Pricing Conflict Risk

Evidence from Sovereign Bonds

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Motivation

Armed conflict is economically costly

- Losses of 2-6% GDP annually (Cerra and Saxena, 2008; Collier, 1999)
- Destroys physical capital capital and stifles investment (Blair et al., 2022)
- Upends global markets (Chesney et al., 2011; Ksoll et al., 2022)
- Conflict is a first-order risk in sovereign bond markets.
- But conflict is inherently hard to predict, lots of uncertainty.

Q: Do bond markets misprice conflict? What determines market responses to violence?

1. Incomplete information: fog of war
2. Wrong beliefs (Gennaioli and Shleifer, 2018; Reinhart and Rogoff, 2009)
   - Biased prior about conflict risk, e.g. availability bias (Schraeder, 2016)
   - Biased expectation about conflict cost, e.g. overoptimism in WW1 (Ahamed, 2009)

A common sentiment: wars seem to always catch investors flat-footed.

Do price swings after violence imply the market doesn't accurately price conflict risk? (Chadefaux, 2017)

Not necessarily: We show swings are consistent with efficient markets and empirically reasonable prior beliefs.

Our insight: must specify *model of investor beliefs* to estimate magnitude of mispricing

Literature primarily comprises case studies, does not systematically investigate mispricing.

Arin et al. (2008), Castañeda and Vargas (2012), Chaney (2008), and Guidolin and La Ferrara (2007)

The Russo-Ukrainian War

Figure: Ukraine sovereign USD index

This paper

We tackle two related questions:

Q1: Does the market misprice conflict on average?

- Estimate event-studies with daily sovereign price data + armed conflicts from 2004-2020
- Bond prices fall by up to 1.2% *only* after *state-involved* conflicts.

- Build bond pricing model calibrated with empirical moments to predict efficient responses.
- Bond markets learn rapidly, internalize at most 74% of conflict shocks.

Q2: How do investors form beliefs about conflict?

- Heterogeneous event-studies show larger effects where conflict is . . .
  Surprising, severe, proximate to the capital, and center-seeking.

- Het. fx + model imply accurate pricing of available conflict information.
- Market responses to ex-ante vs. ex-post information consistent with Bayesian learning.

Data

Conflict data

- We obtain conflict data from UCDP event-level dataset.
- Identify onset date and initially observable characteristics of conflict.

Bond data

- We collect financial data from Cbonds, a global bond-trading platform.
- Daily bond trading prices and loan characteristics for 2347 foreign currency bonds for 122 countries from 2003-2022.

Country and macro data

- We take country macro fundamentals, institutions, risk ratings, and global bond/equity indices from WB WDI/WGI, IMF, ICRG, and FRED.

News media data

- We scrape full text of all news articles containing names of conflict actors from LexisNexis

Final sample after merging:

- 262 conflicts, 1731 bonds (667 T, 1064 C), 120 countries (44 T, 76 C)

Stacked event-study estimation

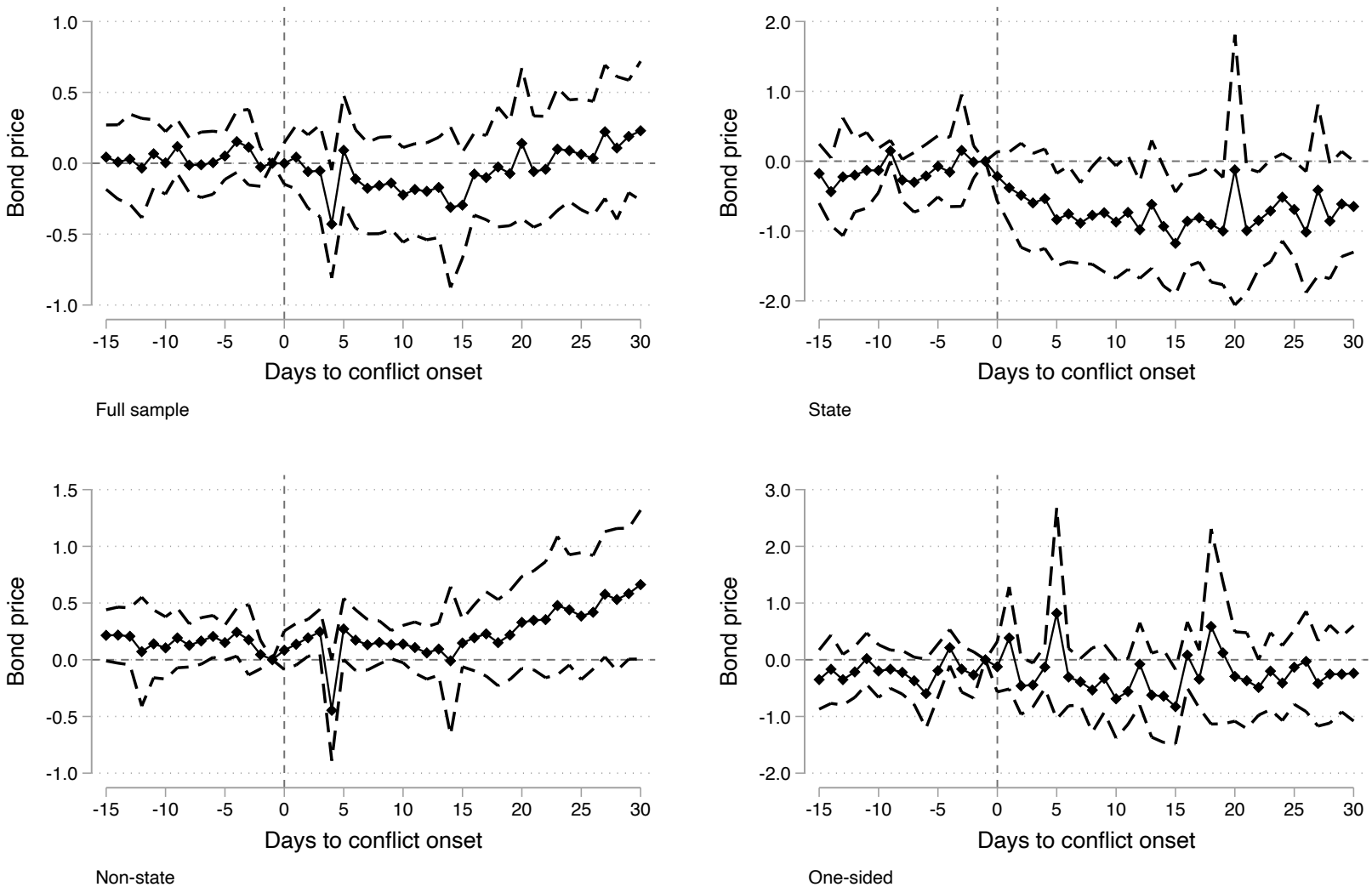
Stack bond-day data event-wise (Baker et al., 2021; Dube et al., 2022). Then estimate for bond b at calendar day t issued by country c in conflict event e, for $t \in [k_e - 30, k_e + 30]$:

