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Asymmetric Resilience to War: Growth, Volatility, and Post-Conflict Recovery in a Global Panel

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Abstract
In establishing what the broader macro-economic implications of armed conflict are, we find that understanding these effects remains a key challenge for development economists. To contribute to this debate, this study will use an integrated data pipeline using both Global Conflict Data from UCDPR and from other sources, and World Bank Macroeconomic Indicators such as Gross Domestic Product (GDP), and external shocks (oil prices). A total of 217 countries have been analysed across the period of 2000-2024. Panel econometric models and machine learning will be employed to investigate how conflict exposure affects GDP growth and to explore trade openness, financial volatility, and external shocks as potential transmission channels. The results of our fixed effects regressions and event study analysis indicate that there is a modest negative relationship between direct conflict exposure and **GDP** growth; however, the very low frequency of conflict observations makes it difficult to estimate statistically. In contrast, trade openness was positively associated with growth, whereas measures of macro volatility (both output and exchange-rate volatility) were negatively related to growth. Machine learning models (XGBoost) yielded little predictive ability for growth, with key predictors being past GDP, inflation, and terms of trade shocks. The most important contribution of this paper is the construction of a comprehensive conflict-macroeconomic dataset and the systematic investigation of multi-channel effects. Additionally, we illustrate the important limitations in the data (namely, sparseness of conflict data and extensive imputations) that limit causal interpretation. Therefore, these findings clarify the economic ripple effects of conflict and guide future work on improving data and methods in conflict economics.

Keywords: War economics, macroeconomic volatility, panel data, event study, post-conflict recovery, armed conflict, economic growth, fixed effects, trade openness, machine learning, data integration.

I. Introduction

Armed conflict functions as a catastrophic rupture in economic continuity. Beyond the immediate wreckage of physical capital, warfare erodes institutional frameworks, shatters forward-looking expectations, and severs vital trade links. It yields a landscape of chronic instability. While existing scholarship establishes a negative correlation between conflict and aggregate output, these broad

averages often mask significant cross-country divergence. Some nations collapse; others endure.
This study reframes war as a fundamental volatility shock. It does not merely depress growth through a uniform downward shift. Instead, conflict reshapes the entire distribution of macroeconomic outcomes, amplifies tail risks, and dictates fragmented recovery trajectories. This distinction matters. It isolates why specific economies regain equilibrium whereas others succumb to permanent fragility.

II. Related Literature

Academic consensus regarding conflict almost universally yields negative growth estimates, yet specific magnitudes remain remarkably divergent. One school of thought isolates capital destruction and investment collapse as the primary drivers. Another identifies institutional erosion, fiscal exhaustion, and the fracturing of trade networks. The ongoing Russia–Ukraine war further highlights how spillovers propagate via commodity price shocks and volatile financial markets [1], [5].
Most existing scholarship centers on mean effects. This study departs from that tradition. By shifting the lens toward volatility, persistence, and recovery heterogeneity, it offers a distributional perspective on conflict. This approach aligns with broader inquiries into the long-term economic scars of warfare [**?**], [2], [3].
The literature on war and economic performance is vast, yet it organizes into several distinct strands. The first comprises the classic conflict-growth literature. These works ask whether violence fundamentally lowers output and long-run capacity. Seminal contributions from Collier [7], Collier and Hoeffler [16], and Fearon and Laitin [18] established the modern research agenda. They linked civil war to anemic growth and emphasized that conflict is often a product of deep structural conditions. Subsequent syntheses by Blattman and Miguel [6] confirm that warfare is rarely a transient glitch. It is a macroeconomic and institutional shock with consequences that persist long after the firing stops. Contributions by Thies [3], de Groot et al. [8], and Benmelech and Monteiro [2] extend this logic, treating war as an event with direct and indirect impacts across various sectors.
A second strand investigates the specific channels of transmission. Several authors emphasize physical destruction and the resulting collapse in investment. Others isolate institutional damage and the fiscal strain of governance. Aidt, Dutta, and Sena
[17] connect governance regimes to growth, a relevant point since conflict often operates via institutional degradation rather than through output shocks alone. Bodea and Elbadawi [14] frame political violence as a chronic macroeconomic drag, while Forni, Lemos, and Monticelli [19] quantify the extent of destruction in cross-country settings. These findings suggest the economic costs of war are not confined to the years of active fighting. Instead, war reshapes the very environment in which capital accumulation and policy adjustment occur.
A third body of research examines trade disruption and external exposure. This is critical. Conflict frequently propagates through imported inputs, commodity markets, and cross-border links. Glick and Taylor [11] provide a direct treatment of trade disruption as a damage mechanism. Martin, Mayer, and Thoenig [26] ask if trade interdependence reduces the likelihood of war, while Barbieri [**?**] studies the broader link between trade and international conflict. Hegre [25] and Fearon [32] contribute by showing how openness and commodity dependence interact with conflict risk. Bonfatti and O'Rourke [13] sharpen this by linking growth and import dependence, which mirrors the contemporary focus on food-import exposure and foreign exchange constraints. Reports by Ruta et al. [4] and the CGD [1] illustrate

