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Economy-wide Effects of Fossil Fuel Price Shocks on Macro, Sectoral and Household Welfare

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Acronyms and Abbreviations

AIDS	*Almost Ideal Demand System*
BERC	*Bangladesh Energy Regulatory Commission*
BIDA	*Bangladesh Investment Development Authority*
BPDB	*Bangladesh Power Development Board*
CGE	*Computable General Equilibrium*
CES	*Constant Elasticity of Substitution*
CPI	*Consumer Price Index*
COP	*Conference of the Parties*
EDRI	*Ethiopian Development Research Institute*
EPRC	*Economic Policy Research Centre*
EU	*European Union*
FY	*Fiscal Year*
G7	*Group of Seven*
GAMS	*General Algebraic Modeling System*
GDP	*Gross Domestic Product*
GFCF	*Gross Fixed Capital Formation*
HICP	*Harmonized Index of Consumer Prices*
IEA	*International Energy Agency*
IEEFA	*Institute for Energy Economics and Financial Analysis*
IFPRI	*International Food Policy Research Institute*
IMF	*International Monetary Fund*
LA-AIDS	*Linear Approximate Almost Ideal Demand System*
LES	*Linear Expenditure System*
LNG	*Liquefied Natural Gas*
LPG	*Liquefied Petroleum Gas*
LTEP	*Long-Term Energy Price*
MMBtu	*Million British Thermal Units*
MTEP	*Medium-Term Energy Price*
ODI	*Overseas Development Institute*
OMS	*Open Market Sales*
OPEC	*Organization of the Petroleum Exporting Countries*
RMG	*Ready-Made Garments*
SAM	*Social Accounting Matrix*
SANEM	*South Asian Network on Economic Modeling*
SMEs	*Small and Medium Enterprises*
STEP	*Short-Term Energy Price*
SVAR	*Structural Vector Autoregression*
TJ	*Terajoule*
TTF	*Title Transfer Facility*
USD	*United States Dollar*
VAR	*Vector Autoregressive*
VGF	*Vulnerable Group Feeding*
WTI	*West Texas Intermediate*

Executive Summary

Bangladesh is structurally dependent on imported fossil fuels such as oil, coal, and liquefied natural gas (LNG) to sustain its rapidly growing energy needs. According to BPDB (2025), natural gas accounts for 44.09% of electricity generation, coal for 26.72%, and oil for 10.73%, while renewable energy contributes only 2.26% of the total power mix. The country's reliance on primary energy imports rose sharply from 47.7% in FY2020–21 to 62.5% in FY2024–25, deepening its exposure to global fossil fuel price volatility. This vulnerability was starkly demonstrated during the 2022 global energy crisis, when surging LNG and oil prices following the Russia–Ukraine war forced Bangladesh to suspend spot LNG purchases, triggering widespread and prolonged power cuts. Against this backdrop, understanding how global fossil fuel price shocks transmit through Bangladesh's domestic economy, affecting macroeconomic performance, sectoral output, and household welfare, is both urgent and policy-critical.

This report investigates the economy-wide effects of fossil fuel price shocks on Bangladesh's macroeconomy, productive sectors, and household welfare using a single-country, static Computable General Equilibrium (CGE) model developed according to the IFPRI standard framework (Lofgren et al., 2002) and calibrated with the highly disaggregated 2022 Bangladesh Social Accounting Matrix (SAM). The SAM covers 86 production sectors, 13 factor categories, and 15 household groups disaggregated by income quintile, location (rural and urban), and farm versus nonfarm status, enabling a granular assessment of both aggregate and distributional effects.

Three simulation scenarios are designed to capture shocks of varying magnitudes and durations: a Short-Term Energy Price (STEP) shock reflecting the 2022 Russia–Ukraine war price surge (39.15 percent increase in crude oil, 102.32 percent in natural gas, and 143.28 percent in coal); a Medium-Term Energy Price (MTEP) shock representing the persistence of elevated prices in 2024 relative to the pre-crisis baseline of 2019 (22.39 percent in crude oil, 39.65 percent in natural gas, and 23.92 percent in coal); and a Long-Term Energy Price (LTEP) shock operationalized as the average annual growth in global fossil fuel prices over 2015–2025 (3.83 percent in crude oil, 4.29 percent in natural gas, and 6.64 percent in coal).

Macroeconomic Impacts: Fossil-fuel price shocks generate significant adverse short-term macroeconomic effects, with impacts moderating over time. Under the STEP shock, GDP contracts by 0.79% as higher intermediate input costs compress output across production sectors, reduce real household incomes, and dampen consumption demand. The consumer price index (CPI) rises by 1.19%, reflecting the immediate pass-through of energy costs to consumer prices. The real exchange rate depreciates sharply by 5.28%, and the terms of trade deteriorate by 6.99%, signaling a worsening of Bangladesh's external price position. Despite these pressures, exports increase modestly by 0.44% as real exchange rate depreciation generates a competitiveness effect, while imports contract by 3.97%. These disruptions moderate substantially under the MTEP shock and become negligible under the LTEP shock, confirming that the economy can absorb gradual and persistent energy price increases over the long run, while remaining acutely vulnerable to sudden and large price spikes of the kind observed in 2022.

