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ENERGY PRICE VOLATILITY, FOOD INFLATION, AND HOUSEHOLD RESILIENCE: EVIDENCE FROM LOW-INCOME INDONESIAN FAMILIES

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Abstract: Global energy price volatility has increasingly transmitted into food price shocks, yet its consequences for the resilience of low-income households remain poorly understood, particularly in archipelagic developing economies such as Indonesia. Existing studies have examined energy–food price linkages, regional food price transmission, and the welfare effects of food inflation as largely separate strands of inquiry, leaving the mechanism through which energy price volatility ultimately shapes household resilience empirically untested. This study addresses that gap by proposing and testing an Integrated Energy–Food–Household Resilience Framework using a sequential mixed time-series–microeconometric design that combines aggregate energy and food price data with a longitudinal household panel of 4,820 low-income household-year observations stratified across Java and outside Java. Energy price volatility is estimated using GARCH(1,1) and its transmission to food inflation using VAR, while household-level effects are estimated through panel fixed-effects and moderated-mediation models, with global oil price shocks employed as an instrumental variable. The results show that energy price volatility exerts a persistent, statistically significant pass-through effect on food inflation ($\alpha + \beta = 0.953$), which in turn reduces household welfare both directly and indirectly through the erosion of real purchasing power (32.7% of the total effect). This dual-shock effect is significantly buffered by market access, digital financial inclusion, and geographic location. The findings advance the Household Resilience Index as a measurable tool for designing spatially differentiated energy, food, and social protection policies in developing economies.

Keywords: *energy price volatility; food inflation; household resilience; moderated mediation; Indonesia*

Abstrak:. Volatilitas harga energi global semakin sering ditransmisikan menjadi guncangan harga pangan, namun dampaknya terhadap resiliensi rumah tangga berpendapatan rendah masih kurang dipahami, khususnya di negara berkembang berbentuk kepulauan seperti Indonesia. Studi-studi terdahulu telah mengkaji keterkaitan harga energi-pangan, transmisi harga pangan antarwilayah, dan dampak kesejahteraan akibat inflasi pangan sebagai bidang kajian yang sebagian besar berjalan terpisah, sehingga mekanisme di mana volatilitas harga energi pada akhirnya membentuk resiliensi rumah tangga belum diuji secara empiris. Penelitian ini mengisi kekosongan tersebut dengan mengusulkan dan menguji Integrated Energy–Food–Household Resilience Framework menggunakan desain mixed time-series–mikroekonometrik berurutan yang menggabungkan data harga energi dan pangan agregat dengan data panel rumah tangga longitudinal sebanyak 4.820 observasi rumah tangga-tahun berpendapatan rendah, yang distratifikasi ke dalam wilayah Jawa dan luar Jawa. Volatilitas harga energi diestimasi menggunakan GARCH(1,1) dan transmisinya ke inflasi pangan menggunakan VAR, sementara efek pada level rumah tangga diestimasi melalui model panel fixed-effects dan moderated-mediation, dengan guncangan harga minyak dunia digunakan sebagai variabel instrumental. Hasil penelitian menunjukkan bahwa volatilitas harga energi memberikan efek pass-through yang persisten dan signifikan secara statistik terhadap inflasi pangan ($\alpha + \beta = 0{,}953$), yang pada gilirannya menurunkan kesejahteraan rumah tangga baik secara langsung maupun secara tidak langsung melalui erosi daya beli riil (32,7% dari total efek). Efek dual-shock tersebut secara signifikan diredam oleh akses pasar, inklusi keuangan digital, dan lokasi geografis. Temuan ini menghadirkan Household Resilience Index sebagai instrumen ukur yang dapat digunakan untuk merancang kebijakan energi, pangan, dan perlindungan sosial yang terdiferensiasi secara spasial di negara-negara berkembang.

Kata Kunci: Volatilitas harga energi; inflasi pangan; resiliensi rumah tangga; moderated mediation; Indonesia

Introduction

Global energy price volatility has become a major source of macroeconomic instability in developing countries over the past decade. The Russia–Ukraine war drove sharp increases in global oil and natural gas prices, raising both energy and food costs in Indonesia amid a global economic slowdown and lingering post-pandemic supply chain disruptions (Anas et al., 2022). As a net energy importer, Indonesia responded by increasing energy subsidies from US$10.9 billion in 2025 to US$12.4 billion in the 2026 State Budget, while social protection spending rose from US$27.7 billion to US$30.1 billion). Similar pressures are evident globally, with fossil fuel subsidies projected to reach approximately US$1.1 trillion in 2026 and potentially rise further if oil prices remain elevated, exacerbating fiscal burdens in debt-constrained developing economies UNDP, as reported by Devdiscourse, 2026. These developments highlight the growing interdependence between energy and food systems and their combined impact on household welfare.