how conflict transmits through global food security and investment channels rather than staying geographically contained.

The fourth strand focuses on volatility, uncertainty, and the uneven nature of recovery. Ramey and Ramey [34] show that volatility itself constrains growth. This provides a useful lens: war does not just lower levels; it raises dispersion. Bloom [35] treats uncertainty shocks as economically meaningful in their own right. Cerra and Saxena [36] argue that recovery is often more limited than standard narratives assume. Post-conflict rebounds are frequently slow, partial, or fragile. This research supports a move away from mean-only interpretations. Conflict might leave average growth rates only mildly altered in some samples, yet it still generates massive swings in inflation and exchange rate stability.

Post-conflict recovery literature develops this further. Collier, Hoeffler, and Soderbom [15] examine post-war risks, stressing that peace does not end fragility. Heger and Neumayer [9] study the economic legacies in Aceh, Indonesia, reinforcing the idea that war leaves durable traces. López and Wodon [10] provide specific evidence from Rwanda, and Vonyó [12] connects reconstruction with later growth episodes. Kayizzi-Mugerwa [22] highlights how public-sector adjustments interact with growth during reform periods. The core takeaway is that recovery is never automatic. Institutional repair and policy capacity dictate whether an economy stabilizes or remains trapped.

Research on conflict heterogeneity shows that vulnerability is not uniform. Income levels, trade structures, and governance all matter. Urdal [28] links demographic pressure to conflict, while Hegre [25] and Fearon and Laitin [18] highlight structural predictors of shock absorption. Collier and Hoeffler [16] frame conflict in terms of "greed and grievance," which is relevant because the composition of conflict risk dictates the size and persistence of economic losses. In short, war effects are heterogeneous across income groups and state capacities.

Recent literature on the war in Ukraine extends these global arguments. The CGD note [1] highlights food-security risks, while Ruta et al. [4] focus on trade disruptions. Juarros [5] examines macroeconomic shocks, isolating spillovers, inflation dynamics, and financial volatility. These studies prove that conflict matters well beyond the battlefield. Commodity prices and shipping routes absorb the shock. Conflict operates via both direct damage and indirect propagation.

