of marriage spending across all three panel waves, use combined sample weights and cluster standard errors at the grid level.

The results are given in Table 5, revealing substantial differences by polygamy status. A 1 SD positive adolescent rainfall shock increases marriage expenditures by 125–248% under polygamy

[51] This survey is described in Online Appendix B.

[52] Still, in the Nigerian context, self-reported marriage costs are likely to be a reasonable proxy for bride prices, since bride wealth is typically transferred by the groom around the time of marriage.

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Table 5. *The Effect of Adolescent Rainfall Shocks on Marriage Expenditures.*

Sample	Full			Polygamous			Monogamous		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Adolescent rainfall shock	0.710*	0.657**	0.345	0.985**	0.812**	1.247***	0.525	0.347	0.282
	(0.401)	(0.322)	(0.300)	(0.411)	(0.393)	(0.454)	(0.572)	(0.546)	(0.453)
Observations	1,562	1,562	1,562	1,032	1,032	1,032	530	530	530
R^2	0.016	0.079	0.234	0.030	0.104	0.284	0.007	0.065	0.324
Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
State FE	No	No	Yes	No	No	Yes	No	No	Yes

Notes: Standard errors, in parentheses, are clustered at the grid-cell level. The outcome variable is the log of marriage expenditures at the household level. The independent variable is mean adolescent rainfall shock in the GHS cluster, calculated using first wave (2010) data. Sample is every household incurring a wedding expenditure marriage expenditure across all three GHS waves (2010, 2013, 2015). All models include survey year dummies. Controls are lagged rainfall deviation, population density in 2005, annual mean temperature in the survey year, average age of men and women, distance to national borders, and share Muslim. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

(columns 4–6), but generates no significant effect in monogamous villages, thought the point estimates remain positive and sizeable.[53] Figure A12 in Appendix A confirms that rainfall shocks in the sample of polygamous villages experienced between 8 years before birth and roughly 8 years after birth are uncorrelated with present marriage expenditures, while those experienced after this period have increasing positive effects.[54]

6.4. *Recruitment Mechanism*

The model predicts that insurgent recruitment responds to adolescent rainfall shocks in polygamous markets. As recruitment is unobservable, the analysis uses data on attacks and fatalities to test the model predictions. However, violence may not be a good proxy for recruitment. In this section, I present several pieces of evidence to support the recruitment mechanism.

Increases in recruitment may be reflected in increased sympathy for extremist groups. To test this, I use a 2015 public opinion survey of 2,400 Nigerian respondents (BenYishay *et al.*, 2017) to measure the extent to which individuals express sympathy for extremist groups.[55] Figure 7 plots the correlation between adolescent rainfall shocks and extremist sympathy among different demographic groups. In the non-Muslim sample there is no relationship between the rainfall shocks and sympathy, while in the Muslim sample the relationship is weakly positive. However, when we restrict to Muslim men under the age of 35, Boko Haram's prime recruitment target, the relationship becomes positive and significant. In Online Appendix Table D3, columns (7)–(8), I estimate that moving from the 25th to the 75th percentile of the adolescent rainfall shock distribution is associated with a significant 5.1 percentage point increase in sympathy for extremism among young Muslim men, or 14% of the group mean.

[53] Interacting the polygamy dummy with all of the variables in the model reveals that the differential effect implied by columns (6) and (9) is large, at 0.97, but noisily estimated and insignificant with a standard error of 0.65.

[54] To reduce estimation noise, I omit all controls except 2010 rainfall deviation and mean female age. Similar patterns are obtained when I include the full set of controls and state fixed effects, although the confidence bands are wider.

[55] To measure extremist sympathy, I code answers to the question: 'what is the main reason why some people in Nigeria support and assist armed extremist groups?' Answers coded as expressing sympathy are that people support extremist groups out of a sense of injustice, because of their religious beliefs, out of coercion, or because of poor government performance. Unsympathetic responses are that individuals support extremist groups because of corruption, a desire for personal enrichment, or to gain personal power. Further details are in Online Appendix B.

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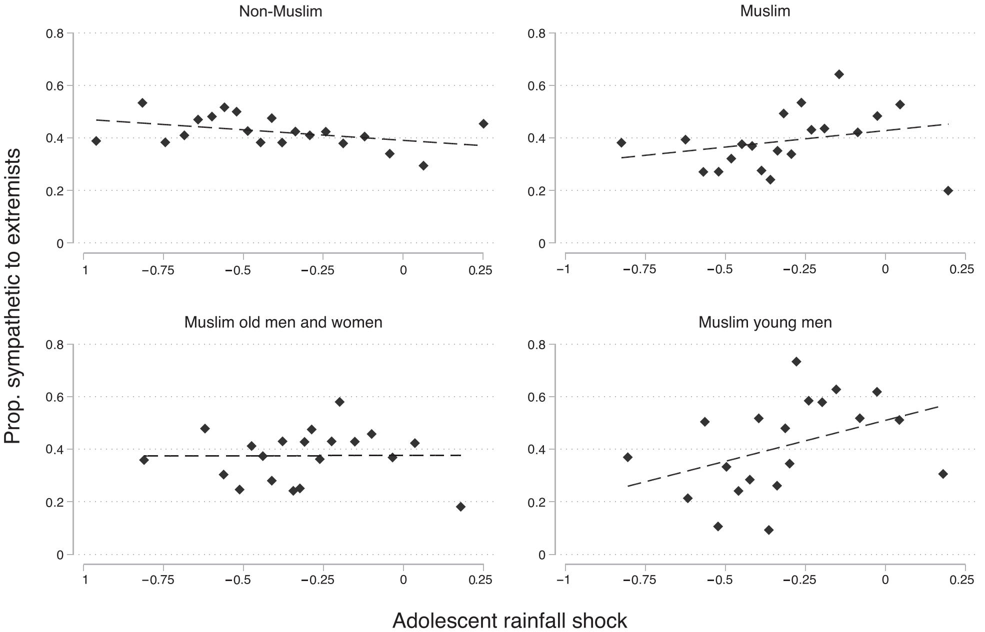

Fig. 7. *Adolescent Rainfall Shocks and Sympathy for Extremism. The figure shows binned conditional correlations between the share of respondents expressing sympathy for Islamist extremists and the adolescent rainfall shock. Subsample is indicated in subfigure header. All specifications include controls for current and lagged rainfall deviations and cohort fixed effects.*

Young men are both the primary recruitment targets of Boko Haram (Onuoha, 2014; Cold-Ravnkilde and Plambech, 2015) and the group predicted by the model to be most negatively affected by female income shocks in polygamous markets. As such, we should expect that marriage market adjustments are concentrated primarily among young men. If instead these aggregate effects are driven by older men unlikely to join Boko Haram, then the recruitment mechanism is less plausible. In Figure A13 in Appendix A, I estimate the first-stage effects by male age. Panels (a) and (b) plots rainfall shock effects by polygamy status for the under-30 unmarried rate, while panels (c) and (d) plots for the over-30 unmarried rate.