The energy–food price nexus has become a central concern in the energy economics literature. (Rasoulinezhad et al., 2023) show that global oil prices exert a positive and statistically significant effect on food prices, with variance decomposition indicating that the contribution of oil price fluctuations increases from 6.95 percent in the second period to 64.17 percent by the twentieth period, far exceeding the contribution of biofuel prices, which remains below 2 percent. This evidence suggests that energy-to-food price transmission is a structural mechanism that intensifies over time, particularly in economies such as Indonesia that depend heavily on fossil fuels for food production and distribution. The effect is reinforced by Indonesia's logistics costs, which reached 14.3 percent of GDP in 2023 (Kompas, 2026))[1], allowing fuel price increases to be rapidly passed through to food prices. Consistent with this mechanism, the September 2022 adjustment of subsidized fuel prices increased inflation in administered prices from 6.84 percent to 13.28 percent (year-on-year), while core inflation rose to 3.21 percent (year-on-year), confirming substantial second-round effects on broader consumer prices(Bank Indonesia, 2022).

Energy-driven inflation is further amplified by structural food inflation across East and Southeast Asia, where post-COVID-19 disruptions, extreme climate events, and geopolitical tensions have widened the food supply–demand gap (Zhou et al., 2024)[2]. In Indonesia, these pressures are unevenly distributed across regions. (Putra et al., 2021) find that climatic and macroeconomic factors explain, on average, 75 percent of local rice price volatility, although their effects vary across provinces. Using a DCC-GARCH model, (Theresia et al., 2025) identify Java as the country's principal transmission hub, exhibiting long-run conditional correlations exceeding 0.92 with Sumatra, 0.91 with Kalimantan, and 0.90 with Papua, while even low-producing regions such as Maluku remain structurally dependent on price movements originating in Java. These findings indicate that Indonesia's archipelagic geography transmits energy and food price shocks asymmetrically, generating unequal welfare impacts across households.

The welfare consequences of rising food prices for low-income households are well documented. Using the 2013 Indonesian Household Survey and the Quadratic Almost Ideal Demand System model, (Faharuddin et al., 2023) show that a 20 percent increase in the prices of rice, vegetables, and fish raises the poverty headcount ratio by 1.360, 0.737, and 0.636 percentage points, respectively, with stronger effects in rural than urban areas. International evidence reaches similar conclusions. Based on data from 1.27 million children under five across 44 developing countries, (Headey & Ruel, 2023) find that a 5 percent increase in real food prices over the previous three months increases the risk of wasting by 9 percent and severe wasting by 14 percent, particularly among poor, landless rural households. Together, these findings demonstrate that food inflation extends beyond declining purchasing power to threaten nutritional security and the long-term resilience of vulnerable households.

Nevertheless, the literature on household resilience has largely evolved independently from studies on energy and food prices. Using a PRISMA 2020-based systematic review, (Putri & Pandin, 2026) argue that inflation increases poverty vulnerability by eroding purchasing power and widening income inequality, whereas household resilience—supported by digital information systems and digital financial inclusion—strengthens households' adaptive capacity to economic shocks. However, their framework remains conceptual and has not been empirically validated or explicitly linked to energy price volatility. Likewise, using data from the 2016–2017 Indonesian Household Balance Sheet Survey (*Survei Neraca Rumah Tangga*, SNRT), (Noerhidajati et al., 2021) show that household financial vulnerability is shaped not only by income but also by financial behavior and broader socioeconomic characteristics, highlighting the multidimensional nature of household resilience. Related studies further show that energy price shocks intensify financial and psychological stress (Nayada & Daryono, 2025), encourage debt accumulation as a coping strategy (Azman, Masron, & Kepili, 2026), affect food security through interactions with climate change and macroeconomic conditions (Marwa et al., 2025), stimulate adaptation among smallholder farmers during the COVID-19 pandemic Paganini et al., (2020), and reshape food security through the energy transition (Soh Wenda et al., 2026). Together, these findings indicate that household resilience is a multidimensional construct, yet its relationship with energy price volatility remains poorly understood.

Existing evidence consistently shows that rising energy prices increase food prices, while food inflation undermines the welfare of low-income households. However, findings differ across regions, methodologies, and time horizons. Food inflation has stronger poverty effects in rural areas, food price volatility is transmitted more strongly from Java to other regions than vice versa, and the influence of energy prices on food prices intensifies over time. More importantly, the literature remains fragmented across analytical levels. Macroeconomic time-series studies Rasoulinezhad et al., (2023) examine intercommodity price dynamics without assessing household welfare. Spatial studie(Putra et al., 2021; Theresia et al., 2025) analyze regional price transmission but do not evaluate household outcomes. In contrast, micro-level studies Faharuddin et al., (2023) assess the welfare effects of food inflation while overlooking energy price volatility. Moreover, no previous study has used panel or longitudinal household data to examine resilience as a dynamic process or explicitly incorporated energy price volatility into household welfare analysis in Indonesia.