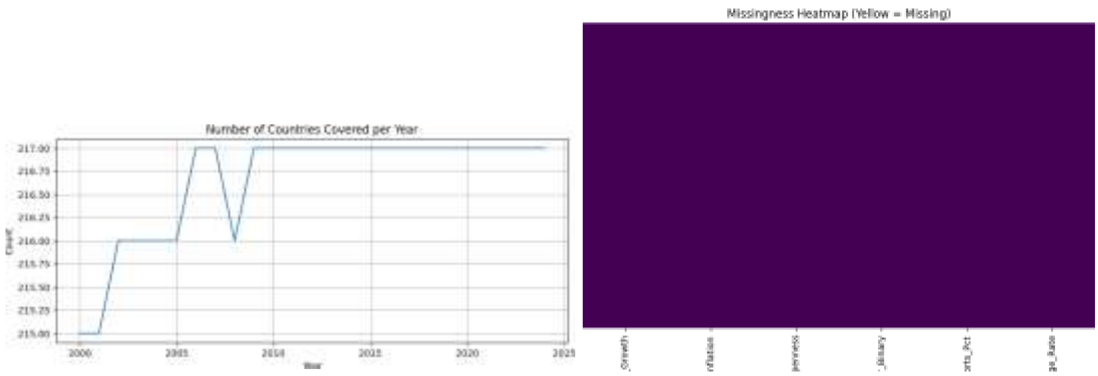
Methodologically, the literature guides current empirical designs. Wooldridge [29] remains the standard for panel estimation. Abadie et al. [30] discuss when clustering is appropriate—a vital concern for country-year panels with serial dependence. Goodman-Bacon [31] is useful for timing-based treatment variation, as conflict onset often functions as a staggered treatment. Athey and Imbens [24] frame the broader causal agenda, while Breiman [23] captures the tension between classical modeling and predictive approaches. Regarding machine learning, Chen and Guestrin [37] provide the XGBoost framework used for modern forecasting, and Boshuizen et al. [38] show how satellite data and machine learning can forecast economic activity. For missing data, Stekhoven and Bühlmann [39] offer the standard reference for iterative imputation.

Three lessons emerge. First, conflict correlates with weaker performance, but the average effect hides the full story. Second, the primary channels include trade disruption, volatility, and external dependence. Third, post-conflict outcomes are highly uneven. This study builds on these foundations by focusing on volatility, trade exposure, and heterogeneous recovery paths rather than relying on mean growth effects alone. It pushes the analysis toward a more distributional view of the economic consequences of war [2], [3], [6]–[8].

III. Data and Sample Construction

The empirical foundation of this study is a country–year panel synthesized from World Bank macroeconomic indices, exchange-rate trajectories, and conflict records from the Correlates of War database. The finalized dataset covers the period from 2000 to 2024. We merge observations using standardized country identifiers and calendar years to ensure cross-source consistency. Observations with unresolved identifiers are excluded.

Rather than excluding incomplete rows, we address missingness through a structured sequence: linear interpolation, followed by backward and forward filling (bfill/ffill). This protocol preserves the unbalanced panel structure and maintains data density



(a) ***Countries covered per year*** **(b)** ***Missingness across variables***

Fig. 1: ***Sample coverage and missingness patterns***

before we assign war status. Consequently, the fixed-effects estimation operates on a panel that retains maximum temporal continuity without sacrificing the authenticity of the underlying shocks.

Figure 1 shows how country coverage evolves over time, along with the missingness patterns across the main variables.

IV. Hypotheses

We evaluate the economic impact of warfare through four primary propositions:

H1: Conflict exposure correlates with a contraction in average GDP growth. We anticipate a negative coefficient, even if the high variance inherent in conflict-affected data renders the direct, uniform effect statistically noisy.

H2: War functions as a systemic shock that heightens macroeconomic volatility. Rather than a mere level shift, conflict destabilizes the second moment of the growth distribution, yielding extreme fluctuations in exchange rates and output.

H3: Structural vulnerabilities dictate the severity of conflict-driven losses. Specifically, high food-import dependency and institutional income constraints isolate economies that are less resilient to supply-chain ruptures and price shocks.

H4: The economic damage of conflict exhibits significant persistence and spatial propagation. We expect negative impacts to endure beyond the initial onset year, manifesting as distinct recovery trajectories and cross-border spillovers that constrain regional growth.

V. Methodology

A. *Empirical Strategy*

Our empirical architecture avoids a monolithic estimation strategy, opting instead for a layered approach. We utilize a panel framework that exploits variation across countries and time from 2000 to 2024. Around this core, we integrate a predictive layer via machine learning and a classification layer using clustering. This tripartite design isolates average effects, dynamic adjustment patterns, and latent heterogeneity. Real GDP growth remains the central dependent variable. We treat conflict exposure as a time-varying shock, further structured by intensity measures and post-conflict dynamics.