The aggregate marriage market effects are driven entirely by younger men: while the under-30 effects exhibit the same pattern as the overall market (Figure 5), over-30 marriage rates do not respond to adolescent rainfall shocks.[56] This pattern is consistent with the model prediction that poorer young men bear the brunt of marriage market adjustments. Furthermore, Figure A14 in Appendix A demonstrates that only under-30 unmarriage rates are positively correlated with Boko Haram conflict. Taken together, the results demonstrate that young men—the demographic most at risk of Boko Haram recruitment—are both (*i*) more likely to exit the market in response to shocks and (*ii*) the group whose marriage performance is most correlated with conflict.

Several additional pieces of evidence support the recruitment mechanism. First, Boko Haram presence on the extensive margin may be a better proxy for recruitment than conflict intensity

[56] The corresponding estimates can be found in Table A5 Panel B, which confirms that the under-30 effects are large, significant, and robust to fixed effects, while the over-30 effects are typically small and insignificant.

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as measured by deaths. Table 2 column (1) demonstrates that the results remain strong when I use the binary outcome. Second, in Online Appendix F.14 I show that Boko Haram violence is concentrated in and around Boko Haram's core territories, suggesting that—consistent with numerous qualitative reports—the group does indeed recruit and carry out attacks in the same communities. In Online Appendix F.15, I show that the results are robust to dropping militant events—suicide attacks, bombings and remote violence—that are likely to be committed in areas distant from Boko Haram's core recruitment areas. Lastly, as mentioned in Subsection 5.5.2, Online Appendix E.5 shows that the while the marriage market effects of shocks are universal, the conflict effects are concentrated only in the Muslim-majority communities vulnerable to Boko Haram recruitment.

6.5. *Abductions and Violence Against Women*

When marriage market conditions worsen in polygamous regions as a result of positive premarital economic shocks for women, men join Boko Haram. To meet growing demand in this non-civilian marriage market, Boko Haram must procure more brides. In addition to attention-grabbing mass abductions, the group also conducts frequent abductions of both women and men on a smaller scale. Abductions are one way in which Boko Haram obtains brides for its troops.[57] Empirically, we should observe an increase in abductions in response to adolescent rainfall shocks in polygamous markets. We should also observe an increase in violence against women, who are likely to be disproportionately targeted by rising violence.

In total, abductions occur in 3% of the DHS clusters, while violence against women occurs in 3.6%, a relatively small proportion of the overall data.[58] There may be concern that rising abductions might violate the exclusion restriction, since this directly affects the supply of brides in the civilian sector. I do not have the cluster-level data on the number of marriage-age women abducted required to rule this out. However, the extreme rarity of abduction events suggests that this effect is small enough to be safely ignored.

Table 6 provides the results. Columns (1)–(3) use an abductions dummy as the outcome variable, while (4)–(6) use a violence against women dummy. The results are consistent with the hypothesis that adolescent rainfall shocks increase (differentially by polygamy) these particular types of violence. The results on abductions are positive and significant in all specifications, while those on violence against women are also positive but not always significant.

Insurgents may not necessarily abduct brides only in the polygamous villages affected by shocks; there may be spillovers to neighbouring villages as rebels broaden their search. However, given the clear costs of moving kidnapping victims across geographies, these spillovers should decline in distance.[59] I estimate geographic spillovers by drawing concentric rings around each cluster and measuring kidnapping probability in these rings. Figure A15 in Appendix A plots coefficients from regressions of these outcome variables on the instrument and controls. The results demonstrates significant spillover effects that are localised within 15 kilometres of the

[57] However, as Matfess (2017) makes clear, the abduction narrative is overly simplistic. Women also willingly join the group, though the frequency is unknown.

[58] For reference, any Boko Haram attack occurs in 22.1% of the DHS clusters. There is a legitimate concern that these abductions may not refer to the abductions of women. However, if we restrict the sample further to consider only events that contain the kidnapping strings and a reference to women, such events occur in less than 1% of the clusters. This sample is too small to be useful for analysis, so I consider separately the full sample of abductions and the full sample of attacks against women.

[59] Long distance travel outside of core areas of control increases the likelihood of detection by authorities.

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Table 6. *Adolescent Rainfall Shocks, Abductions, and Violence Against Women.*

Outcome	Abductions			Violence against women		
	(1)	(2)	(3)	(4)	(5)	(6)
Adolescent rainfall shock × polygamous	0.068***	0.109***	0.068***	0.028	0.093***	0.022
	(0.022)	(0.033)	(0.022)	(0.023)	(0.033)	(0.022)
Mean dependent variable	0.030			0.036		
Observations	1,771	1,771	1,771	1,771	1,771	1,771
R^2	0.217	0.261	0.316	0.325	0.356	0.446
Controls	Yes	Yes	Yes	Yes	Yes	Yes
DHS Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Tribe FE	No	Yes	Yes	No	Yes	Yes
State FE	Yes	No	Yes	Yes	No	Yes

Notes: Standard errors, in parentheses, are clustered at the grid-cell level. Outcome variable is an indicator variable if the cluster experienced any Boko Haram abduction or attack against women. Adolescent rainfall shock is the mean annual rainfall deviation from the long-run average among women between the ages of 12 and 16. Controls are slope, standardised rainfall deviation in the survey year, lagged rainfall deviation, population density in 2005, the wealth index Gini, distance to national borders, average age of men and women, share Muslim, and share Hausa. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

cluster and decline in distance, consistent with increasing kidnapping costs as insurgents widen the area of their search.

7. Conclusion

It is well known that societies can be destabilised when a large mass of young men are excluded from marriage. This paper provides new evidence that traditional marriage practices can exacerbate marriage market tightness, highlighting a novel economic rationale underlying the extreme gender-based violence of insurgent groups like Boko Haram. When young women experience good income realisations in the years before they enter the marriage market, their families raise their standards over the types of men they are willing to marry. This is manifested in lower annual marriage hazard rates, increased age of marriage, higher average bride prices, and selection into richer and more polygamous households. Critically, this effect is amplified by the existence of a polygamy norm. Where polygamy is widely practised, women have the option to draw from a pool of richer, older, already-married men. The existence of this option increases the bride price families must be offered, and also their sensitivity to changes in their outside option.

These choices affect marriage markets with severe social consequences. Young men in polygamous markets where women have good outside options face a choice: enter the high-priced civilian marriage market with a low expectation of success, or turn to insurgents who offer the promise of marriage and income. This leads to greater recruitment into insurgent ranks and more overall violence. Consistent with this, polygamous villages where the average woman experienced good rainfall in her adolescence have lower marriage rates, higher marriage inequality, and more Boko Haram violence. Young Muslim men in these villages express greater sympathy for extremism. Insurgent groups respond strategically; as unmarried men become more plentiful, abductions and violence against women increase to satisfy demand.