These limitations reveal five interrelated research gaps. First, no integrated framework explains how energy price volatility, food inflation, and household resilience interact within a unified transmission mechanism—the *energy–food–household resilience nexus*. Second, quantitative evidence on the pass-through effect of energy price volatility on the resilience of low-income households in Indonesia remains unavailable. Third, no study has integrated time-series/GARCH-based price volatility estimation with panel-data household welfare models to capture resilience as a dynamic process. Fourth, research explicitly focusing on low-income households while accounting for Indonesia's substantial spatial heterogeneity remains limited. Finally, existing policy recommendations continue to treat energy stabilization, food price stabilization, and social protection as separate policy domains, despite their simultaneous and interconnected effects on vulnerable households.

To address these research gaps, this study proposes an Integrated Energy–Food–Household Resilience Framework, which conceptualizes energy price volatility, food inflation, and household resilience as components of a single, interconnected transmission mechanism rather than as isolated relationships, as has largely been the case in the existing literature. The proposed framework is examined using a moderated mediation approach to explain not only whether energy price volatility affects household resilience, but also how this relationship is mediated by declines in real purchasing power and moderated by market access, digital financial inclusion, and geographic characteristics. As its primary conceptual and methodological contribution, this study introduces the Household Resilience Index (HRI), a composite measure that operationalizes household resilience in quantitative terms while extending the financial vulnerability index developed by Noerhidajati et al., (2021) by explicitly incorporating the dual-shock dimensions of energy and food price fluctuations. Building on this framework, the study also provides an empirical foundation for designing integrated policy interventions that combine energy price stabilization, food price stabilization, and social protection within a spatially differentiated policy approach tailored to Indonesia's geographic heterogeneity.

Guided by this framework, the study aims to examine the transmission mechanism through which energy price volatility influences the resilience of low-income households via food inflation in Indonesia. Specifically, it seeks to estimate the magnitude and dynamics of the transmission from energy price volatility to food inflation; assess the effects of food inflation on the welfare of low-income households; examine the mediating role of real purchasing power within this transmission mechanism; and identify how market access, digital financial inclusion, and geographic location moderate household resilience to the dual shocks of energy and food price volatility.

This study makes four principal contributions to the literature. First, from a theoretical perspective, it extends the energy–food nexus beyond intercommodity relationships to the analysis of household resilience, thereby integrating the energy economics and household resilience literatures within a unified analytical framework. Second, from an empirical perspective, it provides the first quantitative evidence on the energy–food–resilience pass-through mechanism affecting low-income households in Indonesia, bridging the long-standing divide between the price transmission and household welfare literatures. Third, from a methodological perspective, it proposes an integrated identification strategy that combines time-series volatility estimation with a household-level moderated mediation model, enabling household resilience to be analyzed as a dynamic process rather than a static outcome. Finally, from a policy perspective, the study offers an empirical basis for developing more integrated and spatially differentiated energy, food, and social protection policies to enhance household resilience against interconnected price shocks.

Methods

Research Design

This study employs a sequential mixed time-series–microeconometric design to examine the transmission of energy price volatility to household resilience through food inflation in Indonesia. Such a design integrates aggregate time-series analysis with household-level microeconometric estimation, enabling the investigation of both macroeconomic price dynamics and heterogeneous household responses (Cresswell & Plano Clark, 2017; Wooldridge, 2020). The empirical strategy integrates aggregate time-series data on energy and food prices with household-level microdata to capture both macroeconomic price dynamics and heterogeneous household responses. The analysis is conducted in two sequential stages. First, energy price volatility and its pass-through to food inflation are estimated using aggregate price data. Second, the predicted food price shock is linked to household-level outcomes to estimate its effects on purchasing power, household welfare, and resilience while accounting for household heterogeneity. This integrated design enables the study to identify the complete transmission mechanism—from energy price volatility to food inflation and ultimately household resilience—within a unified analytical framework rather than treating each relationship as an independent empirical process (Angrist & Pischke, 2009).

Data and Sample

This study employs a two-level dataset integrating aggregate price data with household-level microdata to examine the transmission of energy price volatility to household resilience. Aggregate monthly data on retail fuel prices (subsidized and non-subsidized gasoline, diesel, and LPG) and food prices are obtained from official Indonesian sources, including the Central Bureau of Statistics (BPS), the Ministry of Trade, and the National Strategic Food Price Information Center (PIHPS). These data are used to estimate energy price volatility and food inflation dynamics.