$$y_{btce} = \alpha + \sum_{k \neq -1} \tau_k \mathit{Treat}_{ce} \times 1(k = t - k_e) + \delta_{be} + \delta_{te} + \xi' X_b \times \gamma_{te} + \upsilon_{btce}$$

- k_e: event date
- y: bond price (or current yield)
- Treat_{ce}: indicator if c is affected country in event e
- δ_{be}, δ_{te}: bond-by-event and day-by-event effects.
- X_b: time-invariant bond-level characteristics
- SEs clustered at country-level
- Only never-treated controls included in each stack (Callaway and Sant'Anna, 2021).

Reduced-form results

Figure: Event-study: conflict groups



Estimates

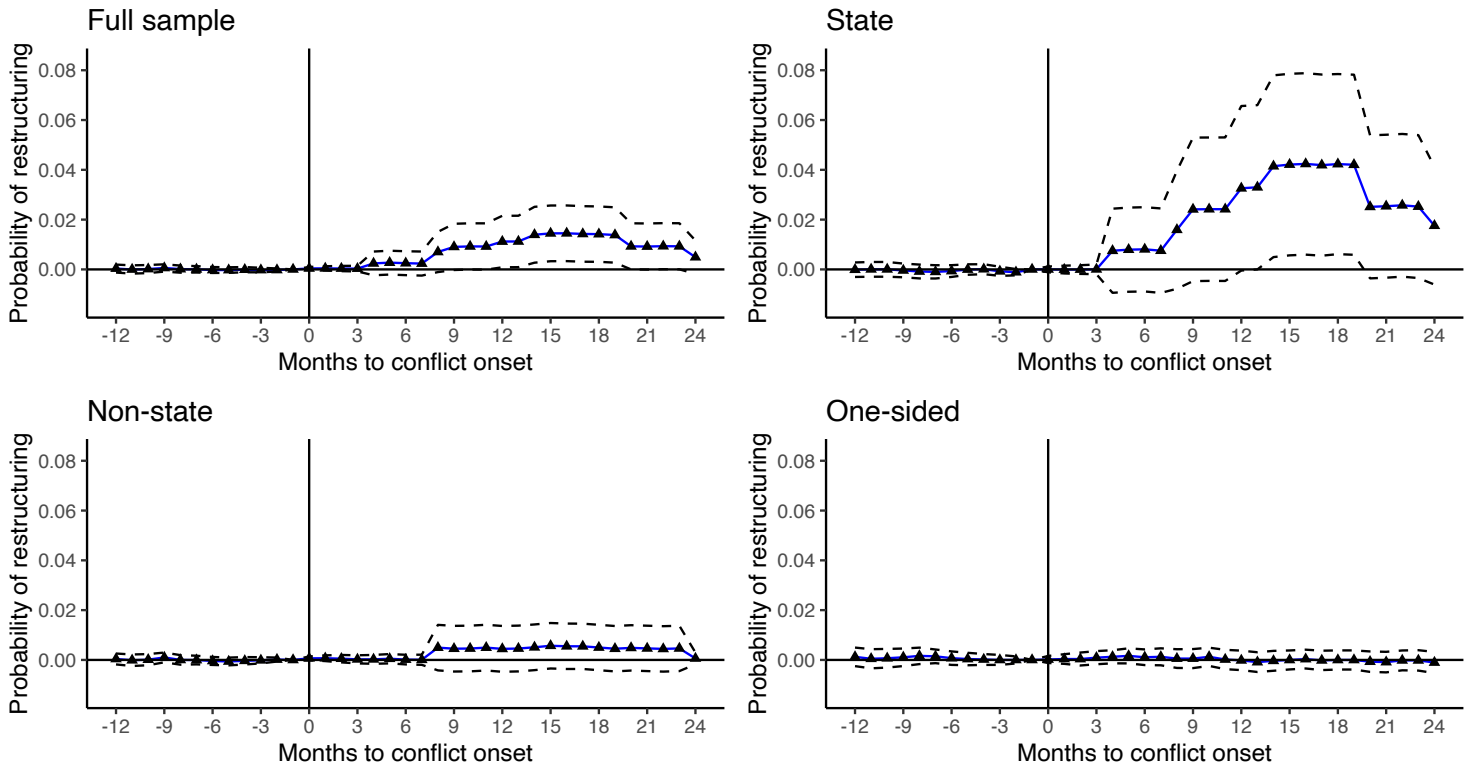
Mechanisms

- Bond market responds *only* to state conflict.
- This is rational, as state-involved conflicts uniquely costly for sovereign.