Standard theory and existing evidence suggests that improved economic conditions increase the opportunity costs of violence. These findings ignore the role of marriage market imbalances in promoting violence. Once this mechanism is accounted for, good economic conditions—even those experienced long ago—may actually exacerbate violence depending on the prevailing marriage norms. The northern Nigerian case is not exceptional. Many traditional, patriarchal

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societies are structurally similar, exhibiting polygamy, bride price, large age differentials at marriage, marriage market inequality, religious extremism, and a high prevalence of violence against women. Therefore, the results should be seen as generalisable for societies with similar cultural traits and marriage market conditions. The results highlight for the first time the marriage market as a critical mechanism linking economic shocks to violence, and complicate—though ultimately support—the standard opportunity cost paradigm that has dominated the empirical study of conflict.

Appendix A. Supporting Empirical Results

A.1. *Appendix Figures*

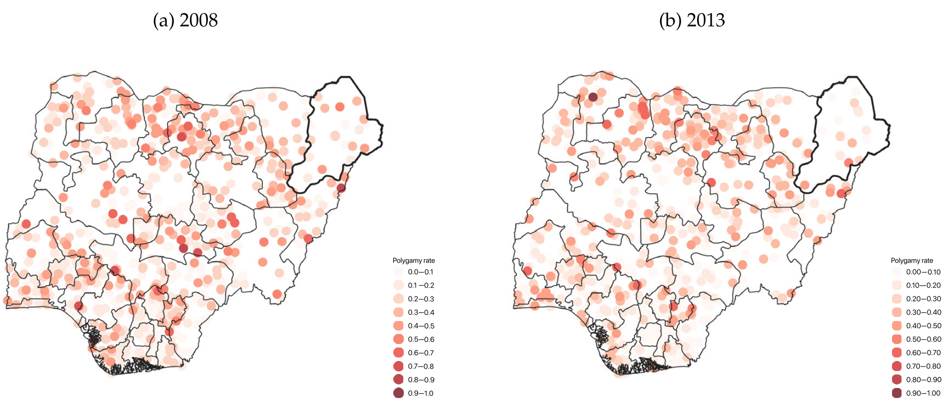

Fig. A1. *Polygamy Rate. The figure shows the geographic distribution of the cluster-level polygamy rate among men for DHS rounds 2008 and 2013. The boundaries of Borno State are highlighted in bold.*

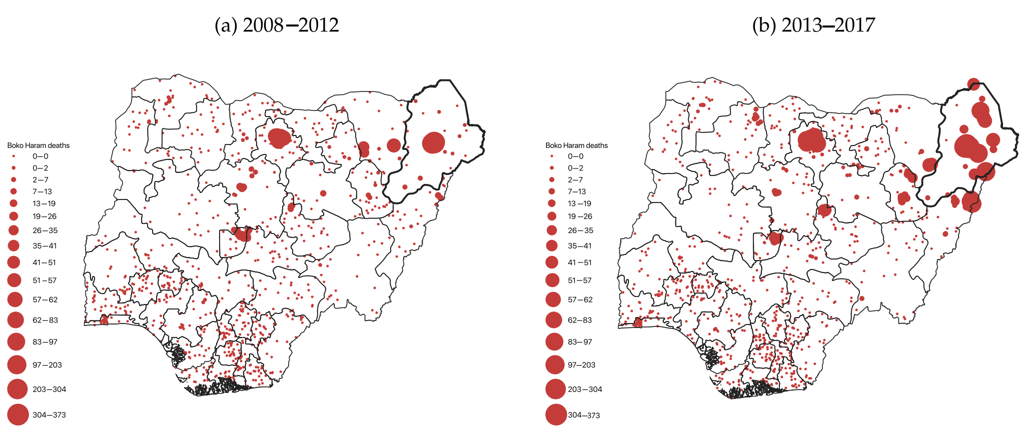

Fig. A2. *Boko Haram Deaths. The figure shows the geographic distribution of the cluster-level average annual Boko Haram-related fatalities over the periods 2008–12 and 2013–17, corresponding to DHS rounds 2008 and 2013. The boundaries of Borno State are highlighted in bold.*

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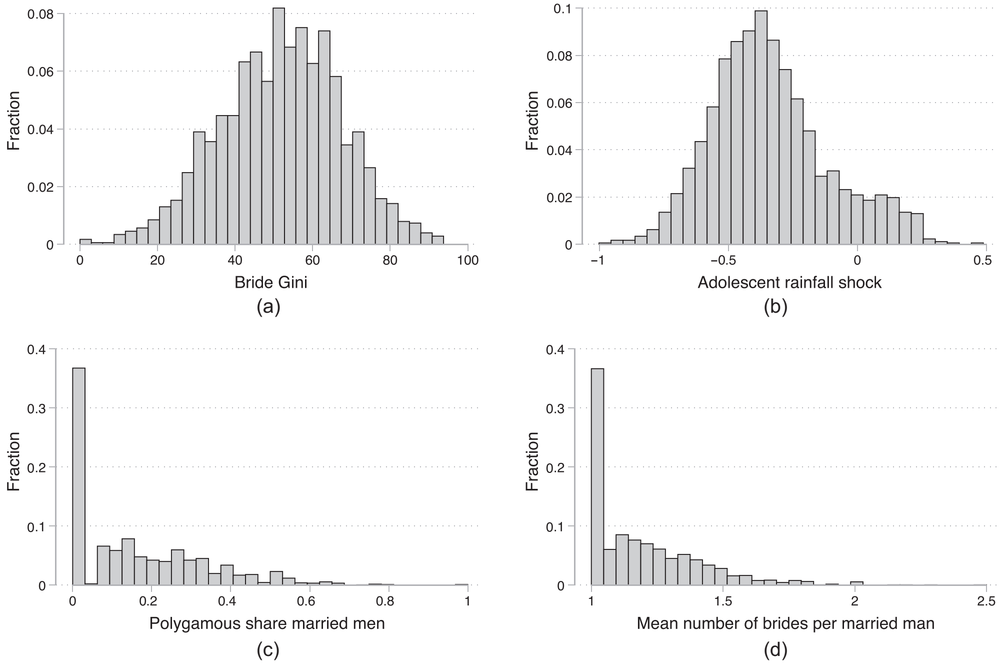

Fig. A3. *Distributions of Key Cluster-Level Variables. Figure plots the frequency distribution of the cluster-level bride Gini (a), mean adolescent rainfall shock (b), share of married men in polygamous households (c), and mean number of brides per married man (d).*

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Fig. A4. *Distributions of Marriage Inequality by Polygamy. The figure plots the probability distribution of the village-level Gini coefficient of brides for monogamous and polygamous villages.*