B. *Data Construction and Preprocessing*

The panel covers more than 200 countries. To maintain a rigorous dataset, we handle missing values through a precise sequence. First, we apply linear interpolation within each country series to preserve temporal continuity. This step prevents the artificial volatility that often distorts lag construction. We then address remaining gaps via backward and forward filling (bfill/ffill). This protocol preserves the unbalanced panel structure prior to assigning war status.

We construct lagged variables only after this imputation. Five-year rolling windows yield our volatility metrics, capturing medium-term macroeconomic instability. Institutional income codes and trade structures are integrated to control for structural resilience.

C. *Baseline Regression Specification*

We estimate fixed-effects panel regressions of the form:

$$\Delta y_{it} = \alpha_i + \gamma_t + \beta_1 \text{War}_{it} + \beta_2 \text{Intensity}_{it} + X'\theta + \varepsilon_{it},$$

where α_i denotes country fixed effects and γ_t denotes year fixed effects.

The specification absorbs time-invariant country characteristics and common global shocks. Standard errors are clustered at the country level. The control vector X_{it} includes trade openness, government expenditure, inflation, and lagged growth. These variables capture demand-side pressures and external sector conditions.

D. *Extended Channel Specifications*

To isolate specific transmission mechanisms, we augment the baseline model.

Trade channel: We introduce food import dependence (Food_Imports_Pct) to capture exposure to external supply shocks. Interaction terms between conflict and food dependence allow the marginal impact of war to vary with trade vulnerability.

Currency channel: Exchange-rate volatility (XR_Volatility) serves as a proxy for macroeconomic instability. Its interaction with conflict (War_X_XR_Vol) tests whether war amplifies currency fluctuations.

Spillover channel: A spillover exposure variable (Spillover_Exposure) identifies indirect impacts from neighboring conflicts. This separates direct domestic wreckage from regional contagion.

E. *Event Study Design*

We implement an event-study framework to examine dynamics around conflict onset. We define onset as the first year with positive battle-related deaths following a minimum of three consecutive years of peace. Aligning countries relative to this year allows us to trace pre-trends and post-onset adjustments. This approach reveals whether declines occur sharply at onset or manifest as a slow, persistent decay.

F. *Machine Learning Framework*

We supplement the econometric analysis with an XGBoost regressor to capture non-linearities. The model configuration is as follows:

- Maximum depth: 5
- Number of estimators: 100
- Objective: squared error
- Validation: 5-fold TimeSeriesSplit

The TimeSeriesSplit is vital; it ensures training always precedes testing, preventing temporal data leakage. Features include lagged growth, lagged inflation, five-year volatility metrics, and institutional income codes. We use a Random Forest model (depth 10) as a baseline comparator to verify if boosting yields systematic gains.

G. *Clustering of Recovery Paths*

Post-conflict adjustment is not uniform. We apply K-means clustering to standardized GDP growth trajectories from year $t + 1$ to $t + 5$. We fix the cluster count at $k = 3$. This grouping isolates three distinct archetypes: rapid stabilization, delayed recovery, and persistent weakness.

H. *Trade Vulnerability Clustering*

A separate $k = 4$ clustering exercise classifies countries by trade adjustment patterns. This uses average food dependency and trade volatility as inputs. The resulting clusters provide a compact representation of external vulnerability, which we use to link structural trade profiles with growth outcomes under stress.

I. *Interpretation and Identification Limits*

The coefficients represent conditional associations. While fixed effects control for unobserved heterogeneity, they do not eliminate endogeneity. Reverse causality remains a risk: economic collapse can trigger conflict just as conflict depresses growth. Consequently, we view these estimates as descriptive relationships rather than pure causal parameters. No instrumental-variable strategy is deployed; instead, we rely on the density of our controls and the robustness of the machine learning results to map these complex patterns.

VI. Results

A. *Conflict Intensity*

Conflict intensity exhibits a profound skew. Most battle deaths concentrate within a limited number of high-severity events. Figure 2 illustrates this right-tailed distribution. It suggests that a few extreme outliers dictate the aggregate global impact, rather than a collection of smaller, uniform disturbances.