- We find differential increases in:
  - Default/restructuring risk Default event-study
  - Military spending Expenditure estimates
  - Inflation Inflation estimates

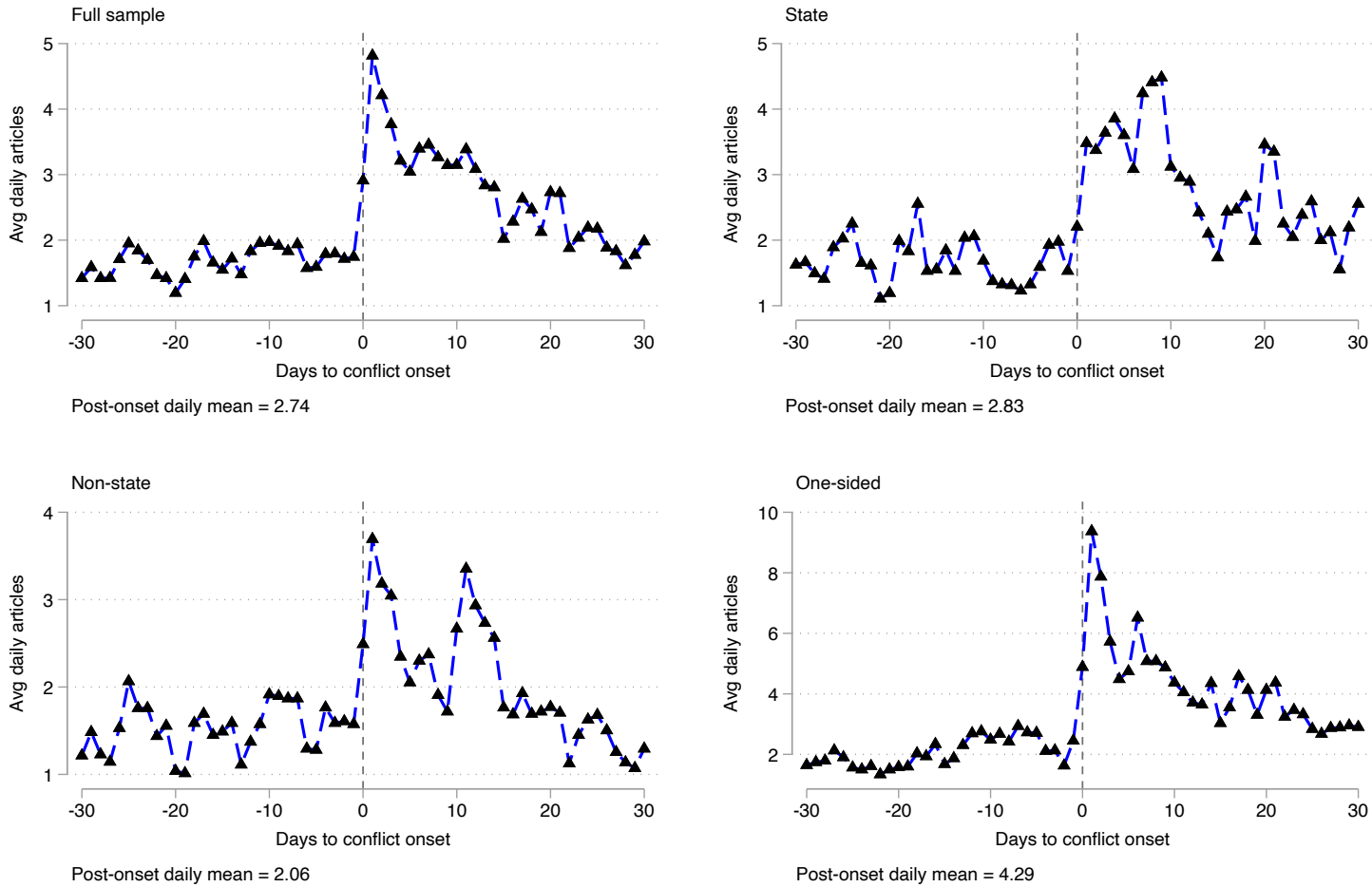
- Robustness tests rule out wide variety of confounders. Robustness tests
- Fx not driven by differential severity (fatalities). Fatalities
- Fx not driven by differential media coverage.

Figure: Event-study: restructurings



Are investors learning?

Figure: News coverage dynamics



A simple quantitative framework

Questions:

1. How do we reconcile large economic fx of conflict with small bond market response? Does market under-react?
2. What does the effect size say about investor beliefs?

- We build and calibrate a simple risk-neutral bond pricing model.
- 3 parameters that govern investor response, which may be biased:

  ζ_0: prior on conflict risk
  ζ_0: update after conflict news
  γ: annual expected cost of conflict

- Use data to simulate full-info, unbiased, efficient response, compare to empirical estimate.
- Result: Investors price in at most $\sim 75\%$ of the shock.