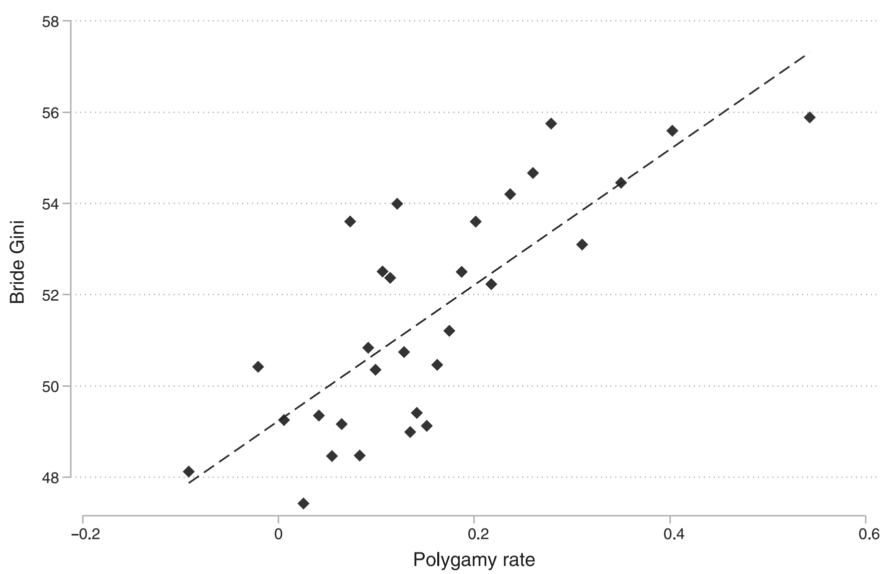

Fig. A5. *OLS Correlation Between Bride Gini and Polygamy. The figure shows the partial correlation between the bride Gini and the polygamy rate among men. Scatterplots are binned using 30 quantiles of the polygamy rate. Panel A controls for DHS round and ethnic homeland fixed effects, slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa and share Muslim.*

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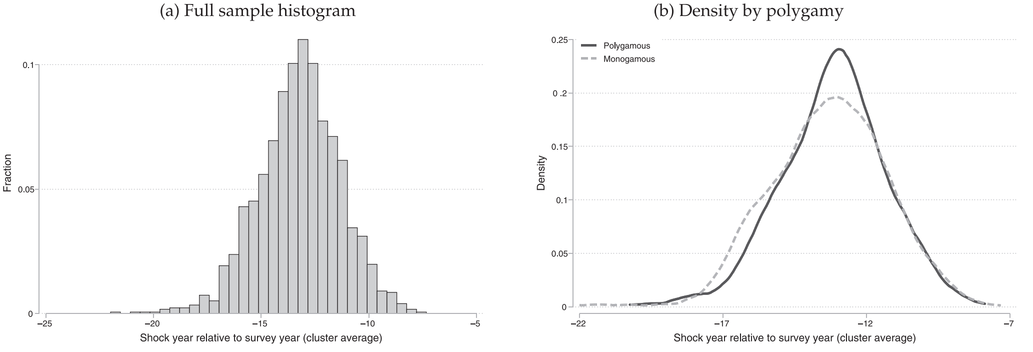

Fig. A6. *Distribution of Shock-Years Relative to Survey Year. The figure shows the distribution of cluster-level differences between the final year of the shock and the survey year. For each woman I calculate this difference based on the calendar year at age 16, and then calculate the cluster-level average of these differences. Panel (a) presents the histogram of these cluster-level differences, while panel (b) plots the probability distribution by cluster-level polygamy status.*

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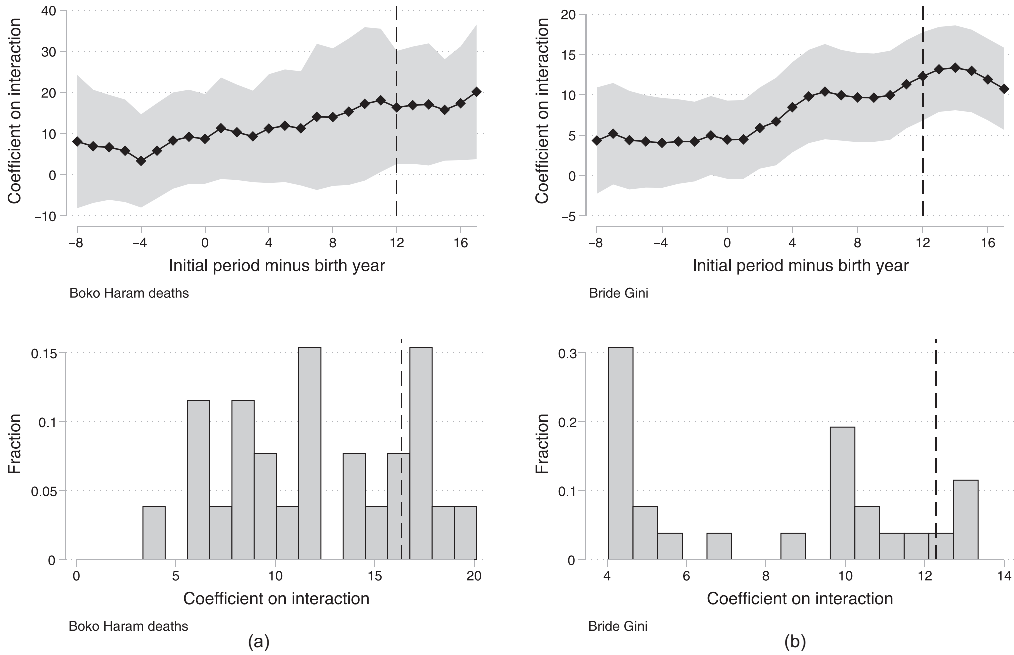

Fig. A7. *Placebo Tests: Marriage Inequality and Boko Haram Violence. The figure plots the coefficients from cluster-level regressions of Boko Haram fatalities (a) or the bride Gini (b) on rainfall shocks* s^{τ}_{jr}*, where* τ *refers to the first year, relative to the year of birth, of a four-year window over which the shock is calculated. Coefficients on the interaction between* s^{τ}_{jr} *and* p_{jr} *are plotted for each* τ*. Top panels present the distribution of these coefficients, while bottom panels plot their time path, with a vertical line at age 16. All regressions include DHS round fixed effects, ethnic homeland fixed effects, and controls for slope, current and lagged rainfall shock, population density in 2005, the wealth index Gini, distance to national borders, average age of women, share Muslim, and share Hausa. 95% confidence intervals use standard errors clustered at the grid-cell level.*

