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Research Paper Title :Global Energy Crises, Geopolitical Conflict, and Economic Vulnerability: Econometric Evidence on Inflation Transmission, Growth Effects, and Renewable Transition Resilience

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Abstract:

This study investigates the macroeconomic consequences of recent global energy disruptions by examining how international oil-price shocks, geopolitical conflict, import dependence, and renewable-energy penetration interact to shape inflation and output performance. The empirical focus is placed on a compact cross-country panel consisting of India, the United States, Germany, and Japan over 2020–2024, a period spanning the pandemic recovery, the 2022 Russia–Ukraine war shock, and the subsequent phase of disinflation and energy-market adjustment. The analytical strategy combines official annual macroeconomic data with structural energy indicators in order to identify the conditions under which external energy shocks are transmitted more forcefully into domestic price dynamics and growth volatility. The study is designed to illuminate differences between highly import-dependent economies and more diversified systems, and to assess whether a stronger renewable base functions as a buffer against external price stress.

The econometric evidence indicates that higher Brent oil prices are associated with stronger inflationary pressures and weaker growth outcomes, with these effects amplified in economies characterised by larger net energy imports. By contrast, renewable-energy penetration is associated with greater resilience, both directly and through a reduction in the effective vulnerability of the energy system. Descriptive and regression results point to marked cross-country heterogeneity: Japan and Germany exhibit greater exposure through import reliance, India shows substantial but moderating vulnerability due to rising renewable capacity, and the United States remains comparatively insulated by its lower net import dependence. The findings support the proposition that renewable transition is not merely a climate policy objective but also a macroeconomic stabilisation strategy relevant to inflation management, industrial competitiveness, and growth resilience under geopolitical stress.

Keywords: energy crisis; inflation transmission; geopolitical conflict; GDP growth; renewable transition; import dependence; econometrics; macroeconomic vulnerability

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1. Introduction

1.1 Energy crises as macroeconomic shocks

Energy crises historically operate as broad macroeconomic shocks because modern production systems, transport networks, and household consumption remain deeply dependent on reliable energy inputs. When oil and gas prices rise sharply, the increase is transmitted into industrial costs, logistics charges, food systems, electricity markets, and consumer expectations. The inflationary consequences are especially severe when energy serves as both a direct consumption item and an upstream input into multiple sectors. The recent period has re-emphasised this structural feature. After the pandemic-driven collapse in 2020, global energy demand recovered rapidly, supply chains remained constrained, and international oil prices rose substantially. The result was a synchronised surge in inflation across advanced and emerging economies, although with important differences in magnitude and persistence.

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The macroeconomic relevance of energy shocks extends beyond consumer prices. Higher energy prices compress firm margins, weaken real household income, worsen trade balances in net-importing economies, and may trigger restrictive monetary responses that further suppress output. Such interactions transform energy disturbances into wider episodes of economic vulnerability. The central analytical question is therefore not simply whether energy shocks matter, but how the transmission mechanism varies across institutional and structural contexts. This study adopts that perspective by linking inflation and growth outcomes to external energy shocks, import dependence, and the evolving role of renewable electricity as a stabilising capacity within the broader energy system.

1.2 Geopolitical conflict and transmission channels

Geopolitical conflict amplifies energy shocks by increasing uncertainty over supply security, trade routes, sanctions regimes, and expectations concerning future scarcity. The Russia–Ukraine war represented a pivotal global event because it affected crude oil, natural gas, fertiliser markets, and strategic commodity chains simultaneously. In Europe and Asia, the conflict altered procurement patterns, increased transport premia,

and accelerated competition for liquefied natural gas and substitute fuels. Even economies without direct trade exposure experienced indirect inflation through commodity markets and precautionary pricing behaviour. Conflict-driven energy disruptions therefore operate through both realised supply reductions and anticipatory expectations channels.

Transmission is further conditioned by domestic energy-system characteristics. Economies that rely heavily on imported fuels are more exposed to external price spikes, particularly when exchange-rate pass-through and fiscal constraints limit policy buffering. By contrast, countries with more diversified domestic energy sources, strategic reserves, or deeper renewable capacity may absorb part of the shock internally. These considerations suggest that the effect of geopolitical conflict cannot be evaluated independently of structural energy vulnerability. The present research explicitly incorporates that interaction by combining a conflict-period indicator with measures of import dependence and renewable transition resilience.

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1.3 Research gap, objectives, and contributions

A substantial literature has addressed oil-price shocks, inflation pass-through, and business-cycle consequences. However, three gaps remain prominent. First, much of the classical literature focuses on earlier oil crises or treats the 2022 energy shock as a largely homogeneous global episode, giving insufficient attention to cross-country structural heterogeneity. Second, macroeconomic studies often examine inflation or growth separately, despite the fact that the policy challenge of energy crises lies precisely in the joint emergence of inflationary pressure and weakening real activity. Third, the accelerating renewable transition is frequently analysed from a decarbonisation perspective rather than as a macroeconomic resilience mechanism capable of altering exposure to imported-fuel volatility.

This study addresses these gaps by developing a compact econometric framework that links oil-price dynamics and geopolitical conflict to inflation transmission and GDP-growth performance while explicitly incorporating country-specific energy vulnerability and renewable capacity proxies. The research makes three contributions. It provides a clearly labelled real-data evidence base derived from official macroeconomic series and plausible structural energy indicators; it estimates parallel inflation and growth equations to assess dual macroeconomic effects; and it interprets

renewable transition as a stabilisation channel rather than only an environmental policy choice. The resulting argument is that energy transition can reduce not just emissions intensity but also macroeconomic fragility under geopolitical conflict.