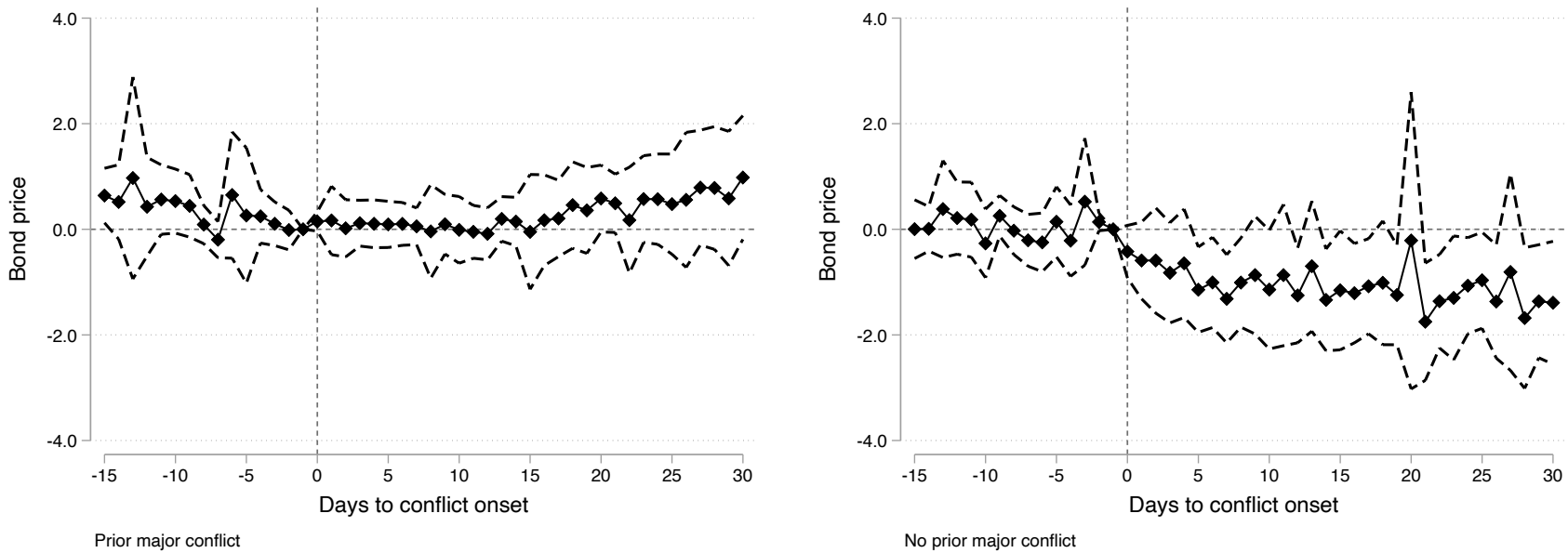
  $\rightarrow$ 24% underestimate of true γ (0.044 vs. 0.058).
- Rapid learning in days after conflict

Model

Conflict history

How do investors form prior beliefs about ζ_0?

Figure: Event-study: conflict history



Beliefs up-weight more recent, severe conflicts. Conflict history estimates

Investor beliefs about cost heterogeneity

How do investors form beliefs about γ?

Table: Heterogeneous effects by conflict cost

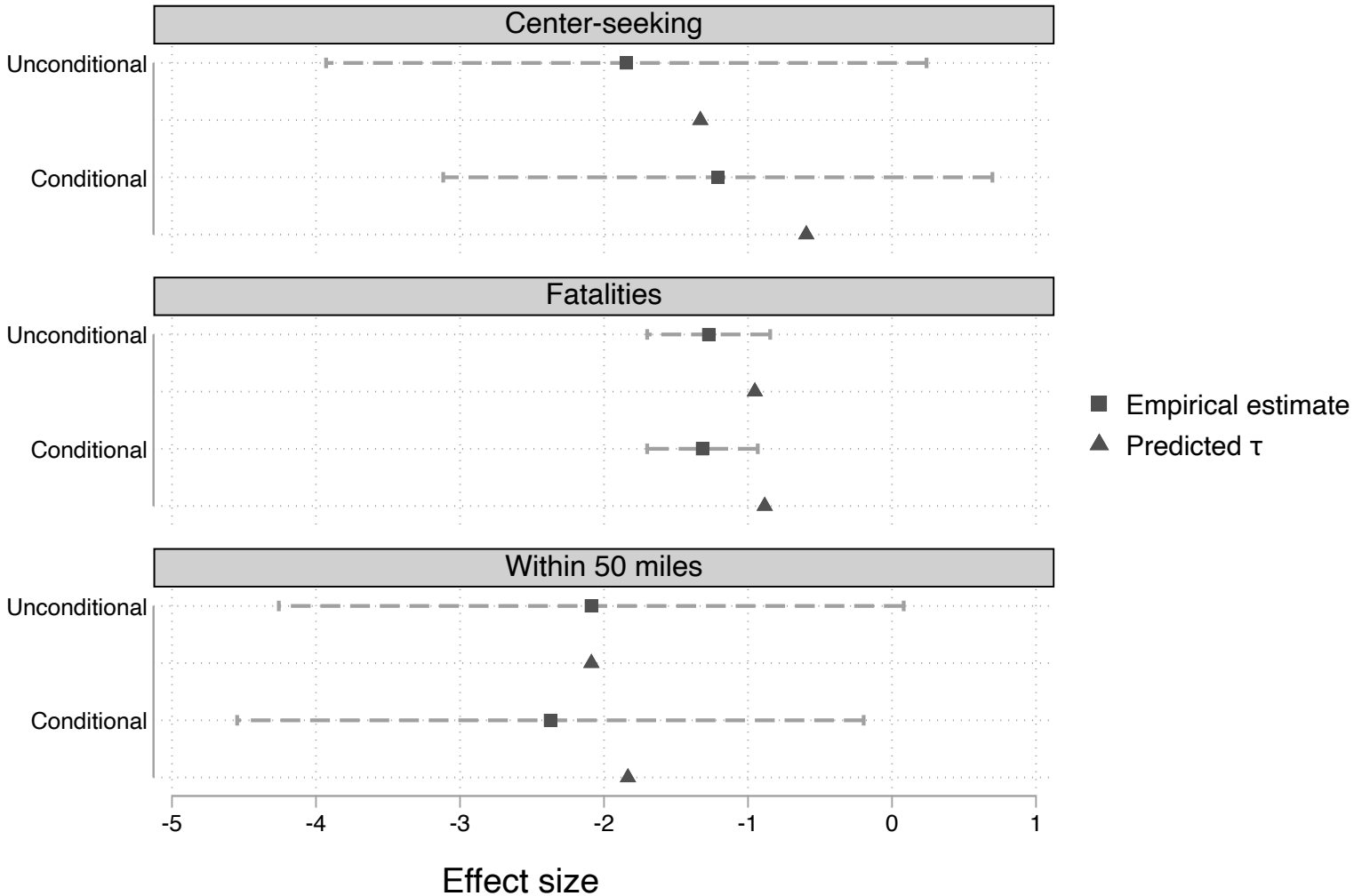
	(1)	(2)	(3)	(4)
Panel A: Conflict cost	log(*GDP*)			
Conflict	-0.036	-0.009	-0.023	0.002
	(0.027)	(0.027)	(0.024)	(0.025)
Conflict × Fatalities	-0.035**			-0.033**
	(0.017)			(0.016)
Conflict × Within 50 miles		-0.078***		-0.068**
		(0.028)		(0.028)
Conflict × Center-seeking			-0.050*	-0.022
			(0.030)	(0.031)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	5928	5928	5928	5928
R^2	0.992	0.992	0.992	0.992
Panel B: Bond Market	Bond price			
Post × Treated	-0.251	-0.749**	-0.491	0.272
	(0.318)	(0.316)	(0.301)	(0.425)
Post × Treated × Fatalities	-1.273***			-1.316***
	(0.218)			(0.196)
Post × Treated × Within 50 miles		-2.089*		-2.372**
		(1.107)		(1.110)
Post × Treated × Center-seeking			-1.845*	-1.210
			(1.064)	(0.973)
Bond × event FE	Yes	Yes	Yes	Yes
Day × event × maturity FE	Yes	Yes	Yes	Yes
Observations	966222	966222	966222	966222
R^2	0.977	0.977	0.977	0.977