Sectoral Impacts: Energy price shocks affect sectors asymmetrically, producing a clear divide between energy-producing and energy-intensive sectors. The mining sector, encompassing coal, crude oil, and natural gas extraction, expands strongly by 9.86% under the STEP shock, as higher global prices increase the domestic value of fossil fuel production. The solar electricity sector expands by 5.80%, reflecting the improved competitiveness of renewable energy relative to fossil-fuel-based generation, an important structural signal for Bangladesh's energy transition agenda. In contrast, most sectors experience output contractions. Electrical equipment (-2.04%), water supply and sewage (-1.62%), restaurants and food services (-1.46%), food processing (-1.12%), transportation and storage (-1.09%), and construction (-1.04%) record the largest declines under the STEP shock. Agriculture contracts by 0.69%, reflecting higher costs of irrigation, mechanization, and fertilizers. Within manufacturing, Bangladesh's dominant export subsector, such as textiles, clothing, and leather goods, contracts by 0.47% in the short term but recovers to positive territory in the medium and long term as exchange rate depreciation restores export competitiveness. Sectoral impacts diminish across all scenarios, with most sectors recovering to near-baseline levels under the LTEP shock.

Household Welfare Impacts: Fossil fuel price shocks generate regressive welfare losses, with poorer, rural, and farm households bearing a disproportionately large burden. Under the STEP shock, aggregate real household income declines by 2.78%, and real consumption falls by 1.91%. Across income quintiles, the poorest households (Quintile 1) suffer the largest real income loss (-2.91%), compared with -2.73% for the richest quintile (Quintile 5), confirming the regressive character of energy price shocks through the income channel. The pattern differs for real consumption losses, where higher-income households experience slightly larger declines (-2.09% for Quintile 5 versus -1.64% for Quintile 1), reflecting their greater expenditure on energy-intensive goods and services. Rural farm households consistently experience larger welfare losses than rural nonfarm households across both income (-2.90% versus -2.68%) and consumption (-2.19% versus -1.75%) dimensions, driven by greater exposure to agricultural input and fuel costs. Welfare disparities narrow in the medium term and largely converge across household groups in the long term, though rural and farm households remain structurally more exposed across all time horizons.

Policy Recommendations: The findings call for proactive, coordinated, and time-sensitive policy responses across three dimensions. On macroeconomic policy, Bangladesh Bank should adopt a carefully calibrated monetary response that mitigates second-round inflationary effects without excessively compressing output. At the same time, the Ministry of Finance deploys countercyclical fiscal measures as explicitly time-limited interventions. The government should allow controlled exchange rate flexibility to support export competitiveness, maintain adequate foreign exchange reserves, diversify energy import sources, and establish a dedicated Energy Transition Fund to scale up investment in solar and renewable infrastructure (Raihan et al., 2025b).

On sectoral policy, the government should establish a Sectoral Energy Shock Relief Facility providing concessional credit and temporary energy tariff relief to the most severely affected sectors, conditional on energy efficiency commitments. A national Energy Efficiency and Industrial Modernization Program should offer tax incentives and investment grants for cleaner production technologies, particularly in food processing and manufacturing. Strategic support for the textile and RMG sector, including export facilitation and green certification incentives, and a Fuel Cost Stabilization Mechanism for commercial freight transport, is essential to protect export competitiveness and supply chain connectivity. Windfall revenues from the mining sector's expansion should be channeled into a Sovereign Energy Stabilization Fund.

On household welfare policy, the government should institutionalize an Automatic Social Protection Stabilizer, a pre-designed cash transfer mechanism triggered by defined global energy price thresholds, to rapidly reach Quintile 1 and Quintile 2 households before the full welfare impact of a shock materializes. The Open Market Sales (OMS) program and Vulnerable Group Feeding (VGF) scheme should be expanded specifically in rural agricultural districts, targeting the lowest two income quintiles. A reform of the lifeline electricity tariff structure and a targeted LPG voucher scheme for rural households would directly address energy affordability pressures. Long-term resilience should be built through rural skills development, income diversification programs, and a comprehensive Energy Poverty Reduction Strategy that combines subsidized solar home systems, clean cooking solutions, and community-level renewable energy infrastructure.

Taken together, the results highlight Bangladesh's acute vulnerability to sudden fossil fuel price spikes and the imperative for an integrated policy framework that simultaneously addresses macroeconomic stability, sectoral resilience, and household welfare protection while systematically accelerating the transition away from imported fossil fuels toward a more secure and sustainable energy system.