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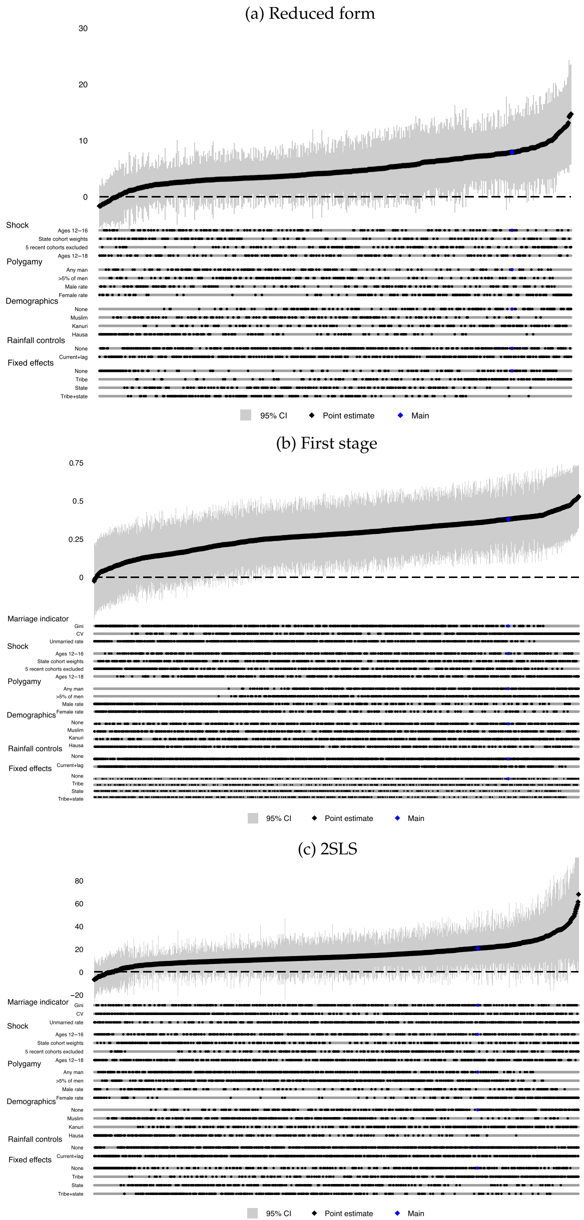

Fig. A8. *Specification Curves. The figure plots specification curves for reduced form (a), first-stage (b), and 2SLS (c) regressions. Specifications represent all possible combinations of three marriage variables (bride Gini, bride coefficient of variation, and male unmarried rate), four shocks (ages 12–16, ages 12–18, ages 12–16 with state-level cohort weights, and ages 12–16 excluding the five most recent cohorts), four definitions of cluster-level polygamy (any polygamous man, more than 5% polygamy, the male polygamy rate, and the female polygamy rate), four different demographic control specifications (no demographics, and shocks interacted with Hausa, Muslim, or Kanuri share) with and without controls for current and lagged rainfall, and four different combinations of fixed effects. Specification combination is indicated below each plot. All regressions include DHS round indicators and the set of cluster-level control variables used throughout. Marriage and polygamy variables are standardised for comparability.*

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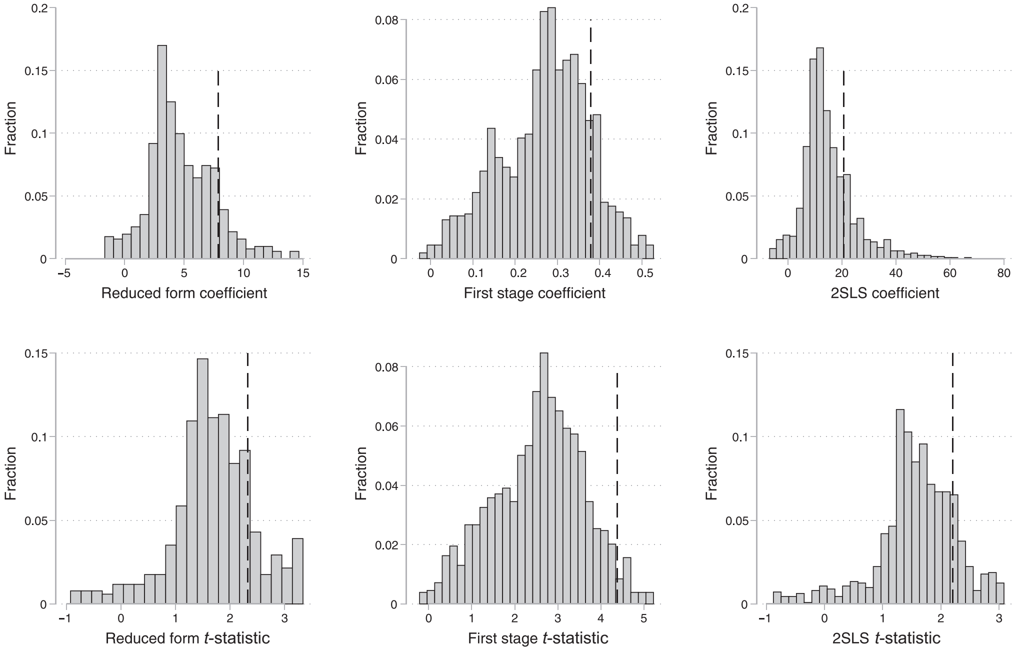

Fig. A9. *Distribution of Specification Statistics. The figure plots the distributions of t-statistics and estimated coefficients for the specification curves in Figure A8. Dashed vertical lines indicate the baseline estimate.*

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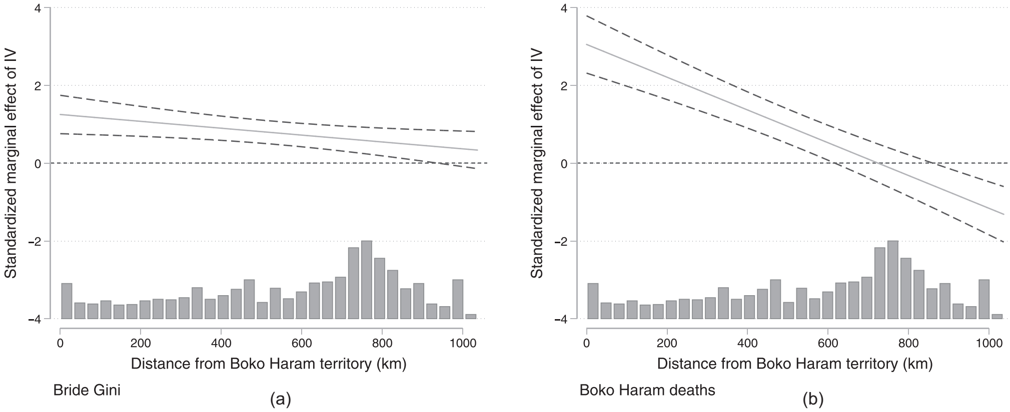

Fig. A10. *Marginal Effects by Distance to Boko Haram Territory. The figure plots the linear marginal effect of the instrument on the bride Gini in panel (a) and Boko Haram fatalities in panel (b) by distance from Boko Haram territory. Outcome variables are standardised for comparability. Histograms show the distribution of the distance, in kilometres, between the cluster and the border of the greatest extent of Boko Haram territory between 2013 and 2015, equal to zero if the cluster falls within this territory. All regressions include DHS round fixed effects and cluster-level controls for slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa and share Muslim.*