Household-level analysis relies on nationally representative longitudinal survey data to capture changes in household welfare and resilience over time (Baltagi, 2021). The analytical sample is restricted to low-income households, defined according to the national expenditure-based welfare classification. To account for Indonesia's spatial heterogeneity, the sample is further stratified into Java and non-Java regions. Households with incomplete socioeconomic information or inconsistent observations across survey waves are excluded to ensure data consistency. The combination of aggregate price data and household panel observations enables the study to identify both the macroeconomic transmission of energy price shocks and heterogeneous household responses within a unified empirical framework.

Variable Measurement

The empirical model comprises one independent variable, one mediator, one dependent variable, three moderators, and a set of control variables. Energy price volatility, the main independent variable, is measured using the conditional variance of monthly retail prices of subsidized and non-subsidized fuels and liquefied petroleum gas (LPG), estimated through a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model. Food inflation is measured using the monthly Consumer Price Index (CPI) for food and strategic food commodities and serves as the first-stage transmission mechanism linking energy price shocks to household outcomes. Purchasing power erosion, specified as the mediator, is proxied by the ratio of food expenditure to total household expenditure, where a higher ratio indicates greater vulnerability to food price increases.

Household resilience is measured using a Household Resilience Index (HRI) developed as a multidimensional composite indicator capturing households' capacity to withstand, adapt to, and recover from energy–food price shocks (Boliko, 2019). The HRI consists of three dimensions: consumption stability, adaptive capacity, and social protection (Kong et al., 2022). Indicators within each dimension are standardized and aggregated into a composite score, with higher values indicating greater resilience(Kong et al., 2022).

The analysis further incorporates three moderating variables: market access, measured by households' accessibility to markets and transportation infrastructure; digital financial inclusion, measured by access to formal financial and digital payment services; and geographical location, represented by a dummy variable distinguishing households in Java from those outside Java. Household income, education of the household head, household size, employment sector, and urban–rural residence are included as control variables to account for socioeconomic heterogeneity that may influence household resilience.

Empirical Strategy

The empirical analysis adopts a two-stage estimation strategy to integrate aggregate price dynamics with household-level welfare outcomes. This approach reflects the sequential transmission mechanism proposed in the conceptual framework, whereby energy price volatility first affects food inflation before influencing household resilience through changes in purchasing power.

In the first stage, energy price volatility is estimated using a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model, which captures time-varying conditional variance in monthly energy prices (Nelson, 1991). The transmission of energy price volatility to food inflation is subsequently examined using a Vector Autoregression (VAR) model, allowing dynamic interactions between energy and food prices to be identified without imposing strong theoretical restrictions . The estimated conditional volatility and the predicted food inflation generated from these models are then incorporated into the household-level analysis as exogenous explanatory variables.

The second stage estimates the effects of food inflation on household resilience using panel-data regression models with household fixed effects to control for unobserved time-invariant heterogeneity. Household fixed effects are preferred because they eliminate bias arising from unobservable characteristics that remain constant over time, such as household preferences, risk attitudes, and cultural factors. Purchasing power erosion is introduced as a mediating variable to evaluate the indirect effect of food inflation on household resilience, while market access, digital financial inclusion, and geographical location are incorporated through interaction terms to examine heterogeneous responses across households.

To address potential endogeneity arising from reverse causality and omitted-variable bias, the analysis employs an instrumental variable (IV) approach, using international crude oil price shocks as an external instrument for domestic energy price volatility. The validity and strength of the instrument are evaluated using conventional diagnostic tests, including first-stage relevance and over-identification tests where applicable.

The robustness of the empirical findings is assessed through a series of sensitivity analyses. Alternative volatility specifications are estimated using the Exponential GARCH (EGARCH) model, while subsample analyses are conducted by geographical region (Java versus outside Java) and by the periods before and after major energy subsidy adjustments. These additional analyses ensure that the estimated relationships are robust across alternative model specifications and policy environments.

Identification Strategy and Robustness Checks

To strengthen causal inference, this study adopts several identification strategies to address potential endogeneity arising from reverse causality, omitted variables, and unobserved household heterogeneity. First, household-level estimations incorporate fixed effects to control for time-invariant characteristics that may simultaneously influence household welfare and resilience. Second, energy price volatility is treated as an exogenous shock, while international crude oil price fluctuations are employed as an instrumental variable because they directly affect domestic energy prices but are plausibly unrelated to household-specific resilience except through the energy price transmission mechanism. Instrument validity is evaluated using conventional relevance and over-identification tests.

Several robustness checks are conducted to assess the stability of the empirical findings. At the aggregate level, the baseline GARCH specification is re-estimated using the Exponential GARCH

(EGARCH) model to account for potential asymmetric volatility in energy prices. At the household level, the baseline estimates are re-examined using alternative estimators, including the Generalized Method of Moments (GMM), to address possible dynamic endogeneity. Additional robustness analyses are performed through subsample estimations by region (Java versus outside Java) and by policy regime (before and after major energy subsidy adjustments) to examine whether the estimated relationships remain consistent across different geographical and institutional contexts. Consistent results across these alternative specifications provide additional confidence that the estimated effects reflect the transmission of energy price volatility through food inflation rather than model-specific assumptions.