Note: Standard errors in parentheses clustered at the country level. Outcome variable is either log(*GDP*) (A) or the daily bond price (B). Event sample is all conflicts involving state forces. Sample is either the country-year panel (A) or the stacked bond panel (B). Fatalities are measured in hundreds. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Pricing conflict cost

How accurately does the market price information about γ?

Figure: Benchmarking heterogeneous responses by conflict cost predictors



Learning from the news

How do investors update $\tilde{\zeta}_0$?

Table: Heterogeneous effects: news coverage

Dependent variable	Bond price						
Quartile of news coverage	All	25	50	75	All		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post × Treated	-0.631**	-0.676**	-0.923**	-1.195*	1.024	-0.377	1.001
	(0.295)	(0.331)	(0.450)	(0.625)	(0.648)	(0.619)	(0.667)
Post × Treated × Above median news coverage, $t \in [0, 15]$					-1.139	-2.800***	-2.024***
					(0.832)	(0.619)	(0.602)
Post × Treated × Within 50 miles					-2.391**		-2.380**
					(1.144)		(1.144)
Post × Treated × Center-seeking					-1.507		-1.501
					(1.010)		(1.016)
Post × Treated × Fatalities					-1.338***		-1.329***
					(0.226)		(0.226)
Post × Treated × Above median news coverage, $t \in [-30, -1]$						2.254***	0.903
						(0.829)	(0.867)
Bond × event FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day × event × maturity FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	894973	740570	476597	290783	894973	894973	894973
R^2	0.976	0.977	0.979	0.974	0.977	0.976	0.977

Note: Standard errors in parentheses clustered at the country level. Outcome variable is the daily bond price, indexed to 100 (par). Event sample is the first event of all conflicts involving state forces. Header indicates the sample is all conflict events with news coverage in the first 15 days greater than a given quantile of the event-level distribution. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Conclusion

We show

- State-involved violent conflict lowers bond prices, increases credit risk.
- Markets underprice conflict shocks, but learn rapidly via int'l news.
- Investor responses to conflict characteristics suggest sophisticated knowledge.
- Model estimates imply data-driven, accurate beliefs on conflict cost.
- Differential response to ex-ante and ex-post news consistent with Bayesian updating.

$\rightarrow$ The upshot: markets learn from the news and form data-driven, broadly accurate beliefs about the conflict process.

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Stacked event-study estimation

Stack bond-day data event-wise (Baker et al., 2021; Dube et al., 2022). Then estimate for bond b at calendar day t issued by country c in conflict event e, for $t \in [k_e - 30, k_e + 30]$:

$$y_{btce} = \alpha + \sum_{k \neq -1} \tau_k \mathit{Treat}_{ce} \times 1(k = t - k_e) + \delta_{be} + \delta_{te} + \xi' X_b \times \gamma_{te} + \upsilon_{btce}$$

- k_e: event date
- y: bond price (or current yield)
- Treat_{ce}: indicator if c is affected country in event e
- δ_{be}, δ_{te}: bond-by-event and day-by-event effects.
- X_b: time-invariant bond-level characteristics
- SEs clustered at country-level
- Only never-treated controls included in each stack (Callaway and Sant'Anna, 2021).

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Data

Conflict data

- We obtain conflict data from UCDP event-level dataset.
- Identify onset date and initially observable characteristics of conflict.

Bond data

- We collect financial data from Cbonds, a global bond-trading platform.
- Daily bond trading prices and loan characteristics for 2347 foreign currency bonds for 122 countries from 2003-2022.

Country and macro data

- We take country macro fundamentals, institutions, and risk ratings from WB WDI/WGI, IMF, ICRG, and FRED.
- We use daily global equity and bond indices as controls as well.