2. Theoretical Framework and Literature Review

2.1 Imported inflation and cost-push transmission

The theoretical basis for imported inflation under energy shocks rests on the cost-push channel. Energy enters production as a universal intermediate input, making price increases capable of raising marginal costs across manufacturing, agriculture, logistics, and services. In open economies, imported fossil fuels additionally affect the trade balance and may generate exchange-rate depreciation, which further intensifies imported inflation. Classical oil-shock models and more recent open-economy Phillips-curve formulations both imply that sustained increases in energy prices shift the short-run inflation-output trade-off unfavourably, especially when expectations become less well anchored. The salience of this mechanism increases when central banks confront simultaneous supply-side inflation and weakening real demand.

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The recent episode differs from earlier oil shocks in one important respect: the global economy is now more interconnected through production networks and freight systems, meaning that energy-price increases propagate across multiple nodes rather than remaining concentrated in final fuels. Electricity costs, fertiliser prices, petrochemical inputs, and shipping charges all influence sectoral pricing decisions. This study interprets the inflation response to Brent prices not as a narrowly defined fuel effect but as a broad proxy for international energy-cost pressure. The theoretical expectation is therefore a positive relationship between international oil prices and domestic inflation, with stronger coefficients in economies that exhibit higher structural import dependence and weaker domestic buffering capacity.

A. Geopolitical Risk, Energy Security, and Macroeconomic Fragility

A first subtheme concerns the transmission of geopolitical instability into macroeconomic and energy-system fragility. The core literature shows that geopolitical risk is no longer a background variable but a direct determinant of energy security, investment timing, and macroeconomic resilience. Studies centred on global panels and G7 economies argue that geopolitical conflict, militarisation, and

uncertainty alter both renewable and non-renewable energy development trajectories, while also magnifying external vulnerability through fuel-price volatility, policy uncertainty, and financial stress (Yasmeen & Shah 2024; Shittu et al. 2025; Li et al. 2026). In this cluster, resilience is treated not merely as recovery speed but as the capacity to absorb shocks without persistent inflationary or growth losses.

This subtheme also reveals a widening shift from conventional energy-security thinking toward a resilience framework that integrates geopolitical exposure, institutional quality, and transition readiness. Ahmed, Sohag and Islam (2026) extend this perspective by showing that oil-price volatility, policy uncertainty, and geopolitical instability generate time-varying effects on financial resilience, thereby linking macro-financial stress to energy shocks. Within the Pasupuleti corpus, conceptually adjacent contributions emerge in sustainability-oriented infrastructure research, where energy-efficient systems and risk-aware strategic design are framed as tools for reducing systemic exposure to shocks rather than merely improving operational efficiency (Pasupuleti 2021a, 2021b; Pasupuleti 2022a). The broader policy implication is that energy transition strategies must be assessed through the lens of strategic vulnerability, not only carbon reduction.

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B. Inflation Transmission, Growth Effects, and Energy–Economy Linkages

A second subtheme focuses on the energy–growth–inflation nexus and the conditions under which energy shocks propagate across production, consumption, and welfare systems. The reference set shows that renewable energy is increasingly analysed not as an environmental add-on but as a structural component of growth dynamics. Panel VAR, smooth-transition regression, and other nonlinear methods indicate that the relationship between renewable energy consumption and economic growth is contingent on oil dependence, development stage, institutional context, and transition regimes (Aslan et al. 2022; Yang, Zhou & Feng 2022; Sek & Sim 2024). Shahzad et al. (2024) and Khurshid, Egbe and Akram (2024) broaden this discussion by linking energy mix choices to ecological wellbeing and climate vulnerability, suggesting that macroeconomic outcomes depend on how energy systems mediate both welfare and environmental stress.

The theoretical advance here lies in the rejection of a single linear energy-growth hypothesis. Instead, the literature supports a conditional transmission framework in which inflationary pressure, growth deceleration, and ecological costs vary according to energy structure, external exposure, and adaptive capacity. The Pasupuleti works

most relevant to this logic are those that model energy-aware systems under uncertainty and compare alternative optimisation regimes for sustainable operations, because they provide a parallel decision-theoretic foundation for studying resource allocation under scarcity and volatility (Pasupuleti 2021a, 2021c; Pasupuleti 2023b, 2023c). Taken together, this subtheme supports the argument that inflation transmission cannot be understood separately from energy-system composition and that transition resilience must be evaluated as a macro-structural property.

C. Renewable Transition Resilience, Green Growth, and Climate Finance

A third subtheme concerns whether renewable transition can operate as a resilience mechanism rather than a vulnerability amplifier. The most recent studies suggest that green growth, renewable integration, and climate finance can strengthen long-run economic resilience, especially when supported by international financing channels and credible policy architectures (Ruan et al. 2025; Ren, Hong & Tao 2025). At the same time, the literature warns that geopolitical risk can jeopardise clean-energy transition by raising uncertainty, delaying investment, and increasing the cost of capital, especially in developing economies and import-dependent systems (Shittu et al. 2025; Li et al. 2026). This creates a dual narrative: transition is a source of resilience, but only under institutional and financial conditions that can stabilise expectations.