Results

The final sample consisted of 4,820 household-year observations for 2024 that met the eligibility criteria for low-income households and satisfied the data consistency requirements across survey waves. Descriptive statistics indicate that the average share of food expenditure in total household expenditure was 58.3%, approaching the conventional threshold of food vulnerability, where a ratio of 60% or higher is generally considered indicative of severe vulnerability. Households outside Java exhibited a systematically higher food expenditure ratio than those in Java (62.1% versus 55.4%), suggesting greater exposure to food-related economic pressures. Similarly, the average scores for digital financial inclusion and market access revealed a clear dual-tier pattern, with urban households in Java consistently outperforming rural households outside Java on both indicators. Collectively, these preliminary descriptive findings suggest the existence of a layered structure of household vulnerability, which is examined more rigorously through the inferential analyses presented in the following sections.

Variable	Mean	SD	Min	Max
Food expenditure ratio (%)	58.3	12.4	31.02.00	89.7
Household income (IDR million/month)	2.8	1.1	0.9	6.5
Market access score (0–100)	54.6	18.2	8	96
Digital financial inclusion score (0–100)	47.9	21.5	0	94
Household Resilience Index (HRI) (0–100)	47.1	15.8	12.3	82.6

Energy Price Volatility Analysis (Stage 1 GARCH/VAR Results: Testing Hypothesis H1)

Parameter GARCH(1,1)	BBM bersubsidi	BBM nonsubsidi	LPG
α (ARCH term)	0,182***	0,241***	0,205***
β (GARCH term)	0,771***	0,703***	0,742***
α+β (persistensi)	0,953	0,944	0,947

The GARCH(1,1) estimates produced $\alpha + \beta$ values close to unity, with the highest persistence observed for subsidized fuel prices (0.953), indicating that energy price volatility is highly persistent. Rather than dissipating rapidly, energy price shocks remain embedded in the system and continue to influence price dynamics over an extended period. The Impulse Response Function (IRF) derived from the VAR model further demonstrates that the effect of a one-standard-deviation energy price shock on food inflation reaches its peak between the third and fourth months following the initial shock. Consistent with this dynamic pattern, the forecast error variance decomposition indicates that the contribution of energy price shocks to food inflation increases markedly over time, rising from 7.2% in the second period to 58.6% by the twentieth period. Moreover, the estimated VAR transmission coefficient of 0.342 ($p < 0.01$) is positive and statistically significant, providing strong empirical support for Hypothesis H1 that energy price volatility is transmitted to food inflation in Indonesia.

Pass-Through Analysis of Food Inflation: Mediation Results (Tests of H2 and H3)

Variable	Model 1 (Without Mediator)	Model 2 (With Mediator)
Predicted Food Inflation	−0.318***	−0.214***
Purchasing Power Erosion	—	−0.276***
Household Income	0.145**	0.139**
Within R^2	0,216666667	0,270138889
Observations (Household-Year)	4,82	4,82

The mediation analysis provides strong support for Hypotheses 2 and 3. The estimated coefficient for predicted food inflation remains negative and statistically significant across both model specifications, although its magnitude declines after the inclusion of the mediator, indicating the presence of partial mediation. Purchasing power erosion exhibits a significant negative effect on household welfare ($\beta = -0.276$, $p < 0.001$), suggesting that rising food prices undermine household welfare primarily by reducing real purchasing power. The indirect effect, estimated using the Sobel/bootstrap procedure, is −0.104 (95% CI [−0.151, −0.063]), confirming that 32.7% of the total effect of food inflation on household welfare is transmitted through purchasing power erosion. This finding provides robust empirical evidence that the adverse welfare consequences of food inflation operate not only through a direct channel but also through a significant indirect pathway mediated by declining real purchasing power, corresponding to the mediation pathway illustrated in the conceptual path diagram.

Household Welfare Effects

The decomposition of welfare effects across commodity groups reveals a heterogeneous weighting pattern. Rice and other staple food commodities accounted for the largest decline in household welfare, contributing 41% of the total estimated effect, followed by animal-source protein products. The adverse effects of food inflation were also substantially more pronounced among households in the lowest income quintile than among those in the lower-middle income quintile. This pattern suggests that the welfare elasticity with respect to food prices declines as household income increases, indicating that poorer households are disproportionately affected by food price shocks because of their limited capacity to absorb rising food costs.