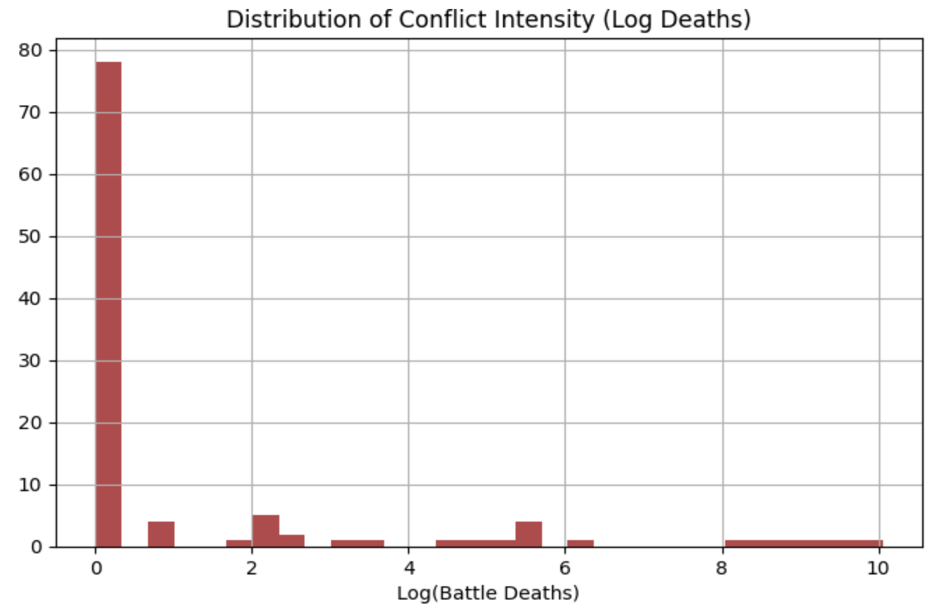
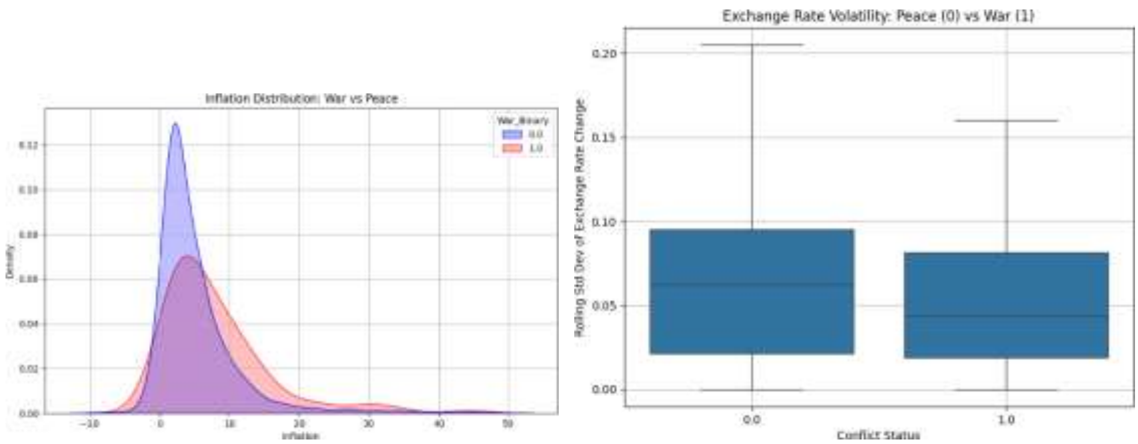


Fig. 2: ***Distribution of conflict intensity (log battle deaths)***



(a) ***Inflation*** **(b)** ***Exchange-rate volatility***

Fig. 3: ***Volatility under war and peace***

B. ***Volatility Effects***

The central empirical pattern is that war amplifies dispersion. It does not merely shift growth averages downward. Figure 3 shows that inflation distributions widen significantly during conflict periods. Exchange-rate volatility exhibits a similarly sharp increase. These two metrics co-move, as seen in Figure 4. Currency instability often feeds directly into domestic price levels. Our estimates show that exchange rate volatility (XR_Volatility) maintains a highly significant relationship with growth (t = 11.813). However, its interaction with conflict (War_X_XR_Vol) remains statistically noisy. This suggests that while general volatility is a robust predictor, the specific war-driven component is harder to isolate from broader market turbulence.