1. Introduction

1.1 Background

Global fossil fuel price fluctuations have long been seen as a key source of macroeconomic instability, particularly for developing and energy-importing countries (Raihan et al., 2025a). Hamilton (1983) showed that nearly all post-war recessions in the United States followed oil price spikes. Since then, many studies have explored how energy price shocks affect production costs, inflation, output, and employment. Blanchard and Galí (2007) found that oil shocks hit hardest in the 1970s. However, changes such as more flexible labor markets and better monetary policy have lessened, though not eliminated, these effects in recent decades. Kilian (2009) added that the impact of oil price changes depends on whether the shock stems from supply-side factors or shifts in global demand, highlighting the need to identify the source when assessing economic effects.

In recent years, fossil fuel prices have hit record highs due to geopolitical tensions, supply disruptions, and post-pandemic demand surges. These issues are especially serious for developing countries that import energy and have limited resources. The existing literature on this topic falls into three main areas. The first area looks at how oil price shocks affect economies and household welfare. For example, Essama-Nssah et al. (2007) and Twimukye and Matovu (2009) showed that rising oil prices hurt economic performance and household welfare in developing countries, with the poorest groups suffering the most. Mohanasundari et al. (2025) found that energy price swings did not affect all industries equally and that effects could spread across sectors, making the overall impact larger or smaller. Studies from South Asia, including Afghanistan, Bangladesh, India, and Pakistan, showed that key economic indicators such as inflation, output, and exchange rates were highly sensitive to global oil prices and that each country reacted differently depending on its structure and policies (Ahmad et al., 2022).

The second area of research examines non-oil fossil fuels, which have become increasingly important in developing countries but have received less attention. Studies on coal price shocks showed that their effects varied widely across industries and regions, with energy-intensive sectors facing the biggest challenges (Lin & Lan, 2025). Recent research on natural gas price shocks, including models of how gas prices affect different sectors, government revenue, and household income, showed that gas price changes worked differently from oil price changes (Hasanov et al., 2025). These findings highlighted the need to study all fossil fuel prices together, not just oil.

The third area of research examines the economic effects of carbon taxation and reforms to fossil-fuel subsidies. Aydın (2018) studied carbon taxes in Turkey and found that while they could lower emissions, they also created high costs that were not shared equally across sectors. Other studies, such as Dennis (2016), Zeng and Chen (2016), Okereke et al. (2024), and Okorie and Wesseh (2024), showed that cutting fossil fuel subsidies in developing countries often hurt low-income and energy-poor households the most, as they faced a bigger share of the welfare losses from higher energy prices.

Despite these contributions, the existing literature had some key gaps. First, most studies examined macroeconomic, sectoral, and household welfare effects separately or only in part, rather than using a single framework to show how these effects are connected. So far, no study has fully examined all these impacts together in one integrated model. Second, most research focused on oil price shocks and subsidy reforms, leaving out the combined effects of changes in oil, coal, and natural gas prices, which are important for countries that rely on multiple fossil fuels. Third, many studies used traditional partial equilibrium models, such as vector autoregressive (VAR) and structural VAR (SVAR), which were useful for identifying specific links but could not capture the complex ways energy price shocks spread across the entire economy.

To address these limitations, the present study adopts a Computable General Equilibrium (CGE) modeling framework. CGE models are particularly well-suited to the analysis of fossil fuel price shocks because they explicitly account for the interdependencies among production sectors, factor markets, commodity markets, and households, enabling a comprehensive and internally consistent assessment of both aggregate and distributional effects. This methodological approach represents a significant advancement over the partial-equilibrium analyses that dominate the existing literature and allows for a more policy-relevant investigation of the channels through which energy price changes affect welfare across heterogeneous households and economic sectors.

In Bangladesh, several studies have employed CGE frameworks to examine economy-wide impacts across a range of policy scenarios. Timilsna et al. (2017) analyzed the economy-wide consequences of electricity price increases, while Raihan et al. (2025d) investigated the broader macroeconomic effects of energy price shocks in the transport sector. In a related study, Raihan et al. (2025f) assessed the implications of expanding solar electricity generation to 10% of total power supply by 2035, and Raihan et al. (2025e) examined the economy-wide impacts of climate change on agricultural productivity. However, there is still a gap: no study has yet used a CGE model to look at the combined effects of oil, coal, and natural gas price shocks on the economy, sectors, and households in Bangladesh.