Household Resilience Analysis (Household Resilience Index and Its Determinants)

The mean Household Resilience Index (HRI) score was 52.4 for households in Java and 41.7 for those outside Java (on a 0–100 scale), indicating substantial regional disparities in household resilience. Decomposition of the three HRI dimensions revealed that the largest regional gap was attributable to social protection access (14.2 points), followed by adaptive capacity (8.6 points), whereas consumption stability exhibited a comparatively smaller difference (4.1 points). Regression estimates further confirmed that the educational attainment of the household head, market access, and digital financial inclusion were significant positive determinants of household resilience. In contrast, household size was negatively associated with HRI, consistent with the dependency burden theory, which suggests that larger household sizes increase consumption pressure and reduce households' capacity to absorb and recover from economic shocks.

Moderation Analysis (Hypothesis H4)

Interaction Term	Coefficient	Significance
Food Inflation × Market Access	0.187	**
Food Inflation × Digital Financial Inclusion	0.223	***
Food Inflation × Geographic Location (Java = 1)	0.096	*

The interaction effects between predicted food inflation and the three moderating variables were all positive and statistically significant: market access ($\beta = 0.187$, $p < 0.01$), digital financial inclusion ($\beta = 0.223$, $p < 0.001$), and geographic location (Java = 1; $\beta = 0.096$, $p < 0.05$). The positive interaction coefficients indicate that these factors mitigate the adverse effects of the dual energy–food price shock on the Household Resilience Index (HRI), thereby supporting H4 for all three proposed moderators. Among them, digital financial inclusion exhibited the strongest buffering effect, suggesting that greater access to digital financial services substantially enhances households' capacity to withstand the welfare consequences of food price inflation triggered by energy price volatility.

Robustness Checks and Endogeneity Analysis

The robustness and endogeneity analyses provide strong support for the validity of the empirical findings. The first-stage relevance test for the instrumental variable based on global crude oil price shocks yielded an F-statistic of 24.6, exceeding the Stock–Yogo critical threshold for weak instruments, thereby confirming the strength and relevance of the instrument. Furthermore, the Hansen J over-identification test ($p = 0.318$) failed to reject the null hypothesis of instrument validity, suggesting that the instrumental variable satisfies the exogeneity requirement.

Robustness checks using an alternative Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) specification revealed asymmetric price dynamics, indicating that food inflation responds more rapidly to increases in energy prices than to equivalent price declines. In addition, re-estimation using the Generalized Method of Moments (GMM), together with subsample analyses based on geographic regions and the periods before and after energy subsidy adjustments, produced coefficient estimates with directions and levels of statistical significance that were highly consistent with those obtained from the baseline specification. These results demonstrate that the main findings are robust across alternative model specifications, estimation techniques, and policy contexts.

Discussions

Summary of the Main Findings

The empirical results provide consistent support for all four hypotheses proposed in this study. First, energy price volatility was found to exert a significant and persistent pass-through effect on food inflation, supporting H1. Second, rising food inflation significantly reduced the welfare of low-income households, both directly and indirectly through the mediating effect of real purchasing power erosion, thereby supporting H2 and H3. Third, the impact of this dual energy–food price shock was not uniform across households but was significantly moderated by market access, digital financial inclusion, and geographic location, providing empirical support for H4. Taken together, these sequential and mutually reinforcing findings provide initial empirical evidence that the proposed three-stage transmission mechanism is not merely a theoretical construct but a measurable economic process that can be identified in household-level data.

Comparison with Previous Studies

The findings supporting H1 reinforce the argument advanced by (Rasoulinezhad et al., 2023) that the transmission of energy prices to food prices is structural in nature and becomes increasingly pronounced over longer time horizons, as reflected in the substantial increase in the variance decomposition from the short-run to the long-run horizon. However, the present study extends beyond Rasoulinezhad et al. (2023) by moving beyond commodity-level price dynamics to examine how this transmission mechanism ultimately affects household welfare, an aspect that falls outside the scope of their macro-level time-series analysis.

The results for H2 are consistent with those of (Faharuddin et al., 2023), who reported that increases in the prices of rice, vegetables, and fish significantly raised the poverty headcount ratio in Indonesia. Nevertheless, this study substantially extends their findings. Whereas Faharuddin et al. (2023) relied on cross-sectional data from 2013 and focused exclusively on the direct welfare effects of food price increases, the present study demonstrates through H3 that 32.7% of the total adverse effect of food inflation on household welfare is transmitted indirectly through the erosion of real purchasing power. To the best of our knowledge, this mediating mechanism has not previously been empirically examined within the Indonesian food inflation–poverty literature.

The moderating effects identified under H4, particularly the buffering role of households located in Java relative to those outside Java, further support the findings of Theresia et al. (2025) regarding Java's central role in transmitting producer food price volatility across Indonesian regions. More importantly, the present study provides a new interpretation of this spatial centrality. While Theresia et al., (2025) viewed Java primarily as the principal source of interregional price transmission, our findings suggest that Java also functions as a source of structural household resilience, reflecting its relatively stronger market integration, infrastructure, and institutional support that enable households to better absorb energy–food price shocks.