Final sample after merging:

- 262 conflicts
- 1731 bonds (667 treated, 1064 control)
- 120 countries (44 treated, 76 control)

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Table: Conflict onset and bond prices

Dependent variable	Bond price			
Conflicts	All	State	Non-state	One-sided
	(1)	(2)	(3)	(4)
Post × Treated	-0.096	-0.701***	0.076	0.138
	(0.166)	(0.224)	(0.230)	(0.302)
Bond × Event FE	Yes	Yes	Yes	Yes
Day × Event × Maturity FE	Yes	Yes	Yes	Yes
Events	313	91	159	63
Conflicts	262	78	128	56
Countries	120	106	95	105
Observations	4,396,362	1,282,145	2,218,918	895,299
R^2	0.981	0.978	0.982	0.982

Note: Standard errors in parentheses clustered at the country level. Sample is daily bond panel in stacked event-specific datasets. Outcome variable is the daily bond trading price averaged across all available exchanges, indexed to 100 (par). Each column provides estimates of treatment effects for a different sample of conflicts, indicated in the table header. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Table: Fatalities across types of conflict

Dependent variable	Number of fatalities							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
State	-31.243				-1.102			
	(20.365)				(7.314)			
Non-state		48.877*		46.940*		2.950		2.600
		(24.402)		(25.244)		(6.520)		(7.776)
One-sided			-33.801*	-4.635			-2.091	-0.851
			(18.731)	(11.647)			(7.575)	(8.944)
Observations	262	262	262	262	262	262	262	262
R^2	0.005	0.014	0.005	0.014	0.123	0.123	0.123	0.123
Country FE	No	No	No	No	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses clustered at the country level. Outcome variable is the number of fatalities during conflict onset. Event sample is all conflicts. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Table: Conflict onset and military spending

Dependent variable	Bond price			
Conflicts	All	State	Non-state	One-sided
	(1)	(2)	(3)	(4)
Post × Treated	0.025**	0.033	0.021	0.021
	(0.012)	(0.025)	(0.015)	(0.024)
Country × Event FE	Yes	Yes	Yes	Yes
Date × Event FE	Yes	Yes	Yes	Yes
Events	313	91	159	63
Conflicts	262	78	128	56
Countries	108	94	83	93
Observations	152,796	45,788	77,451	29,557
R^2	0.991	0.991	0.991	0.991

Note: Standard errors in parentheses clustered at the country level. Sample is yearly military spending panel in stacked event-specific datasets. Outcome variable is the logarithm of military spending. Each column provides estimates of treatment effects for a different sample of conflicts, indicated in the table header. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Table: Conflict onset and inflation rate

Dependent variable	Bond price			
Conflicts	All	State	Non-state	One-sided
	(1)	(2)	(3)	(4)
Post × Treated	1.281***	1.545***	1.563***	-0.025
	(0.320)	(0.607)	(0.433)	(0.720)
Country × Event FE	Yes	Yes	Yes	Yes
Date × Event FE	Yes	Yes	Yes	Yes
Events	313	91	159	63
Conflicts	262	78	128	56
Countries	119	108	97	107
Observations	181,178	54,691	92,473	34,014
R^2	0.525	0.616	0.617	0.337

Note: Standard errors in parentheses clustered at the country level. Sample is yearly military spending panel in stacked event-specific datasets. Outcome variable is the annual inflation rate. Each column provides estimates of treatment effects for a different sample of conflicts, indicated in the table header. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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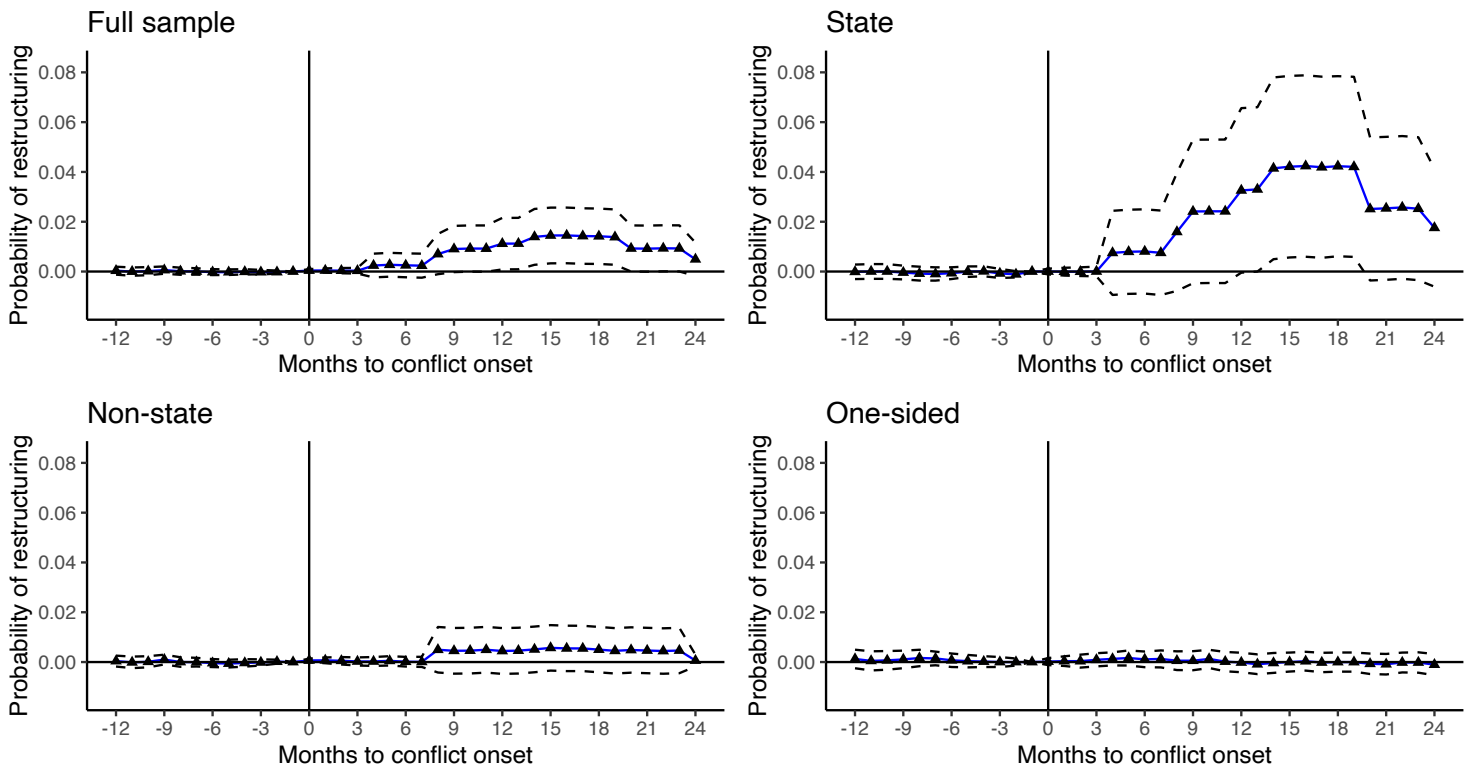
Figure: Event-study: weakly preemptive restructurings