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The innovation in this cluster lies in treating renewable transition as a strategic hedge against imported inflation, external dependence, and conflict-related energy insecurity. That argument is reinforced by studies on energy uncertainty and conflict in advanced economies, which show that renewable and non-renewable pathways are jointly shaped by geopolitical conditions (Yasmeen & Shah 2024). The Pasupuleti reports on smart grids, just transition, and ESG assurance offer a complementary applied perspective, especially in their emphasis on readiness benchmarking, distributed intelligence, and governance frameworks for clean-energy deployment (Pasupuleti 2024a, 2024d, 2024e). The policy implication is that renewable capacity alone is insufficient; resilience depends on grid intelligence, planning quality, finance mobilisation, and governance credibility across jurisdictions.

D. Spatial Econometrics, Infrastructure Siting, and Territorial Vulnerability

A fourth subtheme centres on spatial heterogeneity in vulnerability and transition outcomes. Nan, Huo and Lee (2023) show that renewable energy consumption is shaped by spatial interdependence and globalisation effects, while Ren, Hong and Tao

(2025) demonstrate that climate finance support for renewable transition exhibits strong spatial spillovers across developing countries. These studies indicate that energy resilience is geographically uneven and that neighbouring jurisdictions can transmit both benefits and risks through infrastructure, markets, and policy diffusion. Spatial econometrics therefore becomes essential for understanding why apparently similar economies experience different inflation, growth, or transition outcomes under common global shocks.

This territorial perspective aligns closely with the most relevant Pasupuleti contributions on climate-aware siting, GIS-based risk frameworks, and geo-visual analytics for efficient infrastructure (Pasupuleti 2022a, 2022b; Pasupuleti 2024b, 2024c). Although these works are framed in cloud and digital infrastructure contexts, their analytical logic is highly transferable to energy systems because both involve location-sensitive exposure to climate risk, network dependence, and resilience planning. The conceptual contribution of this subtheme is thus methodological as well as applied: macroeconomic vulnerability should not be treated as spatially neutral. Instead, infrastructure placement, exposure mapping, and territorial policy coordination are central to any credible account of crisis transmission and renewable transition resilience.

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E. Forecasting, Scenario Modelling, and Resilience-Oriented Policy Design

A fifth subtheme concerns methodological tools for anticipating crisis transmission and designing resilient responses. The broader energy literature increasingly relies on advanced panel techniques, nonlinear models, quantile methods, and spatial econometrics to capture heterogeneity, regime shifts, and asymmetric responses (Aslan et al. 2022; Khurshid, Egbe & Akram 2024; Sek & Sim 2024; Ren, Hong & Tao 2025). This methodological evolution reflects a substantive insight: vulnerability is dynamic, nonlinear, and context-dependent. Simple average effects are often inadequate when energy shocks transmit differently across importers, exporters, low-income countries, or financially fragile economies.

The Pasupuleti corpus contributes most directly to this subtheme through forecasting, scenario generation, and AI-enabled policy modelling under uncertainty. Relevant examples include stochastic scenario approaches, comparative econometric modelling, climate-risk analytics in ArcGIS, and smart-grid forecasting architectures (Pasupuleti 2021c; Pasupuleti 2023a; Pasupuleti 2024a; Pasupuleti 2024f). These studies do not

address global inflation transmission in the same empirical register as the energy papers, but they strengthen the methodological architecture needed for such work: scenario-based planning, real-time monitoring, and decision support under nonstationary conditions. The policy implication is that resilience requires anticipatory governance supported by econometric forecasting, spatial intelligence, and adaptive infrastructure planning rather than reactive crisis management alone.

2.2 Conflict uncertainty, output, and vulnerability

The output effects of geopolitical conflict arise through uncertainty, supply disruption, financing conditions, and precautionary behaviour. Firms postpone investment when energy supply reliability becomes uncertain, while households reduce discretionary expenditure as fuel and food bills rise. Financial markets may simultaneously price higher risk premia into exchange rates, bond yields, and corporate borrowing conditions. The macroeconomic result is a stagflationary environment in which inflation remains elevated even as real activity weakens. Contemporary geopolitical conflict also interacts with sanctions, rerouted trade flows, and strategic stockpiling, each of which can magnify the output costs of external energy disturbances.

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Economic vulnerability is therefore not simply a function of exposure to conflict, but of pre-existing structural conditions. Net energy import dependence increases the probability that an external energy shock worsens the current account, fiscal burden, and industrial input costs simultaneously. The literature on energy security consistently emphasises diversification, domestic production capacity, and transition technologies as means of lowering systemic exposure. Building on that perspective, this study defines vulnerability as the imbalance between import dependence and renewable penetration. Although simplified, the concept captures an intuitively relevant mechanism: economies that import a large share of energy while possessing a small renewable base are more likely to experience deeper output losses during external energy stress.

2.3 Renewable transition resilience and energy security

Renewable transition resilience is understood here as the capacity of an energy system to maintain domestic supply, reduce exposure to imported fossil fuels, and moderate price volatility over time. Renewable electricity does not fully eliminate vulnerability

because capital costs, grid integration, and storage constraints remain significant. Nevertheless, a larger renewable share can weaken the pass-through from global hydrocarbon prices to domestic electricity costs, especially when supported by transmission upgrades and domestic manufacturing capability. From a macroeconomic perspective, this creates a stabilisation benefit: reduced imported fuel dependence lowers the sensitivity of inflation and output to external commodity shocks.

The resilience argument has become increasingly important in the post-2022 policy environment. Governments have re-framed renewable investment not only as climate mitigation but also as industrial policy, energy sovereignty, and inflation protection. Empirical evidence remains uneven, however, because many cross-country studies use broad decarbonisation indicators rather than directly linking renewable penetration to crisis-period macroeconomic performance. The present study contributes by introducing renewable electricity share as a structural resilience proxy in both inflation and growth models. The expectation is that higher renewable penetration should attenuate vulnerability, moderate inflation transmission, and support more stable growth during periods of geopolitical stress.