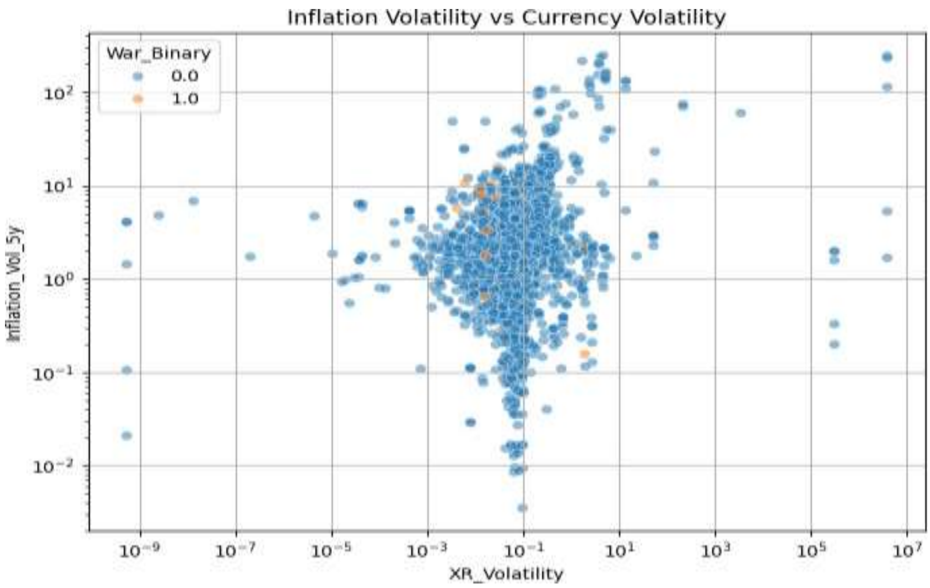
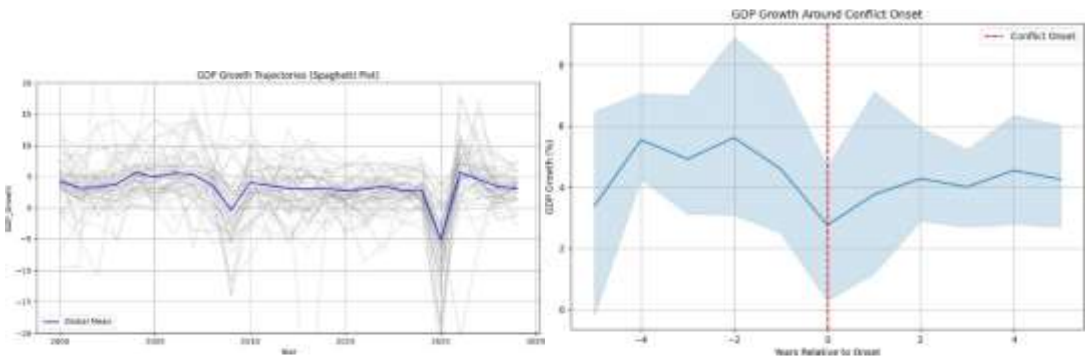