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Robustness tests

- Inference: wild-cluster bootstrapping for small number of events
- Bond characteristics X_b: maturity, currency, size, coupon rate
- Country characteristics
  - Macro variables
  - Institutional covariates
  - Country risk scores
  - Resource dependence
  - Region-by-year FE
- Inverse-propensity weights (IPW) to improve covariate balance
- Pre-trends power and pre-testing (Roth, 2022)
- Macro indices: US equities, VIX, EM bonds
- Commodity price shocks
- Bond price/yield outliers
- Sample construction
- Interrupted time-series estimation
- Varying event-windows
- Event definition

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Quantitative model: how accurate are markets?

Questions:

1. How should bond market respond to information about conflict onset?
2. What does the effect size say about investor beliefs?

Set-up

- Risk-neutral investor considers a fixed-income bond that pays out in every period.
- State of the world is $z_t \in \{0, 1\}$. NO/YES conflict.
- Investors are uncertain about state of the world.
- Probability of conflict: $\zeta_t = pr(z_t = 1)$. Prior belief ζ_0, posterior $\tilde{\zeta}_0$
- Persistence: conflict follows AR(1) process $z_t = \alpha + \rho z_{t-1} + \epsilon_t$
- Expected loss of conflict is γ (haircut)
- Risk-free rate r, coupon rate i
- F is face-value of bond

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Model solution

Ex-ante expected NPV of holding bond at $t = 0$

$$EV_0 = \sum_{t=0}^{T} \frac{1}{(1+r)^t}[iF(1-\zeta_t\gamma)] + \frac{1}{(1+r)^T}[F(1-\zeta_T\gamma)] \tag{1}$$

Assume *i*) no arbitrage, and *ii*) z_t follows a Markov process.

The treatment effect τ of observing conflict, $z_0 = 1$, can then be written

$$\tau = \widetilde{EV}_0 - EV_0 = (\tilde{\zeta}_0 - \zeta_0)[EV_0(1) - EV_0(0)] \tag{2}$$

- $EV_0(z)$ is the expected NPV after observing a realization of z.
- Focus on full info case: $\tilde{\zeta}_0 = 1$

$\implies$ if we know, r, i, T and can estimate γ, ζ_0, α, ρ, we can determine the efficient benchmark pricing τ.

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Estimation

We estimate the parameters of the model with the following three equations:

$$\text{AR(1): } z_{it} = \alpha + \rho z_{it-1} + \epsilon_{it} \tag{3}$$

$$\text{Conflict cost: } \log(y_{it}) = \alpha_0 + \gamma z_{it} + \delta_i + \delta_t + u_{it} \tag{4}$$

$$\text{Accurate prior: } \zeta_0 = \frac{1}{NT} \sum_{i,t} z_{it} \tag{5}$$

We combine these with the event-study coefficients $\hat{\tau}_k$ to calculate the share of the model-predicted shock priced in after k days.

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Table: Parameter estimates for conflict cost and autocorrelation

Outcome	$\log(y_{it})$				z_{it}
	(1)	(2)	(3)	(4)	(5)
γ	1.104***	-0.091*	-0.058**		
	(0.317)	(0.054)	(0.027)		
γ^H				-0.157***	
				(0.040)	
γ^L				-0.048*	
				(0.026)	
ρ					0.801***
					(0.022)
α					0.028***
					(0.004)
Country FE	No	Yes	Yes	Yes	No
Year FE	Yes	No	Yes	Yes	No
Observations	5,932	5,928	5,928	5,925	6,758
R^2	0.037	0.975	0.992	0.993	0.689

Note: Standard errors in parentheses clustered at the country level. Outcome variable is either the log of constant-dollar GDP or a conflict dummy, as indicated in the table header. Sample is all country-years for which data is available from 1990-2000 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Table: Simulation parameter list

Parameter	Description	Value
γ	Annual cost of conflict	0.058
α	AR(1) intercept	0.028
ρ	AR(1) autoregressive term	0.801
ζ_0	Prior probability of conflict	0.140
$\tilde{\zeta}_0$	Posterior probability of conflict	1
r	Risk-free rate	0.029
i	Coupon rate	0.055
T	Maturity	10

Table shows estimated values and descriptions for each parameter of the simulation exercise.