Addressing this gap is both timely and policy-critical for at least three reasons. First, Bangladesh is structurally exposed to global fossil fuel price volatility. Natural gas, including imported liquefied natural gas (LNG), currently accounts for 44.09% of electricity generation, with coal contributing 26.72%, oil 10.73%, and power imports 16.21%. In comparison, renewable energy makes up just 2.26% of the total power mix (BPDB, 2025). Moreover, Bangladesh's reliance on primary energy imports rose sharply from 47.7% in FY2020–21 to 62.5% in FY2024–25, deepening the country's exposure to volatile global fossil fuel markets (Alam, 2026). The severity of this vulnerability was starkly demonstrated during the 2022 global energy crisis, when surging LNG and oil prices forced Bangladesh to suspend spot LNG purchases, triggering widespread and prolonged power cuts across the country (Raihan et al., 2024c). Understanding how such shocks propagate through the domestic economy is therefore essential for macroeconomic management, energy security planning, and fiscal policy design. Second, changes in fossil fuel prices affect productive sectors asymmetrically. Energy-intensive industries, the transport sector, agriculture, and manufacturing face differential adjustments in output, employment, and international competitiveness, making a sectorally disaggregated analysis indispensable for identifying economic winners and losers and for designing appropriately targeted policy responses. Third, the distributional consequences of fossil fuel price shocks are particularly acute in a developing country like Bangladesh, where a large share of the population remains in or near poverty (see Raihan et al., 2025g; Raihan et al., 2021b; Raihan et al., 2020a) and where energy costs constitute a significant proportion of household expenditure. It is therefore vital to understand how price shocks affect different income groups and regions, so that support measures such as targeted subsidies or cash transfers can be designed to protect those most at risk while remaining consistent with broader energy and climate policy goals.

1.2 Objectives

The primary objective of this study is to examine the economy-wide effects of fossil-fuel price shocks on macroeconomic performance, sectoral outcomes, and household welfare in Bangladesh. In pursuit of this general objective, the study addresses three specific aims:

First, it examines the macroeconomic impacts of fossil-fuel price shocks on key aggregate variables, including gross domestic product (GDP), the consumer price index (CPI), export and import volumes, the real exchange rate, and the terms of trade.

Second, it analyses the sectoral consequences of fossil fuel price shocks, with particular attention to energy-intensive sectors, including agriculture, mining, manufacturing, transport, and other services.

Third, it evaluates the household welfare implications of fossil fuel price fluctuations, focusing on distributional impacts across income groups and the urban–rural divide.

1.3 Organization of the Report

The rest of this report is structured as follows. Chapter 2 provides a critical and systematic review of the existing literature on the macroeconomic, sectoral, and household welfare effects of fossil fuel price shocks, situating the present study within the broader scholarly debate. Chapter 3 offers a contextual overview of global fossil fuel price volatility and Bangladesh's growing dependence on energy imports, establishing the empirical motivation for the analysis. Chapter 4 describes the CGE model employed in the study, detailing its theoretical structure, data sources, and the economy's structure. Chapter 5 presents the simulation design and discusses the empirical results across the macroeconomic, sectoral, and welfare dimensions. Chapter 6 concludes the report with a synthesis of key findings and offers evidence-based policy recommendations across three domains: macroeconomic policies, sectoral policies, and household welfare policies directed at government authorities, energy planners, and social protection agencies, respectively.

2. Literature Review

This chapter reviews the existing literature on the economy-wide effects of fossil fuel price shocks, organized around three interrelated themes: macroeconomic consequences, sectoral transmission, and household welfare implications. Across all three themes, the review gives particular emphasis to studies employing Computable General Equilibrium (CGE) and Social Accounting Matrix (SAM) based frameworks, given their comparative advantage in capturing economy-wide interactions, sectoral interdependencies, and distributional consequences that partial-equilibrium and reduced-form econometric approaches are ill-equipped to trace. While non-CGE studies are also discussed where they offer relevant empirical insights, the focus remains on general equilibrium evidence. The review ultimately identifies the key gaps in the existing literature that the present study seeks to address, most notably the absence of an integrated CGE-based analysis that simultaneously examines macroeconomic, sectoral, and household welfare effects of fossil fuel price shocks within the specific context of Bangladesh.

2.1 Fossil Fuel Price Shocks and Macroeconomy

A growing body of literature has employed CGE models to examine the macroeconomic consequences of fossil-fuel price shocks, recognizing the limitations of partial-equilibrium approaches in capturing economy-wide feedback mechanisms. Yang and Gao (2024) applied a CGE framework to examine the effects of energy price fluctuations on China's energy-environment-economy system. They found that higher energy prices exerted a contractionary effect across multiple industrial sectors and the overall macroeconomy, leading to higher prices, reduced output, lower investment, and diminished consumer spending. Using a similar approach, Manzoor et al. (2012) found that reducing energy subsidies in Iran led to decreased economic activity, lower consumer welfare, increased energy exports, and reduced domestic energy demand. Their findings highlighted the complex, economy-wide trade-offs that energy price adjustments entail in heavily subsidized developing economies.