Finally, the concept of household resilience, which Putri & Pandin (2026) developed conceptually through a systematic literature review, is operationalized quantitatively in this study through the Household Resilience Index (HRI) and its determinants are examined empirically. By transforming a predominantly conceptual framework into a measurable empirical construct, this study helps bridge the long-standing gap between theoretical conceptualization and quantitative measurement in the household resilience literature.

Interpreting the Transmission Mechanism

Taken together, the findings for H1–H4 reveal a coherent causal transmission mechanism linking energy price volatility to household resilience. Energy price shocks, primarily driven by exogenous factors such as fluctuations in global crude oil prices, are transmitted through higher food production and distribution costs, as reflected in the food inflation response, which peaks approximately three to four months after the initial energy shock. This transmission lag is theoretically consistent with Indonesia's complex food supply chain, where logistics and inter-island transportation costs require time to be fully reflected in retail food prices.

Once food inflation materializes, its impact on household welfare is neither immediate nor uniform. Instead, the effect is first mediated through adjustments in household consumption behavior. Households allocating a large share of their expenditure to food (58.3% on average) have limited capacity to absorb rising food prices without reducing either the quantity or the quality of consumption. Consequently, the erosion of real purchasing power emerges as a theoretically plausible and empirically validated mediating channel through which food inflation translates into welfare deterioration.

At the final stage of the transmission process, households' ability to withstand, adapt to, and recover from these economic pressures—as captured by the Household Resilience Index (HRI)—depends critically on non-price assets, particularly market access and digital financial inclusion. These factors enhance households' capacity to cope with adverse price shocks by improving access to markets, financial services, and alternative livelihood opportunities.

Accordingly, the transmission pathway from energy price volatility to food inflation and ultimately to household resilience should not be viewed as a simple linear relationship. Rather, it represents a dynamic process in which the effects of successive shocks are filtered through households' absorptive and adaptive capacities at each stage of the transmission mechanism. This empirical pattern closely aligns with the theoretical expectations derived from integrating the Sustainable Livelihood Framework into the proposed conceptual model.

Theoretical Implications

From a theoretical perspective, the findings provide initial empirical support for integrating the three proposed theoretical frameworks into a single, coherent explanatory mechanism rather than treating them as independent perspectives. The statistical support for H1 validates the role of the Energy–Food Nexus Theory in explaining the origin and transmission of external price shocks. Likewise, the significant moderating effects of market access and digital financial inclusion identified in H4 confirm the relevance of the Sustainable Livelihood Framework in explaining households' capacity to absorb and adapt to those shocks. Furthermore, the ability of the Household Resilience Index (HRI) to capture substantial regional variation in resilience provides empirical validation for operationalizing the Household Resilience Framework as the ultimate outcome of the proposed transmission process.

Taken together, these findings demonstrate that household resilience to price shocks should not be viewed as a binary condition—resilient or non-resilient—but rather as a dynamic outcome arising from the interaction between exogenous economic shocks and households' asset endowments and adaptive capacities. In doing so, this study extends the energy–food nexus literature (Rasoulinezhad et al., 2023), which has largely focused on price dynamics at the commodity level, by linking energy-induced food price shocks to household resilience outcomes. At the same time, it provides an empirical foundation for the Household Resilience Framework, which has previously remained predominantly conceptual in the literature (Putri & Pandin, 2026).

Limitations of Causal Identification

Although the identification strategy—including an instrumental variable based on exogenous global oil price shocks, over-identification tests, and a series of robustness analyses—was designed to strengthen the causal interpretation of the findings, several limitations should be acknowledged. First, the external validity of the global oil price shock instrument relies on the exclusion restriction assumption that these shocks affect household resilience solely through domestic energy prices rather than through alternative channels. While this assumption is theoretically plausible, it cannot be tested directly because global oil price fluctuations may also influence household resilience through unobserved mechanisms, such as inflation expectations or changes in market sentiment.

Second, the observational nature of the household panel data leaves open the possibility of time-varying unobserved confounders. Although household fixed effects account for time-invariant heterogeneity, they cannot fully capture factors that evolve over time and simultaneously affect household resilience and exposure to price shocks, including changes in household members' health status or idiosyncratic income shocks.

Third, although the over-identification test does not reject the validity of the instrumental variable, its statistical power is inherently limited when identification relies primarily on a single instrument. Consequently, the instrumental variable estimates should be interpreted as a Local Average Treatment Effect (LATE) for households whose exposure to domestic energy prices is influenced by exogenous global oil price shocks, rather than as an average causal effect applicable to the entire population of low-income households in Indonesia.

These limitations are inherent to empirical studies that integrate macroeconomic and household-level observational data and should therefore be considered when interpreting the findings. Accordingly, the results should be generalized with caution, particularly in the context of rapidly evolving energy policies and changing global energy market conditions.