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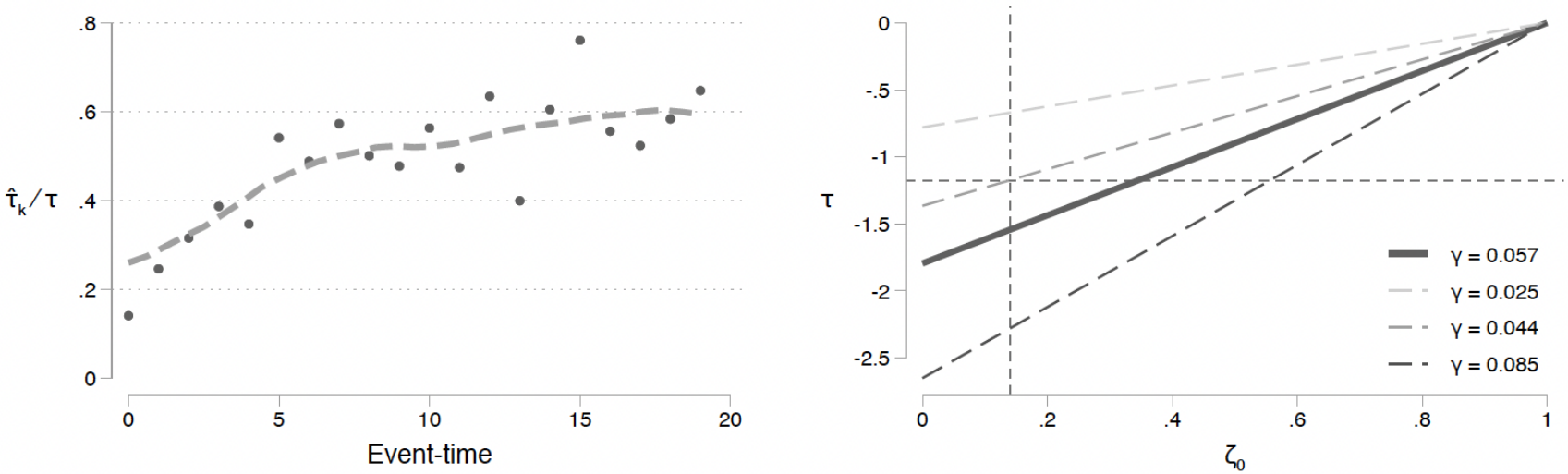
Model Results

Figure: Prior beliefs, conflict costs, and price responses



- Investors price in at most $\sim 75\%$ of the shock.
- Rapid learning in days after conflict
- $\max \tau_k$ implies perceived $\gamma = 0.044$, or $\zeta_0 = 0.35$

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Table: Conflict onset and bond prices: conflict history

Dependent variable	Bond price							
Conflict index	5-year		10-year		15-year		20-year	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post × Treated	-1.647**	-1.632**	-1.481**	-1.506**	-1.369*	-1.440**	-1.337*	-1.448**
	(0.687)	(0.675)	(0.701)	(0.688)	(0.710)	(0.699)	(0.707)	(0.697)
Post × Treated × Conflict index	1.112		0.858		0.699		0.666	
	(0.762)		(0.805)		(0.832)		(0.855)	
Post × Treated × Minor conflict index		0.920		0.702		0.550		0.847
		(0.742)		(0.803)		(0.926)		(0.836)
Post × Treated × Major conflict index		1.357***		1.632**		1.889		0.557
		(0.459)		(0.685)		(1.677)		(1.816)
Bond × event FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day × event × maturity FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	935,938	935,938	935,938	935,938	935,938	935,938	935,938	935,938
R^2	0.980	0.980	0.980	0.980	0.980	0.980	0.980	0.980

Note: Standard errors in parentheses clustered at the country level. Outcome variable is the daily bond price, indexed to 100 (par). Event sample is the first event of all conflicts involving state forces. Conflict index is the share of years in the previous T years in which the country experienced a government-involved conflict. Major conflict defined as more than 1000 battle-related deaths in a given year; minor exceeds 25 deaths. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Table: Conflict onset and bond prices: distance to other major cities

Dependent variable	Bond price (1)
State forces, all episodes	
Post × Treated	-0.801
	(1.630)
Post × Treated × Log distance Index	0.047
	(0.273)
Bond FE × Event FE	Yes
Date FE× Event FE× Maturity	Yes
Observations	1,364,812
R^2	0.981

Note: Standard errors in parentheses clustered at the country level. Outcome variable is the daily bond price, indexed to 100 (par). Event sample is all conflicts involving state forces. The log distance index is the logarithm of an average distance from conflict event location to four major cities after the capital weighted by population level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table: Heterogeneous effects: news coverage

Dependent variable	Bond price							
Quartile of news coverage	All	25	50	75	All			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post × Treated	-0.631**	-0.676**	-0.923**	-1.195*	-0.340	1.024	-0.377	1.001
	(0.295)	(0.331)	(0.450)	(0.625)	(0.609)	(0.648)	(0.619)	(0.667)
Post × Treated × Above median news coverage, $t \in [0, 15]$					-0.583	-1.139	-2.800***	-2.024***
					(0.890)	(0.832)	(0.619)	(0.602)
Post × Treated × Within 50 miles						-2.391**		-2.380**
						(1.144)		(1.144)
Post × Treated × Center-seeking						-1.507		-1.501
						(1.010)		(1.016)
Post × Treated × Fatalities						-1.338***		-1.329***
						(0.226)		(0.226)
Post × Treated × Above median news coverage, $t \in [-30, -1]$							2.254***	0.903
							(0.829)	(0.867)
Bond × event FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day × event × maturity FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	894973	740570	476597	290783	894973	894973	894973	894973
R^2	0.976	0.977	0.979	0.974	0.976	0.977	0.976	0.977

Note: Standard errors in parentheses clustered at the country level. Outcome variable is the daily bond price, indexed to 100 (par). Event sample is the first event of all conflicts involving state forces. Header indicates the sample is all conflict events with news coverage in the first 15 days greater than a given quantile of the event-level distribution. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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