Extending this line of analysis to African contexts, Tefera et al. (2012) applied the IFPRI static CGE model using Ethiopia's SAM to quantify the impact of an increase in the international price of crude oil. They found that the oil price shock caused a depreciation of the Ethiopian Birr, an increase in exports, and a decline in imports, while simultaneously reducing income and consumption across all households, with rural households experiencing disproportionately larger negative effects than their urban counterparts. Ganguly and Das (2016) reached partly complementary findings for India, demonstrating through a CGE model that a decrease in international crude oil prices raised GDP and appreciated the exchange rate, whereas removing energy subsidies had the opposite effect on GDP, despite also appreciating the exchange rate. These contrasting results highlight that the macroeconomic impacts of fossil fuel price changes are sensitive to both the direction of the shock and the concurrent subsidy policy environment.

Taken together, these CGE-based studies confirm that fossil fuel price changes exert both direct and indirect impacts on macroeconomic indicators, particularly in energy-importing developing countries. The specific pathways and intensity of these effects depend critically on structural characteristics, including energy dependence, subsidy mechanisms, exchange rate regimes, and fiscal space, underscoring the need for country-specific general equilibrium analysis tailored to economies such as Bangladesh.

2.2 Fossil Fuel Price Shocks and Sectoral Impacts

The sectoral consequences of fossil fuel price shocks have been examined across agriculture, manufacturing, and services, with both CGE-based and complementary empirical approaches revealing significant heterogeneity in sectoral responses. In the agricultural sector, Wang et al. (2012) developed a Chinese urban-rural input-output model and found that energy price rises led to a 26–47% increase in agricultural product prices, negatively affecting net profit in coastal and central provinces while yielding some benefits in central and western regions, with consumer surplus reduced in both urban and rural areas. Ma et al. (2022) extended this analysis using a price-endogenous partial equilibrium model for China. They found that higher energy prices had limited direct impacts on agricultural production but resulted in significant producer welfare losses and negative effects on energy consumption and carbon emissions. In developing countries dependent on food imports, Gołasa et al. (2022) demonstrated that energy price fluctuations threaten food security by disrupting fertilizer production, which is critical to sustaining agricultural yields.

In the manufacturing sector, the evidence points broadly to adverse effects from energy price increases. Riaz et al. (2016) found a non-linear relationship between oil price volatility and manufacturing production in Pakistan, where output initially increased with price uncertainty before declining once a threshold was exceeded, with impulse response functions confirming short-run contractionary effects. Okuneye and Oluwo (2023) similarly found that rising crude oil prices reduced manufacturing output in Nigeria. Guidi (2009) demonstrated for the United Kingdom that positive oil price changes led to manufacturing output contraction, while Melick (2014) found that a sustained decline in natural gas prices since 2006 generated a 2–3% increase in manufacturing activity across the entire sector, with considerably larger gains of 30% or more in energy-intensive industries, illustrating the asymmetric potential of energy price decreases.

In the services sector, Bilal et al. (2021) found that oil price fluctuations had a significant positive impact on financial performance in Oman. In contrast, Nasim and Downing (2023) demonstrated that energy price shocks negatively affected banking-sector performance across G7 economies. In the transport sector, particularly relevant for Bangladesh, Kabir and Barreto (2022) found that reduced oil availability increased inflationary pressure on transportation costs in Bangladesh, and Buljan and Badovinac (2023) confirmed that crude oil prices exerted a statistically significant positive effect on the harmonized index of consumer prices for transport services across 27 EU countries. Collectively, these studies demonstrate that energy price shocks propagate differentially across sectors, making a sectorally disaggregated CGE analysis essential for identifying specific transmission channels and policy implications.

2.3 Fossil Fuel Price Shocks and Household Welfare

Understanding how changes in fossil fuel prices affect household welfare is critical for designing equitable energy policies, as energy underpins cooking, lighting, heating, transportation, and essential appliances. The welfare consequences are consistently found to be heterogeneous across income groups, geographic locations, and demographic characteristics, with low-income and vulnerable households typically bearing a disproportionate burden.

Okereke et al. (2024) evaluated the welfare impacts of petrol price increases following the removal of subsidies in Nigeria. They found that a 100% increase in petrol prices required compensating payments equivalent to 16% of total household expenditure for the lowest income quintile, compared to 14% for the highest, demonstrating the regressive character of unmitigated fuel price increases. Similarly, Moshiri and Santillan (2018) found that in Mexico, the household welfare effect of energy price changes was 9 times higher for low-income households and 18 times higher for middle-income households than for high-income households. Zeng and Chen (2016) found consistent results in China, confirming that lower-income households were more adversely affected by energy price inflation than higher-income households (see Raihan et al., 2023).

In South Asian contexts, Abrar et al. (2020) found, using an Almost Ideal Demand System (AIDS) model, that the welfare loss from energy price increases was higher for rural consumers than for urban consumers in Pakistan. Bhuvandas and Gundimeda (2020) demonstrated in India that lower- and middle-income groups remained more vulnerable to changes in transport fuel prices, with a 10% price increase resulting in a 1.5% decline in total household expenditure for urban middle-income households.