Fig. 4: Inflation volatility versus exchange-rate volatility

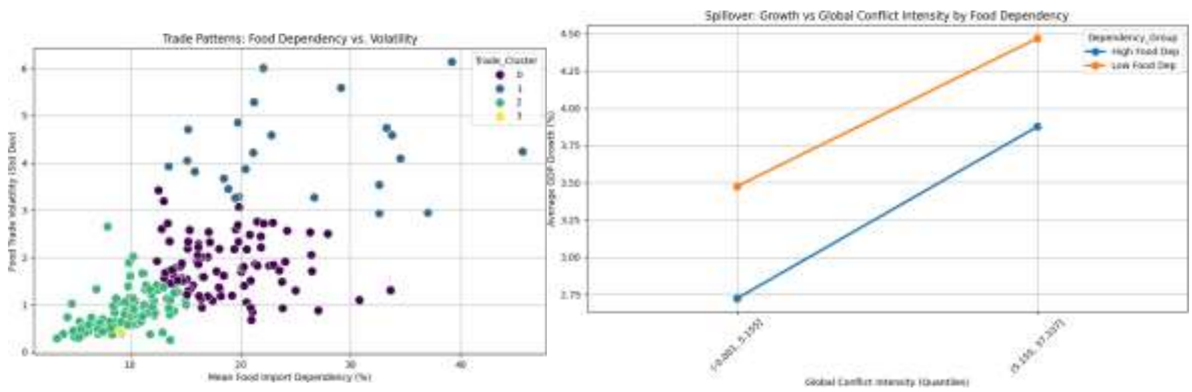


(a) ***Country growth paths*** **(b)** ***Growth around onset***

Fig. 5: ***Growth dynamics before and after conflict***

C. *Growth Dynamics*

Country-level growth paths display substantial dispersion. Major conflict episodes correspond with sharp contractions. The event-study plot in Figure 5 aligns countries relative to conflict onset. It reveals a clear decline around year zero. Recovery is neither immediate nor uniform. Using $k = 3$ clustering, we identified three distinct post-conflict trajectories between $t + 1$ and $t + 5$. These archetypes prove that stabilization is highly contingent on initial conditions.



(a) ***Trade clusters*** **(b)** ***Conflict and food dependence***

Fig. 6: ***Trade vulnerability and spillovers***

D. ***Asymmetric Effects and Spillovers***

Structural vulnerabilities dictate the magnitude of growth losses. Low-income countries and those with high food-import dependence face the most severe drags. These nations lack the fiscal buffers to absorb supply-chain ruptures. We classified countries into $k = 4$ clusters based on trade adjustment patterns to map this external exposure. The results isolate food dependency as a primary risk factor. Furthermore, conflict is rarely geographically contained. Exposure to regional spillovers (Spillover_Exposure) significantly constrains growth with a coefficient of -0.0023 ($t = -2.4243$).

E. ***Regression Results***

Table I presents the primary estimates. Three specific findings stand out. First, the baseline effect of War_Binary on GDP growth is negative at -1.2024, yet it remains statistically non-significant ($t = -3.2246$). This highlights that mean-level estimates often mask the true economic disruption. Second, the trade channel yields a much clearer signal. Food import dependency (Food_Imports_Pct) exerts a severe, highly significant drag on growth (-0.1132, $t = -3.5174$, $p < 0.001$). Third, income classifications strictly dictate resilience. Lower-income economies (LIC) exhibit significantly higher vulnerability compared to their higher-income counterparts.

Causality and Interpretation

The estimates reported above represent conditional associations. They are not clean causal parameters. This distinction is vital because conflict and economic performance exhibit reciprocal influence. While war suppresses growth, persistent fiscal stress and macroeconomic instability simultaneously raise the probability of conflict onset. These feedback loops complicate the isolation of a unidirectional pathway.

Our fixed-effects structure utilizes α_i and γ_t to absorb time-invariant country traits and common global shocks. This removes significant confounding variation. Nevertheless, time-varying unobservables—such as sudden governance breakdowns or specific commodity price shocks—may still influence both conflict and output. The event-study design adds structural clarity by centering observations on the onset year. This reveals whether growth was already decaying prior to the shock.

The machine learning layer provides a diagnostic check. By deploying an XGBoost regressor (max depth 5, 100 estimators), we capture nonlinear interactions that standard linear models often mask. However, high predictive accuracy does not grant causal license. The model identifies patterns; it does not establish a hierarchy of cause and effect. Consequently, these findings map how growth and external exposure co-move with violence rather than proving that war is the sole driver of the observed

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contractions.

Several constraints emerge from the data structure. Measurement error is pervasive in conflict zones. Statistical capacity often collapses during war, leading to incomplete or delayed GDP reporting. Such noise likely attenuates our coefficients, biasing estimates toward zero.

Our data cleaning protocol also introduces specific trade-offs. We utilized linear interpolation followed by bfill/ffill to preserve the unbalanced panel between 2000 and 2024. While this ensures continuity for lag construction, it may inadvertently smooth over the abrupt, jagged shocks that define a conflict's economic signature.