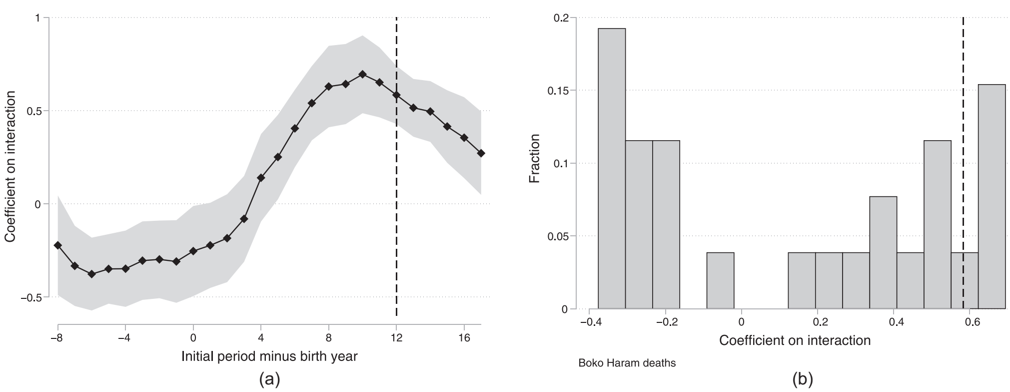

Fig. A11. *Placebo Test of Pre- and Post-Adolescent Rainfall Shocks. The figure plots the coefficients from individual-level regressions of age of marriage on adolescent rainfall shocks s_{ijc}^{τ} where τ refers to the first year, relative to the year of birth, of a four-year window over which the shock is calculated. All regressions include DHS round fixed effects, grid-cell fixed effects, and controls for current rainfall deviation, a quadratic in age, village slope, and indicators for Muslim and Hausa. Panel (b) presents the distribution of these coefficients, while Panel (a) plots their time path, with a vertical line at age 16. 95% confidence intervals are constructed using standard errors clustered at the grid-cell level.*

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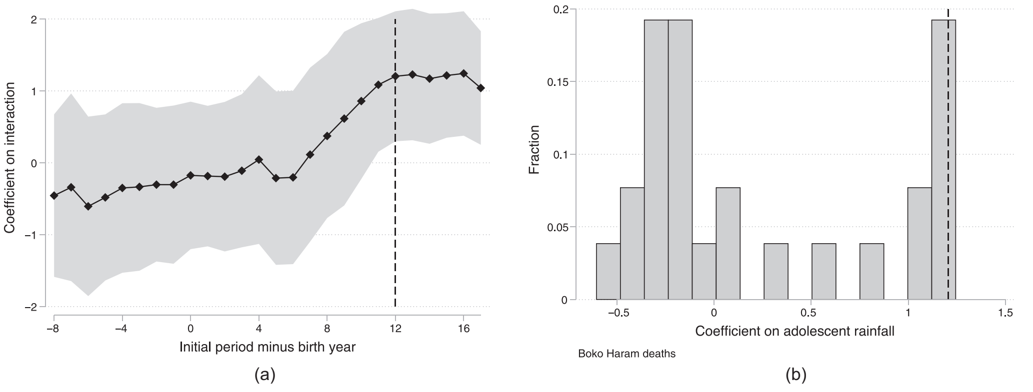

Fig. A12. *Placebo Test for Marriage Expenditures. The figure plots the histogram in panel (b) and time path in panel (a) of coefficients from regressions of log marriage expenditures on village-level mean adolescent rainfall shocks* $s^{\tau}_{j,r}$ *where* τ *refers to the first year, relative to the year of birth, of a four-year window over which the shock is calculated. All regressions control for current rainfall and average female age and are estimated on the subsample of polygamous villages. 95% confidence intervals are constructed using standard errors clustered at the grid-cell level.*

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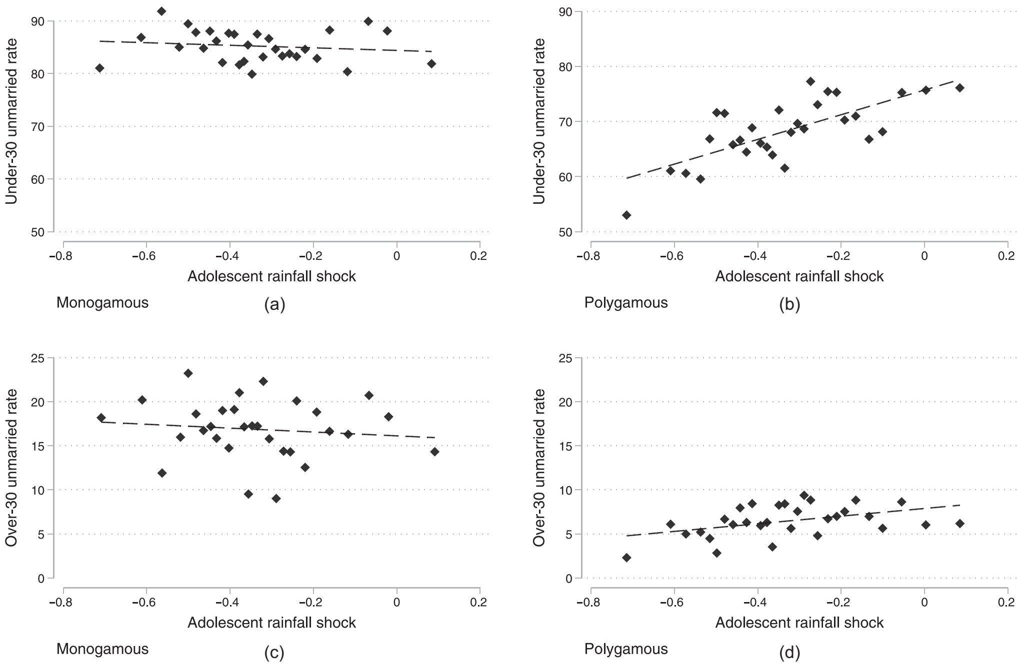

Fig. A13. *Male Unmarried Rate and Adolescent Rainfall Shocks by Polygamy and Age. The figure plots the binned partial correlation between male unmarried rates for under-30 (top) or over-30 (bottom) men and the adolescent rainfall shock, by cluster-level polygamy status. All regressions include DHS round fixed effects and controls for slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa and share Muslim.*