Importantly, welfare impacts are transmitted through both direct and indirect channels. Phoumin and Kimura (2019) found that, in Cambodia, for every 1% increase in the share of energy expenditure to total expenditure, household food expenditure decreased by approximately 4.1% and education expenditure by 5.8%, demonstrating that energy price shocks crowd out investment in human capital. Coady et al. (2015) found that a USD 0.25 per liter increase in fuel prices cut household real incomes by an average of 5.5%, with approximately half of this impact transmitted indirectly through the prices of other goods and services households consume. Dennis (2016) reinforced these findings in a developing-country context, showing that fossil-fuel subsidy reforms often hurt the poorest households most severely unless accompanied by well-targeted compensatory measures.

The literature thus consistently confirms that fossil fuel price shocks have pronounced distributional consequences, with low-income and rural households facing the greatest welfare losses. Effective policy responses must incorporate targeted subsidies, cash transfer mechanisms, and social protection programs to ensure that the costs of energy price adjustments are not borne disproportionately by the most vulnerable.

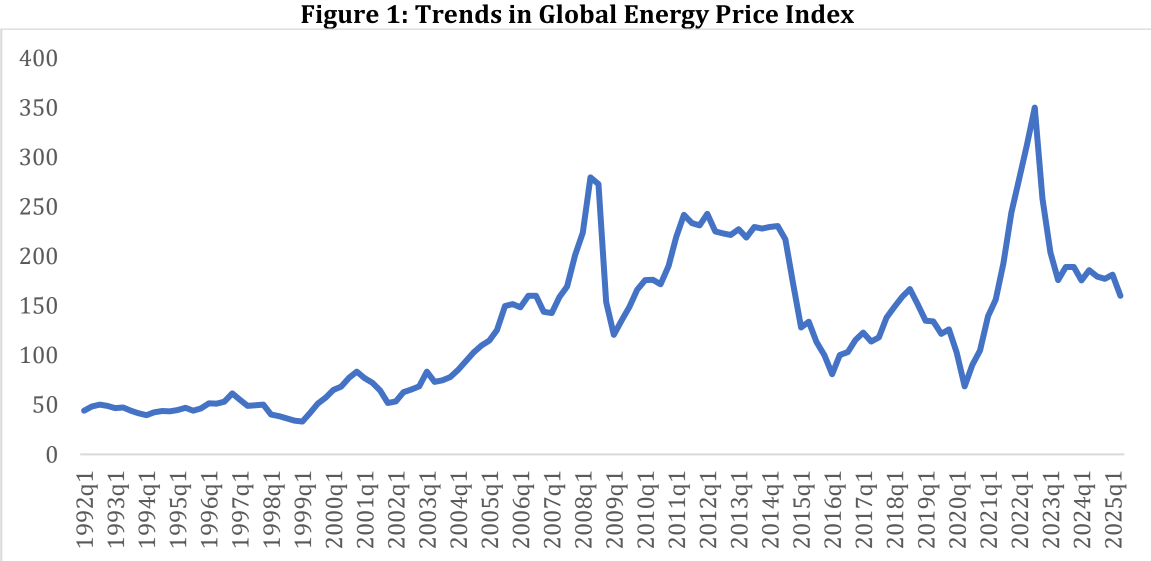
3. Global Energy Price Volatility and Bangladesh's Energy Import Dependence

The global energy landscape has experienced unprecedented volatility in recent years, characterized by sharp price fluctuations across fossil fuel markets. This volatility arises from a complex interplay of geopolitical tensions, supply–demand imbalances, climate-related disruptions, and structural changes in global energy systems. For import-dependent developing economies such as Bangladesh, these dynamics pose serious challenges to energy security, macroeconomic stability, and long-term development prospects. Bangladesh's growing reliance on imported liquefied natural gas (LNG), coal, and other fossil fuels has coincided with a period of exceptional market instability, particularly in the aftermath of the COVID-19 pandemic and the Russia–Ukraine conflict. This chapter examines trends and patterns in global fossil fuel prices over the past two decades and analyses Bangladesh's growing reliance on energy imports amid a volatile global market.

3.1 Global Fossil Fuel Price Volatility: Trends and Patterns

The global energy price index from 1992Q1 to 2025Q2 illustrates a detailed account of how global energy markets are highly sensitive to long-term demand shifts, financial cycles, and geopolitical disruptions. From 1992 to 2007, global energy prices followed a steady upward trajectory with relatively low volatility. This indicates sustained and steady global industrial growth, particularly the rapid expansion of emerging economies such as China and India, and increasing energy consumption in emerging countries, combined with stable supply conditions and deeper integration of global energy trade. By the mid-2000s, commodity markets had become highly active, and prices started to escalate, resulting in a dramatic spike in 2007–2008 as investors anticipated rising demand and tight supply. This highest spike aligns with booming commodity markets. Since the Global Financial Crisis began in late 2008, energy demand declined abruptly, triggering a sharp correction in energy prices by 2009 due to the contraction of global demand, a slowdown in global industrial production, and tighter financial liquidity.