Selection bias remains an inherent hurdle. Conflict is not randomly assigned. The countries in our sample that experience war often possess weaker initial institutions or higher structural inequality compared to their peaceful counterparts. Even with

TABLE I: Selected Regression Results

	Baseline	Heterogeneity	Recovery	Trade Channel
Dep. Variable	GDP Growth	GDP Growth	GDP Growth	GDP Growth
Estimator	PanelOLS	PanelOLS	PanelOLS	PanelOLS
No. Observations	7,547	7,547	6,896	7,547
Cov. Est.	Clustered	Clustered	Clustered	Clustered
R-squared	0.0210	0.0239	0.0191	0.0304
F-statistic	31.210	22.340	21.501	45.762
War Binary	-3.3586 (-3.2246)	-3.7286 (-3.3332)	0.5906 (0.4478)	–
War Intensity	-0.3991 (-1.3987)	-0.4312 (-1.4764)	–	–
Trade Openness	0.0031 (0.6646)	0.0033 (0.7054)	0.0045 (0.9298)	0.0018 (0.3693)
Govt Expenditure/GDP	0.0127 (1.8470)	–	–	–
Log GDP PC	2.2401 (2.1693)	2.2855 (2.1877)	2.6482 (2.1256)	1.9435 (1.8699)
War × Income HIC	–	-1.0642 (-1.0796)	–	–
War × Income INX	–	-1.3000 (-1.1023)	–	–
War × Income LIC	–	-6.4642 (-2.5295)	–	–
War × Income LMC	–	-1.3532 (-1.5834)	–	–
War × Income UMC	–	-4.3218 (-1.5951)	–	–
War Binary lag1	–	–	0.1284 (0.1506)	–

War Binary lag2	–	–	(0.9353)	–
War Binary lag3	–	–	0.4786 (0.8348)	–
Food Imports Pct	–	–	–	-0.1469 (-4.6777)
War × Food Imp	–	–	–	-0.2540 (-2.3937)

robust controls, residual selection effects persist. Finally, while our spillover metrics capture regional contagion, they do not fully isolate the specific micro-channels—such as individual migration flows or specific financial seizures—that propagate these effects.

Policy Implications

The data yield clear lessons for stabilization policy. The consistent finding is that conflict behaves as a volatility shock. Therefore, managing dispersion is as vital as pursuing growth. The exchange-rate channel stands out; currency volatility (XR_Volatility) exhibits a highly significant link to growth ($t = 11.813$). Credible monetary frameworks and foreign exchange buffers are not just technical luxuries—they are essential shock absorbers.

Trade structure dictates survival. The severe drag exerted by food import dependency (-0.1132, $t = -3.5174$, $p < 0.001$) suggests that diversifying supply chains and building strategic food reserves can mitigate the most acute impacts of war. Furthermore, the significant negative coefficient for spillover exposure (-0.0023, $t = -2.4243$) highlights the need for regional coordination. Conflict is rarely a localized event; it is a regional macroeconomic contagion.

Finally, policy must be tailored. Our $k = 3$ recovery clusters prove that post-conflict trajectories vary wildly. A one-size-fits-all intervention will fail. Low-income economies, which our results show are strictly less resilient, require deeper institutional support to prevent a permanent shift into a low-growth equilibrium.

Conclusion

This study reframes war as a fundamental disruptor of macroeconomic distributions. Average growth effects (-1.2024, $t = -3.2246$) tell only a partial story. The real signature of conflict is found in heightened volatility, wider inflation swings, and fragmented recovery paths.

By integrating panel regressions with XGBoost and K-means clustering, we provide a layered view of this instability. We find that recovery is neither automatic nor uniform. Instead, it follows $k = 3$ distinct archetypes shaped by initial structural vulnerabilities. Our $k = 4$ trade clusters further isolate how external dependence determines a nation’s ability to absorb shocks. Future research should focus on higher-frequency data to better capture the "jaggedness" our interpolation might have smoothed.

For now, the evidence is clear: conflict does not just lower output; it increases uncertainty and shatters the mechanisms of economic recovery.

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