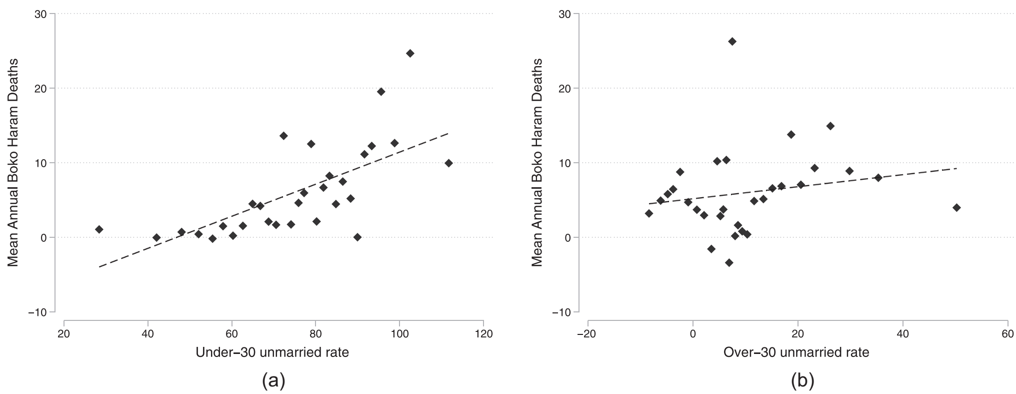

Fig. A14. *OLS Correlation between Boko Haram Violence and Male Unmarried Rate by Age. The figure plots the binned partial correlation between Boko Haram fatalities and male unmarried rates for under-30 (a) and over-30 (b) men. All regressions include DHS round fixed effects and controls for slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa and share Muslim.*

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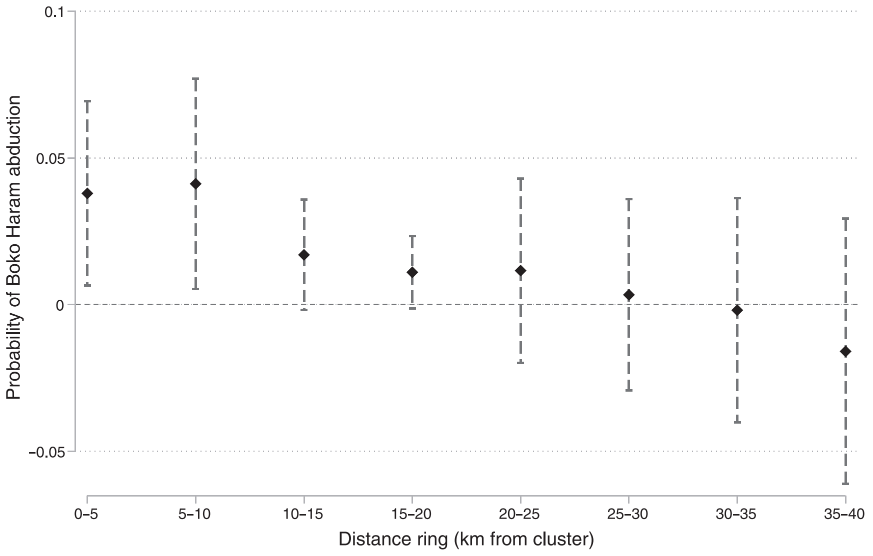

Fig. A15. *Abduction Spillovers by Distance. Figure plots the coefficient from cluster-level reduced form spillover regressions, estimated separately for outcome variables measuring the probability of Boko Haram kidnapping within concentric rings around the cluster coordinates. Ring sizes are 5 km intervals, as indicated in the x-axis. All regressions include DHS round fixed effects and cluster-level controls for slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa, and share Muslim.*

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A.2. *Appendix Tables*

Table A1. *Robustness to Current and Lagged Rainfall.*

Dependent variable	Boko Haram deaths							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Reduced form								
Adolescent rainfall shock × polygamous	16.341**	7.682	7.964**	7.220*	15.631***	14.661**	6.241*	6.804
	(7.006)	(5.611)	(3.464)	(4.111)	(4.678)	(6.109)	(3.177)	(4.839)
Current rainfall deviation × polygamous		5.999*		−0.488		0.046		0.053
		(3.248)		(2.429)		(1.995)		(2.178)
Lagged rainfall deviation × polygamous		2.504		1.226		0.923		−0.626
		(2.293)		(2.998)		(3.812)		(3.786)
R^2	0.081	0.083	0.374	0.374	0.407	0.407	0.464	0.464
Panel B: Two-stage least squares								
Bride Gini	1.331**	0.735	0.835**	0.819	1.380***	1.359**	0.649*	0.744
	(0.605)	(0.562)	(0.406)	(0.533)	(0.481)	(0.659)	(0.349)	(0.552)
Dependent variable	Bride Gini							
Panel C: First stage								
Adolescent rainfall shock × polygamous	12.281***	10.448***	9.533***	8.816***	11.330***	10.785***	9.619***	9.142***
	(2.792)	(2.971)	(2.881)	(3.186)	(3.008)	(3.450)	(3.101)	(3.509)
Current rainfall deviation × polygamous		2.620*		2.085		1.926		1.991
		(1.442)		(1.414)		(1.583)		(1.518)
Lagged rainfall deviation × polygamous		−0.833		−1.354		−1.411		−1.539
		(1.669)		(1.713)		(1.810)		(1.843)
R^2	0.499	0.500	0.527	0.528	0.546	0.546	0.559	0.560
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DHS Round FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	No	No	Yes	Yes	No	No	Yes	Yes
Tribe FE	No	No	No	No	Yes	Yes	Yes	Yes
Kleibergen–Paap F-statistic	19.349	12.369	10.947	7.657	14.185	9.775	9.625	6.789
Anderson–Rubin p-value	0.020	0.172	0.022	0.080	0.001	0.017	0.050	0.161
Observations	1,771	1,771	1,771	1,771	1,771	1,771	1,771	1,771

Notes: Standard errors in parentheses are clustered at the grid-cell level. In Panels A and B, the outcome variable is the average annual number of Boko Haram fatalities within 20 km of the DHS cluster. In Panel C, outcome variable is the Gini coefficient of wives in the cluster. Current rainfall is the standardised deviation of rainfall from its long-run average in the survey year and subsequent 4 years. Lagged rainfall is the standardised deviation of rainfall from its long-run average in the four years prior to the survey year. Controls are slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa, and share Muslim. Sample size refers to all panels. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

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Table A2. *Robustness to Ethnicity and Religion.*

Dependent variable	Boko Haram deaths				
	(1)	(2)	(3)	(4)	(5)
Panel A: Reduced form					
Adolescent rainfall shock × polygamous	15.086***	14.998***	6.327**	9.801**	6.728*
	(4.750)	(4.729)	(2.872)	(4.179)	(3.427)
Adolescent rainfall shock × Kanuri		0.271			0.456
		(1.136)			(1.145)
Adolescent rainfall shock × Hausa			0.684***		0.729***
			(0.192)		(0.229)
Adolescent rainfall shock × Muslim				0.265**	−0.056
				(0.112)	(0.105)
Observations	1,771	1,771	1,771	1,771	1,771
R^2	0.446	0.446	0.456	0.449	0.457
Panel B: Two-stage least squares					
Bride Gini	1.331***	1.306***	0.720*	0.931**	0.709*
	(0.473)	(0.462)	(0.368)	(0.425)	(0.385)
Adolescent rainfall shock × Kanuri		0.854			0.718
		(1.052)			(1.086)
Adolescent rainfall shock × Hausa			0.541***		0.568***
			(0.185)		(0.201)
Adolescent rainfall shock × Muslim				0.227**	−0.023
				(0.104)	(0.093)
Dependent variable	Bride Gini				
Adolescent rainfall shock × polygamous	11.337***	11.481***	8.787***	10.527***	9.492***
	(3.009)	(3.003)	(3.121)	(3.293)	(3.263)
Adolescent rainfall shock × Kanuri		−0.446**			−0.370*
		(0.226)			(0.224)
Adolescent rainfall shock × Hausa			0.199***		0.228***
			(0.053)		(0.061)
Adolescent rainfall shock × Muslim				0.041	−0.048
				(0.046)	(0.050)
Observations	1,771	1,771	1,771	1,771	1,771
R^2	0.546	0.547	0.550	0.546	0.551
Controls	Yes	Yes	Yes	Yes	Yes
DHS Round FE	Yes	Yes	Yes	Yes	Yes
Tribe FE	Yes	Yes	Yes	Yes	Yes
Kleibergen–Paap F-statistic	14.192	14.621	7.928	10.218	8.463
Anderson–Rubin p-value	0.002	0.002	0.028	0.020	0.051
Observations	1,771	1,771	1,771	1,771	1,771