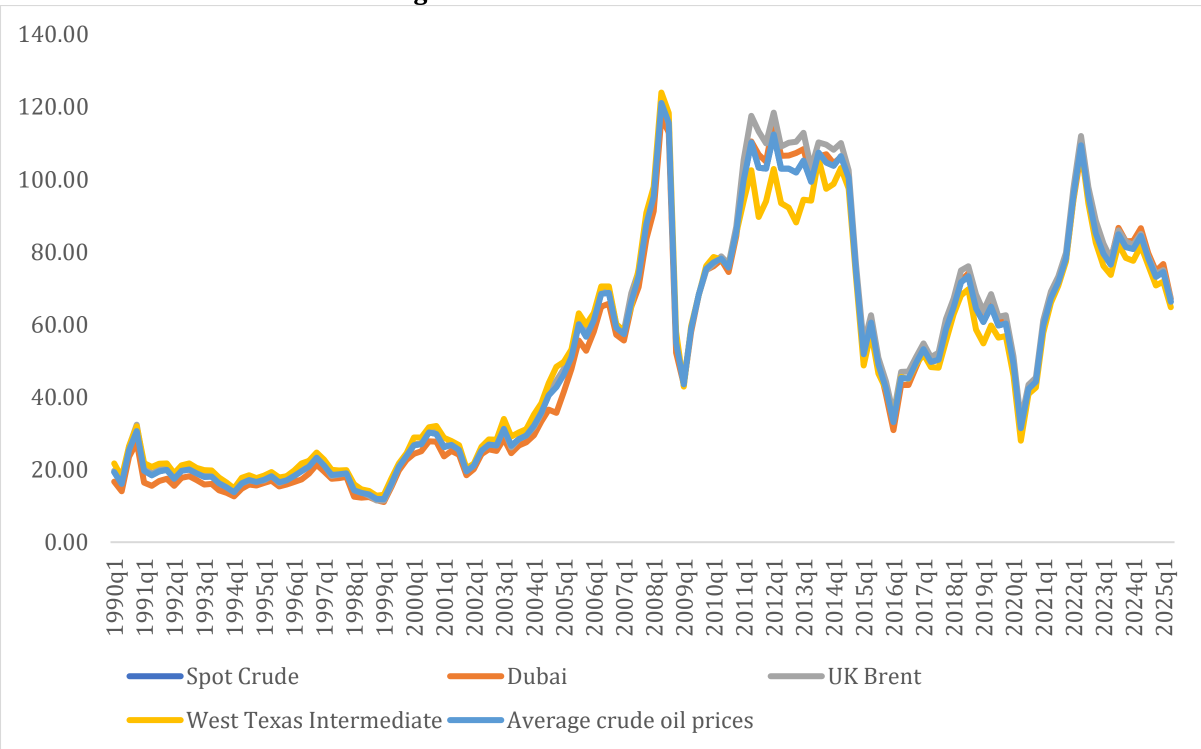
Figure 1: Trends in Global Energy Price Index



Source: International Monetary Fund

Between 2009 and 2019, the index underwent a period of recovery and relative stabilization. Global energy prices fluctuated within a moderate band as the world economy gradually recovered, energy efficiency improved, renewable energy expanded, and OPEC and other major energy producers adjusted output to stabilize markets. Since 2020, the index has demonstrated unprecedented volatility, first tumbling due to pandemic-induced demand shocks, then rapidly escalating to record highs amid supply disruptions as economies reopened. In 2022, the Russia–Ukraine war triggered a severe supply shock, driving prices to record highs and prompting a dramatic reconfiguration of global energy trade flows. Although energy prices have moderated after the 2022 peak, they have remained well above pre-pandemic levels and showed elevated volatility through early 2025. Taken together, the graph shows that global energy prices are shaped not only by gradual demand trends but also by systemic shocks, underscoring the energy market's role in global economic and geopolitical stability.