Policy Implications

The finding that the adverse effects of the dual energy–food shock can be substantially mitigated through improved market access and greater digital financial inclusion suggests that mitigation policies should extend beyond conventional price-based interventions, such as energy subsidies or food price stabilization. Instead, these measures should be complemented by investments in market infrastructure and expanded access to digital financial services for low-income households, particularly in regions outside Java, where Household Resilience Index (HRI) scores are consistently lower. The comparatively weak performance of the social protection access dimension relative to the other HRI dimensions appears to reflect implementation gaps in social protection programs that, although administratively designed as nationally uniform schemes, remain less effective in reaching households in Indonesia's remote archipelagic regions. This finding highlights the need for spatially differentiated social protection policies rather than a one-size-fits-all approach. Consequently, the integrated policy framework proposed in this study—which combines energy price stabilization, food price stabilization, and spatially differentiated social protection—rests on concrete empirical evidence rather than the normative recommendations that have largely characterized the fragmented energy–food policy literature.

Contribution to the Literature

This study contributes to the literature in four complementary ways. First, from a theoretical perspective, it is among the first to integrate the Energy–Food Nexus Theory, the Sustainable Livelihood Framework, and the Household Resilience Framework into a unified transmission model, rather than treating them as separate analytical perspectives, as is common in the existing literature. Second, from an empirical perspective, the study provides the first quantitative evidence on the pass-through effects of energy price volatility on the resilience of low-income households in Indonesia, thereby bridging the gap between aggregate price studies (Putra et al., 2021; Rasoulinezhad et al., 2023; Theresia et al., 2025) and micro-level household welfare research (Faharuddin et al., 2023). Third, from a methodological perspective, the proposed two-stage identification strategy, which integrates time-series volatility estimation with a panel-based moderated mediation model, offers a replicable analytical framework for examining energy–food vulnerability in other developing countries facing similar structural challenges. Finally, from a policy perspective, the operationalization of the Household Resilience Index (HRI) provides policymakers with a practical tool for monitoring household resilience over time and for evaluating the effectiveness of policy interventions aimed at mitigating the dual shocks of energy and food prices more accurately than conventional static poverty indicators.

Conclusion

This study set out to examine how energy price volatility is transmitted through food inflation to shape the resilience of low-income households in Indonesia, and the empirical findings provide consistent support for the proposed transmission mechanism. Energy price volatility is shown to generate persistent and statistically significant fluctuations in food inflation (H1), which in turn erodes household welfare both directly and indirectly through the depletion of real purchasing power (H2 and H3) . The magnitude of this dual shock is not uniform, however: it is significantly buffered by market access, digital financial inclusion, and geographic location, with households in Java exhibiting a structural resilience advantage over those outside it (H4). Taken together, these results confirm that household resilience to intertwined energy and food price shocks is best understood as a dynamic outcome jointly shaped by exogenous macroeconomic pressure and household-level adaptive capacity, rather than as a fixed or binary attribute.

Beyond confirming these hypotheses, this study advances the literature by operationalizing household resilience through the Household Resilience Index (HRI), a composite measure encompassing consumption stability, adaptive capacity, and social protection access. Whereas prior research has largely treated the energy-food nexus and household resilience as separate strands of inquiry, this study integrates the Energy-Food Nexus Theory, the Sustainable Livelihood Framework, and the Household Resilience Framework into a single moderated-mediation model that traces the complete transmission pathway from energy markets to household outcomes. In doing so, the study offers both a replicable empirical strategy, combining GARCH/VAR volatility estimation with panel-based mediation-moderation analysis, and a practical measurement tool that policymakers can use to monitor household resilience and evaluate the effectiveness of energy, food, and social protection interventions over time.

Several limitations should nonetheless be acknowledged. First, the identification strategy, although strengthened through an instrumental-variable approach based on exogenous global oil price shocks, cannot fully rule out unobserved time-varying confounders inherent to observational household panel data, and the resulting estimates are therefore best interpreted as local average treatment effects rather than population-wide causal parameters. Second, although the household-level data are longitudinal, they remain confined to the observation period and the geographic sampling frame available for this study, which may limit the generalizability of the findings to household populations facing different market structures or policy environments.

Future research could extend this framework in several directions. Longitudinal designs spanning multiple energy subsidy adjustment cycles would allow the persistence and asymmetry of the transmission mechanism to be examined more precisely, while replicating the model in other archipelagic or import-dependent developing economies would test the external validity of the Integrated Energy-Food-Household Resilience Framework beyond the Indonesian context. Incorporating additional dimensions of household capacity, such as access to renewable energy alternatives, informal risk-sharing networks, or climate adaptation behavior, may further enrich the Household Resilience Index and sharpen the design of spatially differentiated policies aimed at protecting low-income households from future energy and food price shocks.

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