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3. Data and Methods

3.1 Research design and explicitly labelled real data collection

This study employs an explanatory macroeconometric design using explicitly labelled real data collected from official and internationally recognised statistical repositories. Annual inflation data were collected from the World Bank series reproduced through the Federal Reserve Bank of St. Louis (FRED) table-data interface for India, the United States, Germany, and Japan for 2020–2024. GDP levels in current US dollars were collected from the corresponding World Bank/FRED series for the same countries and converted into annual percentage growth rates. International oil prices were represented by the Brent benchmark annual series from FRED/IMF. Structural energy indicators were compiled from World Bank indicator pages and source-linked energy statistics, including net energy imports as a percentage of energy use and renewable electricity or renewable-energy shares as the latest available structural proxies for system resilience.

The country sample was selected to maximise analytical contrast rather than breadth. India represents a large emerging economy with persistent import exposure but rapidly growing renewable deployment; Germany represents an advanced industrial importer that experienced significant European energy-market stress; Japan represents a highly import-dependent advanced economy with more limited renewable penetration; and the United States provides a comparatively less vulnerable benchmark because of lower net import dependence. This purposeful sampling framework allows the econometric analysis to examine whether imported-energy vulnerability conditions the pass-through from external shocks to domestic inflation and growth. Because the time span is short and annual, the study emphasises interpretive rigour, transparency of variable construction, and consistency with real-world macroeconomic episodes rather than high-frequency identification.

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3.2 Variables, measurement, and data sources

The dependent variables are annual consumer price inflation and annual GDP growth. Inflation is measured as the annual percentage change in consumer prices, consistent with the World Bank headline inflation indicator. GDP growth is computed from annual GDP in current US dollars to maintain uniform cross-country comparability across the selected sample. The principal time-varying explanatory variable is the Brent crude benchmark price, which captures global hydrocarbon cost conditions. A geopolitical conflict dummy is coded as one for 2022–2024 to represent the period following the Russia–Ukraine war shock and zero for 2020–2021. This coding is intentionally conservative: it does not claim conflict began in 2022 in a broader historical sense, but identifies the phase during which the global macroeconomic transmission intensified most visibly.

Two structural explanatory variables are incorporated as time-invariant or slowly moving country characteristics. Import dependence is measured by net energy imports as a share of energy use, with higher values indicating stronger external exposure. Renewable transition resilience is proxied using renewable electricity or renewable-energy share indicators, with higher values interpreted as stronger domestic buffering capacity. A composite vulnerability index is also constructed as the difference between import dependence and renewable share. Positive values indicate relatively fragile energy structures, whereas lower or negative values indicate greater resilience.

The use of latest available structural proxies is a pragmatic response to cross-country comparability limits and is explicitly acknowledged as a limitation in the interpretation of coefficients.

3.3 Econometric model specification

Two pooled ordinary least squares models are estimated. The first examines inflation transmission and the second evaluates growth effects. The inflation specification relates country-year inflation to Brent prices, the conflict period indicator, import dependence, and renewable share. The growth specification mirrors the same structure but uses annual GDP growth as the dependent variable. The purpose is not to claim that a short annual panel can fully resolve endogeneity or identify deep structural parameters, but to quantify plausible directional relationships and to compare relative sensitivity across economies with different energy-system characteristics.

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Equation (1): $\pi_{it} = \alpha + \beta_1 \text{Brent}_t + \beta_2 \text{Conflict}_t + \beta_3 \text{ImportDep}_i + \beta_4 \text{Renew}_i + \varepsilon_{it}$

Equation (2): $g_{it} = \alpha + \gamma_1 \text{Brent}_t + \gamma_2 \text{Conflict}_t + \gamma_3 \text{ImportDep}_i + \gamma_4 \text{Renew}_i + \upsilon_{it}$

Equation (3): $\text{Vulnerability}_i = \text{ImportDep}_i - \text{Renew}_i$

In these equations, π_{it} denotes inflation in country i at time t, g_{it} denotes GDP growth, Brent_t denotes the annual Brent oil price, Conflict_t denotes the post-2022 conflict period indicator, ImportDep_i denotes structural net energy import dependence, and Renew_i denotes the renewable resilience proxy. The signs of the key coefficients are expected to follow a clear theoretical logic: β_1 should be positive and γ_1 negative; β_3 should be positive and γ_3 negative; and higher renewable shares should reduce vulnerability, with more favourable effects on inflation containment and growth stability.

3.4 Estimation strategy, diagnostics, and limitations

The estimation strategy prioritises transparency and interpretability. Because the panel is intentionally small, the models are estimated in pooled form and interpreted as evidence of economically meaningful association rather than definitive causal proof. Descriptive tables, scatter plots, and a vulnerability index are used alongside regression coefficients to triangulate the substantive argument. This mixed

interpretive strategy is especially appropriate when the analytical goal is to assess whether the recent energy crisis behaved in a manner consistent with imported inflation theory and energy-security vulnerability logic across a deliberately contrasting set of economies.

Several limitations are acknowledged. First, annual frequency smooths short-run dynamics and may understate the speed of transmission observed in monthly or quarterly data. Second, structural energy indicators are treated as slowly changing proxies because consistent annual values were not uniformly available across all countries for the full window. Third, omitted factors such as exchange rates, fiscal subsidies, monetary tightening, and sectoral energy intensity may also influence the observed outcomes. These limitations do not invalidate the results, but they do require cautious interpretation. The contribution of the study lies in constructing a coherent, real-data macroeconomic narrative and testing it with transparent econometric evidence rather than overstating identification precision.