Notes: Standard errors in parentheses are clustered at the grid-cell level. Outcome variable is given in the panel header. Adolescent rainfall shock is the cluster-level mean of individual annual rainfall deviations from the long-run average between the ages of 12 and 16. Demographic variables are the cluster share of Kanuri, Muslim and Hausa groups, respectively, measured from 0 to 100. Controls are slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa, share Muslim and share Kanuri. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

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Table A3. *The Effect of Marriage Inequality on Violence: Non-Boko Haram Violence.*

Dependent variable	Attacks			Fatalities		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: OLS						
Bride Gini	0.031*	0.017	0.017	0.077	0.061	0.037
	(0.017)	(0.016)	(0.016)	(0.137)	(0.121)	(0.128)
R^2	0.398	0.520	0.550	0.045	0.244	0.297
Panel B: Reduced form						
Adolescent rainfall shock × polygamous	−0.969	−1.256	−1.263	0.144	1.592	0.922
	(4.240)	(3.936)	(4.393)	(7.638)	(5.456)	(5.803)
R^2	0.404	0.523	0.552	0.050	0.243	0.298
Panel C: Two-stage least squares						
Bride Gini	−0.079	−0.132	−0.131	0.012	0.167	0.096
	(0.347)	(0.417)	(0.445)	(0.618)	(0.552)	(0.569)
Dependent variable		Bride Gini				
Panel D: First stage						
Adolescent rainfall shock × polygamous	12.281***	9.533***	9.619***	12.281***	9.533***	9.619***
	(2.792)	(2.881)	(3.101)	(2.792)	(2.881)	(3.101)
R^2	0.499	0.527	0.559	0.499	0.527	0.559
Kleibergen–Paap F-statistic	19.349	10.947	9.625	19.349	10.947	9.625
Observations	1,771	1,771	1,771	1,771	1,771	1,771
Controls	Yes	Yes	Yes	Yes	Yes	Yes
DHS Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Tribe FE	No	No	Yes	No	No	Yes
State FE	No	Yes	Yes	No	Yes	Yes

Notes: Standard errors in parentheses are clustered at the grid-cell level. In Panels A, B and C, outcome variable is the average annual number of non-Boko Haram attacks (columns 1–3) or fatalities (columns 4–6) within 20 km of the DHS cluster. In Panel D, outcome variable is the Gini coefficient of wives in the cluster. All regressions include DHS round fixed effects controls for slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa, and share Muslim. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

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Table A4. *The Effect of Adolescent Rainfall Shocks by Exposure to Boko Haram Control.*

	(1)	(2)	(3)	(4)
Panel A: Boko Haram deaths				
Adolescent rainfall shock × polygamous	3.128***	3.067*	2.570	2.167
	(1.172)	(1.567)	(2.294)	(2.326)
Adolescent rainfall shock × polygamous × Distance to Boko Haram territory (km)	−0.004***	−0.004**	−0.003	−0.003
	(0.002)	(0.002)	(0.003)	(0.003)
Full-sample effect	0.324	0.575	0.380	0.219
Panel B: Bride Gini				
Adolescent rainfall shock × polygamous	2.619***	1.128	2.409***	2.398***
	(0.930)	(0.774)	(0.831)	(0.840)
Adolescent rainfall shock × polygamous × Distance to Boko Haram territory (km)	−0.002*	−0.001	−0.003**	−0.003**
	(0.001)	(0.001)	(0.001)	(0.001)
Full-sample effect	1.161	0.786	0.630	0.616
Controls	No	Yes	Yes	Yes
DHS Round FE	Yes	Yes	Yes	Yes
Tribe FE	No	No	Yes	Yes
State FE	No	No	No	Yes
Observations	1,771	1,771	1,771	1,771
R^2	0.076	0.503	0.549	0.562

Notes: Standard errors in parentheses are clustered at the grid level. Outcome variable is either the bride Gini or Boko Haram-related fatalities, as indicated, both standardised for comparability. Adolescent rainfall shock is the cluster-level mean of individual annual rainfall deviations from the long-run average between the ages of 12 and 16. Distance to Boko Haram is measured as the kilometres of distance between the cluster and the border of the greatest extent of Boko Haram territory between 2013 and 2015, equal to zero if the cluster falls within this territory. Controls are slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa and share Muslim. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

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Table A5. *The Effect of Adolescent Rainfall Shocks by Male Age.*

Male age group	Under 30				Over 30			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: OLS								
Share unmarried under-30 men	0.215*	0.185*	0.198**	0.165*				
	(0.128)	(0.095)	(0.093)	(0.094)				
Share unmarried over-30 men					0.081	0.077*	0.079	0.073
					(0.056)	(0.040)	(0.051)	(0.048)
R^2	0.092	0.383	0.411	0.471	0.079	0.374	0.401	0.464
Panel B: First stage								
Adolescent rainfall shock × polygamous	18.375***	13.691**	15.894***	11.897**	6.458	5.540	8.138*	6.870
	(5.042)	(5.802)	(5.444)	(6.039)	(3.949)	(4.222)	(4.293)	(4.399)
R^2	0.347	0.385	0.415	0.437	0.204	0.242	0.265	0.283
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DHS Round FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	No	Yes	No	Yes	No	Yes	No	Yes
Tribe FE	No	No	Yes	Yes	No	No	Yes	Yes

Notes: Standard errors in parentheses are clustered at the grid level. Outcome variable is the average annual number of Boko Haram fatalities within 20 km of the DHS cluster (Panel A) or the unmarried rate of the age group indicated in Panel B. Adolescent rainfall shock is the cluster-level mean of individual annual rainfall deviations from the long-run average between the ages of 12 and 16. Controls are slope, current and lagged rainfall deviation, population density in 2005, average monthly temperature in the survey year, the wealth index Gini, average age of men and women, distance to national borders, share Hausa and share Muslim. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

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