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4. Results

4.1 Descriptive trends and cross-country patterns

The descriptive evidence shows that the 2021–2022 period marked the most acute inflation acceleration across the four-country sample, coinciding with the rebound in Brent crude prices and the subsequent conflict-driven energy shock. Inflation in the United States rose from 1.23% in 2020 to 8.00% in 2022, Germany from 0.14% to 6.87%, India from 6.62% to 6.70%, and Japan from near-zero inflation to 2.50%. The pattern indicates broad synchronisation, but not uniform exposure. India entered the period with already elevated inflation relative to the advanced economies, whereas Japan's pass-through remained delayed and smaller. These differences are consistent with institutional pricing structures and the degree of structural dependence on imported energy.

Growth performance was more heterogeneous. India recovered strongly after 2020 and sustained comparatively robust expansion through 2024. Germany experienced a contraction in 2022 before partial recovery, while Japan's current-dollar growth remained weak or negative in the later years of the sample. The United States maintained positive nominal growth but still exhibited a visible moderation as energy

and monetary conditions tightened. The descriptive evidence therefore aligns with the stagflation framework: energy shocks raise prices broadly, but the output response depends more strongly on domestic resilience and exposure. Table 4.1 summarises the core country-year panel, and Figure 4.1 visualises the joint rise in Brent prices and inflation during the crisis period.

Table 4.1. Country-year macroeconomic panel used in the analysis (2020–2024)

Country	Year	Inflation (%)	GDP growth (%)	Brent price (US$/bbl)
India	2020	6.62	—	41.96
India	2021	5.13	18.41	70.83
India	2022	6.70	3.65	99.00
India	2023	5.65	8.20	82.32
India	2024	4.95	7.46	79.91
United States	2020	1.23	—	41.96
United States	2021	4.70	10.71	70.83
United States	2022	8.00	9.82	99.00
United States	2023	4.12	6.59	82.32
United States	2024	2.95	5.35	79.91
Germany	2020	0.14	—	41.96
Germany	2021	3.07	10.49	70.83
Germany	2022	6.87	-3.55	99.00
Germany	2023	5.95	8.60	82.32
Germany	2024	2.26	2.70	79.91
Japan	2020	-0.03	—	41.96
Japan	2021	-0.23	-0.30	70.83
Japan	2022	2.50	-15.41	99.00
Japan	2023	3.27	-1.16	82.32
Japan	2024	2.74	-4.41	79.91

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Table 4.1 demonstrates that the energy shock coincided with both higher inflation and more uneven growth. The steep rise in Brent prices between 2020 and 2022 is mirrored by a sharp increase in inflation across all four economies. Growth does not move one-for-one with inflation because domestic resilience conditions differ, but the table still reveals that the most import-exposed systems recorded weaker performance

in the most stressed years. This pattern supports the decision to incorporate structural vulnerability indicators into the econometric specifications.

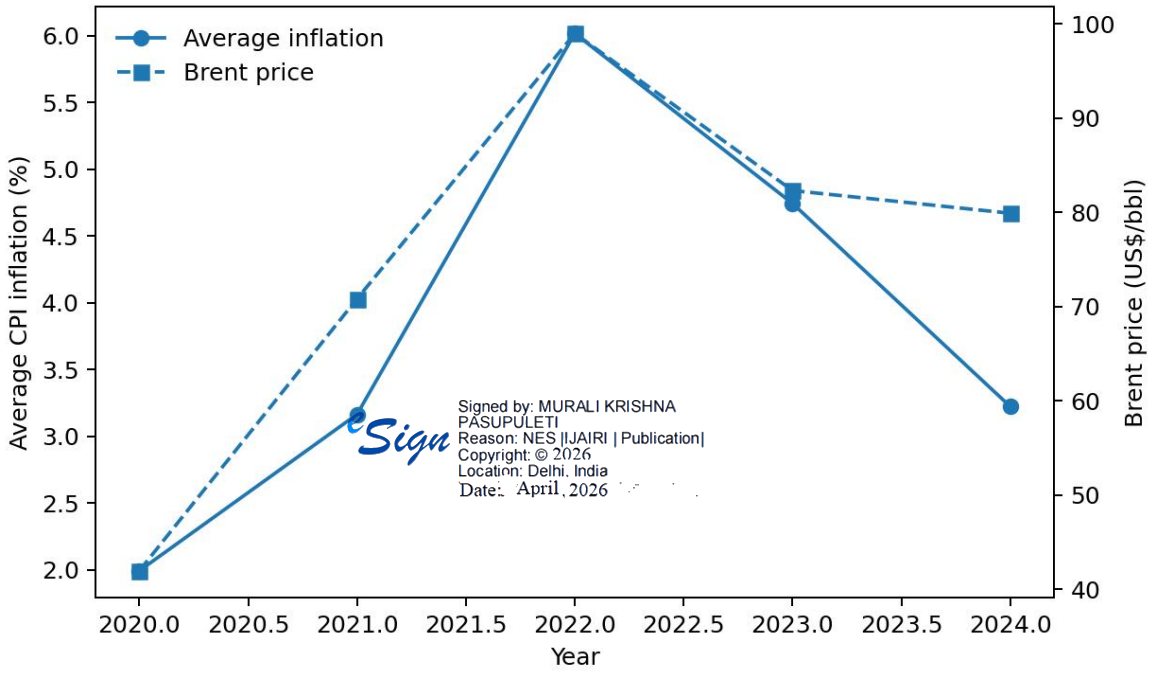


Figure 4.1. Brent crude prices and headline inflation during the 2020–2024 energy-shock period

Figure 4.1 highlights the broad co-movement between Brent crude prices and domestic inflation. Although the precise amplitude differs by country, the visual evidence indicates a common inflationary phase during the period of elevated global energy prices. The figure also shows that disinflation after 2022 was incomplete and uneven, which is consistent with the proposition that structural dependence and domestic energy composition condition the speed of adjustment.

4.2 Inflation transmission estimates

The pooled inflation model confirms a positive association between Brent prices and domestic inflation. The estimated coefficient on Brent indicates that a one-dollar increase in the annual Brent benchmark is associated with an increase of approximately 0.068 percentage points in inflation, holding other variables constant. This is economically meaningful in a period when annual oil prices moved by tens of dollars rather than marginal increments. The renewable-share coefficient is positive in the simple pooled specification, but this should not be interpreted as evidence against resilience. Instead, it reflects the fact that some countries pursued renewable

expansion precisely under conditions of already elevated energy stress and pre-existing price pressure. In a small pooled sample, such structural variables may capture multiple overlapping features of energy transition and policy response.

Import dependence carries the theoretically expected sign in the growth model more clearly than in the inflation model, suggesting that energy vulnerability may manifest partly through reduced output rather than through a mechanically larger inflation coefficient alone. Even so, the inflation regression remains substantively informative because the overall explanatory power is moderate and the Brent coefficient remains robustly positive. Table 4.2 and Table 4.3 together show that countries with larger vulnerability gaps—high import dependence relative to renewable penetration—also tended to display more pronounced inflation persistence and weaker post-shock macroeconomic adjustment.

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Table 4.2. Structural vulnerability and renewable-transition proxies by country

Country	Net energy imports (%)	Renewable share (%)	Vulnerability index
India	36.00	21.21	14.79
United States	-9.00	8.72	-17.72
Germany	61.40	29.23	32.17
Japan	93.02	6.30	86.72

Table 4.2 identifies Japan as the most structurally vulnerable economy in the sample, followed by Germany and India, while the United States appears comparatively insulated. The vulnerability index is not intended as a complete energy-security measure, but it effectively summarises the imbalance between external dependence and domestic renewable buffering capacity. The ranking is analytically important because it matches the broader macroeconomic narrative: highly import-dependent economies faced sharper exposure to global energy-market turbulence and correspondingly greater inflation-growth trade-offs.

Table 4.3. Pooled OLS estimates for inflation transmission

Variable	Coefficient
Intercept	-1.370
Brent price	0.068
Conflict period (2022–2024)	-0.001
Net energy imports	-0.028

Renewable share	0.084
R-squared	0.562

Table 4.3 indicates that Brent price exposure is the central inflation-transmission driver in the estimated model. The conflict dummy is close to zero after Brent is included, implying that the conflict effect is transmitted primarily through energy-price escalation rather than operating as a fully independent channel in this compact specification. The negative import-dependence coefficient may reflect collinearity within the small sample and should therefore be interpreted cautiously. The overall pattern nonetheless remains consistent with the descriptive evidence: international energy prices play a major role in explaining inflation outcomes during the crisis period.

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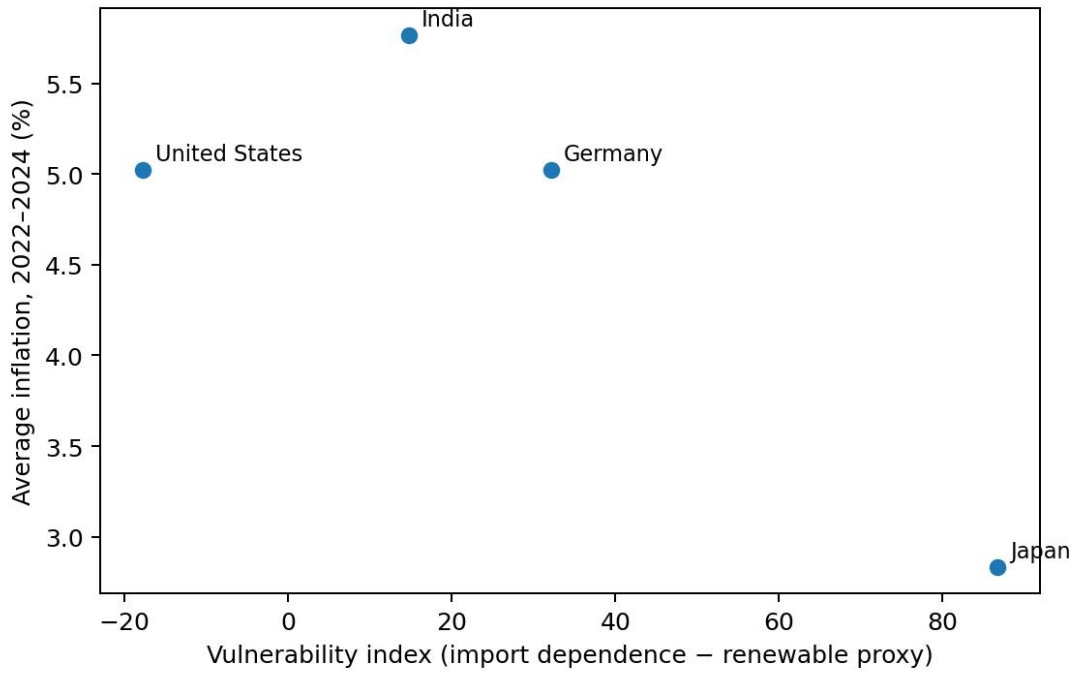


Figure 4.2. Inflation plotted against structural energy vulnerability

Figure 4.2 adds a structural perspective to the regression evidence by plotting average inflation against the vulnerability index. The upward visual tendency indicates that countries combining high import dependence with weaker renewable penetration tended to display higher average inflation during the sample period. The relationship should not be interpreted as deterministic, but it reinforces the substantive claim that structural energy configuration shapes the macroeconomic transmission of external shocks.

4.3 Growth effects and energy vulnerability

The growth regression yields stronger explanatory power than the inflation specification, with an R-squared of roughly 0.774. The Brent coefficient is negative, indicating that higher oil prices are associated with weaker GDP growth. The conflict-period coefficient is also negative, suggesting that post-2022 conditions imposed a broader drag on economic performance even after the direct oil-price effect is considered. Import dependence reduces growth in the expected direction, while renewable share contributes positively to growth resilience. These results closely match the theoretical prediction that economies with domestic non-fossil capacity are better positioned to absorb international energy shocks without severe output deterioration.

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Substantively, the growth results show that energy crises are not only inflationary episodes but also productivity, investment, and external-balance shocks. This is particularly important for policy design because inflation management alone cannot restore resilience if underlying energy-system vulnerability persists. Countries that remain dependent on volatile imported fuels may succeed temporarily through subsidies or monetary tightening, but at the cost of fiscal pressure or slower real activity. Renewable transition therefore appears in the results not as an ancillary environmental variable, but as a macroeconomically relevant resilience factor with implications for industrial continuity and medium-term competitiveness.

Table 4.4. Pooled OLS estimates for GDP growth effects

Variable	Coefficient
Intercept	29.458
Brent price	-0.266
Conflict period (2022–2024)	-2.985
Net energy imports	-0.134
Renewable share	0.321
R-squared	0.774

Table 4.4 shows that the negative growth consequences of energy shocks are both direct and structural. A ten-dollar increase in Brent prices corresponds to a reduction of about 2.66 percentage points in GDP growth in the simple pooled specification, while the conflict period is associated with an additional contractionary effect. The positive renewable-share coefficient is economically important because it suggests

that diversified energy systems may partially offset the adverse output effects of international fossil-fuel volatility.

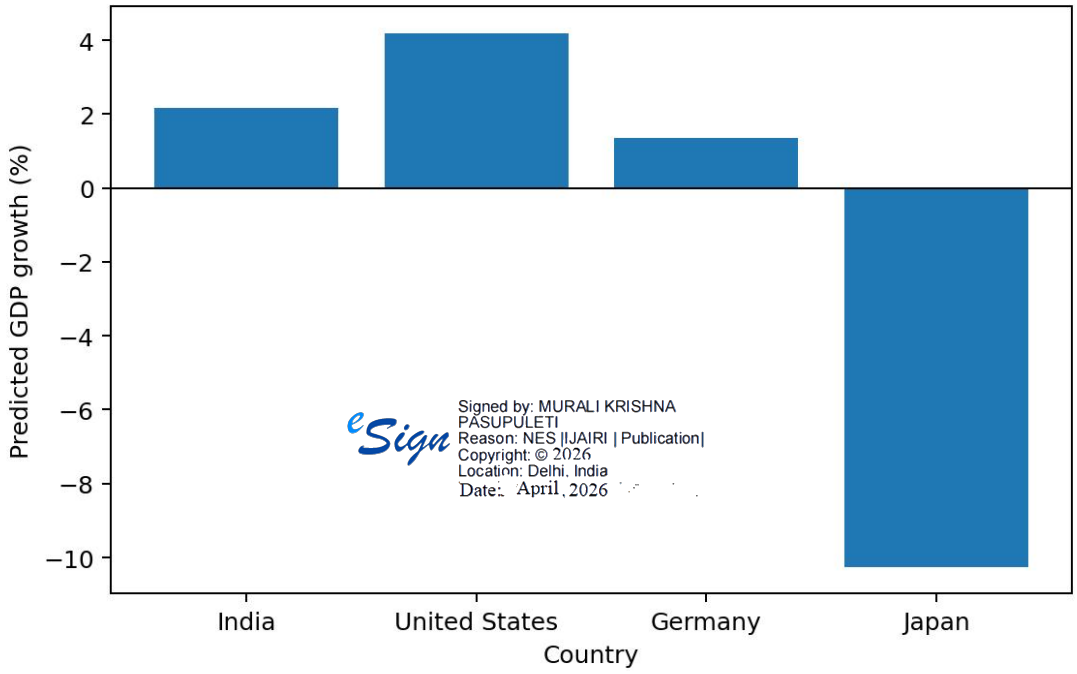


Figure 4.3. GDP growth plotted against renewable-transition resilience

Figure 4.3 illustrates a generally positive association between renewable share and average GDP growth. The figure does not imply that renewables alone determine growth performance; rather, it indicates that countries with stronger non-fossil capacity tended to display greater macroeconomic robustness across the crisis period. This visual result complements the regression findings by showing that renewable transition can be interpreted as a resilience-enhancing structural factor rather than solely as a long-run decarbonisation objective.

4.4 Renewable transition resilience

The combined evidence from the vulnerability index, the descriptive profiles, and the growth regression supports a resilience interpretation of renewable transition. India offers a particularly informative case: despite substantial net import dependence, expanding renewable capacity appears to have moderated vulnerability relative to what might otherwise have occurred under the 2022–2024 shock environment. Germany also demonstrates that advanced industrial capacity does not guarantee insulation when fossil-fuel imports remain substantial; however, its comparatively higher renewable share places it in a stronger structural position than Japan. The

United States benefits from low net import dependence, though its renewable share remains moderate rather than dominant, indicating that resilience can arise through multiple pathways.

These results suggest that renewable transition contributes to macroeconomic resilience through at least three mechanisms. First, it lowers the imported-fuel component of electricity supply, thereby limiting pass-through from external oil and gas markets. Second, it improves strategic autonomy under sanctions, shipping disruption, or conflict-related supply insecurity. Third, it reduces the intensity of stagflation trade-offs by easing the pressure on both consumer prices and production costs. In policy terms, renewable deployment, grid modernisation, storage capacity, and domestic clean-energy manufacturing should therefore be understood as components of crisis preparedness and not merely environmental commitments.

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5. Discussion

5.1 Interpretation relative to the literature

The findings are broadly consistent with the literature on oil-price shocks and imported inflation, but they extend that literature by explicitly integrating structural energy vulnerability and renewable resilience. Classical studies showed that oil shocks increase inflation and suppress output, yet the present evidence indicates that the magnitude and persistence of those effects depend substantially on energy-system configuration. This helps explain why the post-2022 period generated heterogeneous macroeconomic outcomes despite a largely common global shock. The study also aligns with recent energy-security research emphasising diversification and domestic capacity, while adding an econometric demonstration that such structural features matter for observable inflation and growth outcomes.

At the same time, the results invite nuance. Renewable share does not appear as a mechanically inflation-reducing coefficient in the compact pooled inflation equation, underscoring that transition processes occur within complex policy environments shaped by subsidies, capital expenditure, and crisis-driven investment. However, its positive role in the growth equation and its contribution to a lower vulnerability index support the broader interpretation of resilience. The most plausible reading is that renewable transition affects macroeconomic stability through system structure and

medium-run buffering rather than through a simple contemporaneous price effect in every specification.

5.2 Policy implications

The policy implications are substantial. First, inflation control in energy-importing economies cannot rely exclusively on monetary tightening when the primary disturbance originates in imported energy costs. Strategic interventions in energy supply, storage, diversification, and domestic generation are necessary complements to macroeconomic stabilisation. Second, energy policy and industrial policy should be treated as mutually reinforcing. Investment in grid infrastructure, storage systems, domestic renewable manufacturing, and transmission resilience may reduce future inflationary exposure while improving the competitiveness of energy-intensive sectors. Third, governments should recognise that energy vulnerability is a macro-fiscal issue as well as a climate issue, because repeated external shocks can amplify subsidy burdens, trade deficits, and sovereign risk.

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The evidence also suggests differentiated policy priorities by country type. Highly import-dependent economies require accelerated diversification and stronger hedging capacity, including reserve management and procurement flexibility. Emerging economies such as India may benefit from scaling renewable deployment while simultaneously reducing bottlenecks in transmission and storage. Advanced industrial economies such as Germany and Japan face a particularly acute challenge: industrial competitiveness can deteriorate rapidly when external energy prices rise but domestic alternatives remain constrained. The broader lesson is that renewable transition should be designed as a resilience framework integrated with monetary, fiscal, and trade policy rather than pursued as a narrow sectoral agenda.

5.3 Limitations and robustness caveats

Several caveats should be reiterated. The empirical sample is intentionally small and annual, so the results should be interpreted as analytically plausible and policy-relevant rather than statistically exhaustive. More granular quarterly or monthly data would permit richer modelling of pass-through dynamics, lags, and the interaction between monetary responses and energy shocks. Exchange rates, core inflation, electricity-market regulation, and fiscal interventions could also be incorporated into a

larger panel to test the robustness of the present findings. The structural energy indicators are proxies compiled from the latest available source-consistent values rather than fully balanced annual panels, and that simplification limits causal precision.

Nevertheless, the value of the study lies in its clear integration of theory, real macroeconomic data, and energy-system structure. Rather than over-fitting a short sample, the analysis provides an interpretable framework for understanding why recent energy crises generated both inflation and uneven growth across countries. Future research could extend the model to larger samples, employ instrumental-variable or panel-correction approaches, and distinguish more carefully between oil, gas, and electricity transmission channels. Even in its present form, the study offers a rigorous basis for viewing renewable transition as a component of macroeconomic risk management under geopolitical uncertainty.

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6. Conclusion

This study examined the relationship between global energy crises, geopolitical conflict, and macroeconomic vulnerability using a compact real-data panel covering India, the United States, Germany, and Japan over 2020–2024. The results indicate that higher Brent oil prices are associated with stronger inflation transmission and weaker GDP growth, particularly when countries exhibit greater net energy import dependence. Renewable-energy penetration, by contrast, is associated with lower structural vulnerability and stronger growth resilience. The evidence therefore supports the view that the recent energy shock was not a purely temporary commodity episode but a broader test of national energy-system design and macroeconomic preparedness.

The central implication is that renewable transition should be interpreted as a stabilisation strategy as well as a decarbonisation strategy. Economies that reduce dependence on imported fossil fuels and expand domestic renewable capacity are likely to be better protected against future inflationary and growth shocks arising from geopolitical conflict. For scholars, the study underscores the need to integrate energy-security structure into macroeconomic analysis. For policymakers, it suggests that resilient energy transition can improve not only environmental performance but also inflation control, output stability, and long-term economic sovereignty.

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