Figure 2: Trends in Crude Oil Price



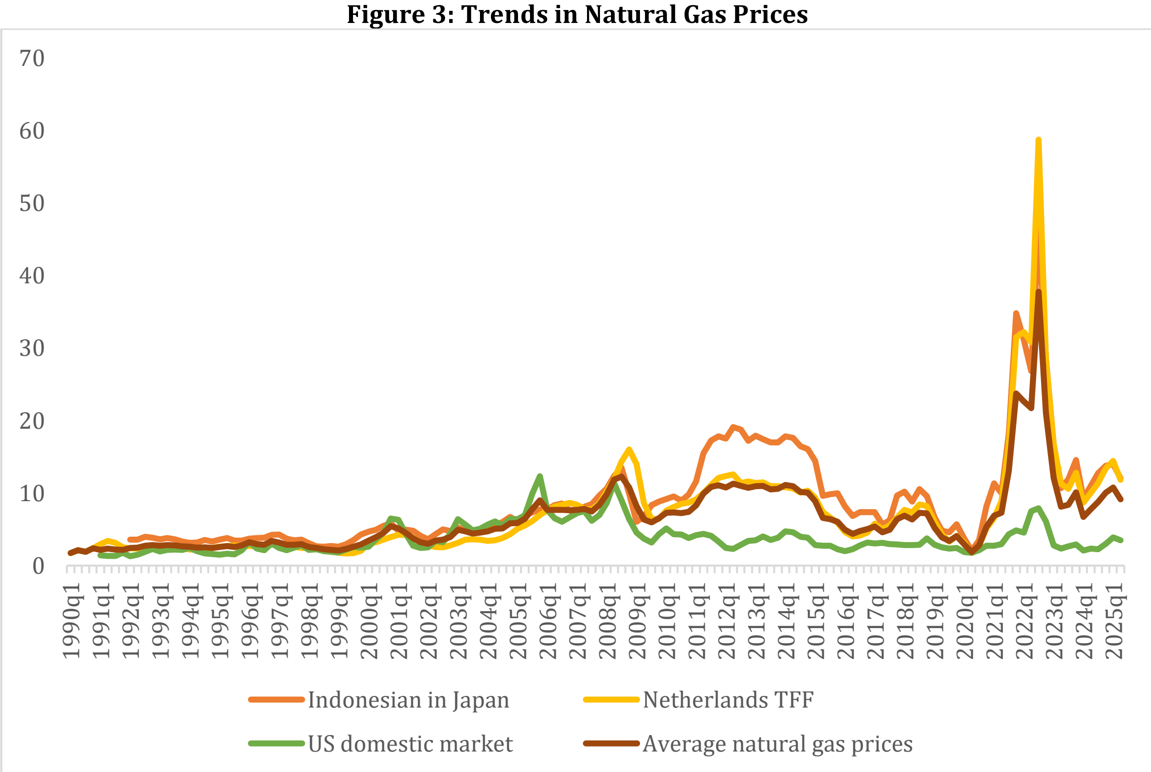
Source: Primary Commodity Prices, IMF

Figure 2 reflects the movement of major crude oil price benchmarks—Spot Crude, Dubai, UK Brent, and West Texas Intermediate (WTI)—along with the average crude oil price from 1990Q1 to 2025Q1. The benchmarks align closely across the periods, indicating their integration into the global oil market despite regional differences. During the 1990s, oil prices remained relatively stable, fluctuating around $20 per barrel, reflecting stable supply and demand alongside OPEC's production management. A sharp upward trend began in the early 2000s as global demand expanded, particularly from emerging economies. This reached a dramatic peak in 2008, when crude prices rose to $120 per barrel, driven by booming commodity markets and expectations of constrained supply, before collapsing during the Global Financial Crisis as demand declined.

From 2009 to 2019, oil prices recovered and fluctuated widely, reflecting cycles of economic recovery, OPEC+ interventions, and shifting dynamics in U.S. shale oil production. Brent and WTI often reflected minor divergences due to regional supply and transportation factors, though overall oil price trends were consistent across the benchmarks. After 2020, the oil market experienced unprecedented volatility: prices collapsed at the onset of the COVID-19 pandemic as global demand collapsed, but recovered sharply with the reopening of economies and supply constraints. The Russia–Ukraine war in 2022 led to further upward pressure on oil prices, pushing oil prices once again above $100 per barrel across benchmarks. Although prices remained moderate after the 2022 peak, by early 2025, they remained high relative to pre-pandemic levels, reflecting the ongoing sensitivity of crude oil markets to geopolitical events and supply disruptions. Together, the indices confirm that despite regional variations, crude oil markets are globally interconnected and strongly influenced by systemic shocks.

Figure 3 demonstrates long-term trends in natural gas prices from 1990 to 2025, focusing on three major benchmarks: Indonesian gas in Japan, Netherlands TTF, and the U.S. domestic market. Indonesian gas prices in Japan reflect East Asia's dependence on imported LNG, with relatively stable movements in the 1990s and early 2000s, followed by significant increases after 2010. The escalation around 2021–2022 reflects Japan’s heavy reliance on LNG imports, which made it vulnerable to global supply chain disruptions and price volatility during the global energy crisis. In contrast, the Netherlands TTF benchmark captures European market dynamics, showing a sharp upward spike in 2022 as Europe faced supply shortages following the Russia–Ukraine war. The dramatic price surge and subsequent correction emphasize the European Union’s struggle to diversify away from Russian pipeline gas, with TTF emerging as the most volatile global gas index in recent years.

Figure 3: Trends in Natural Gas Prices

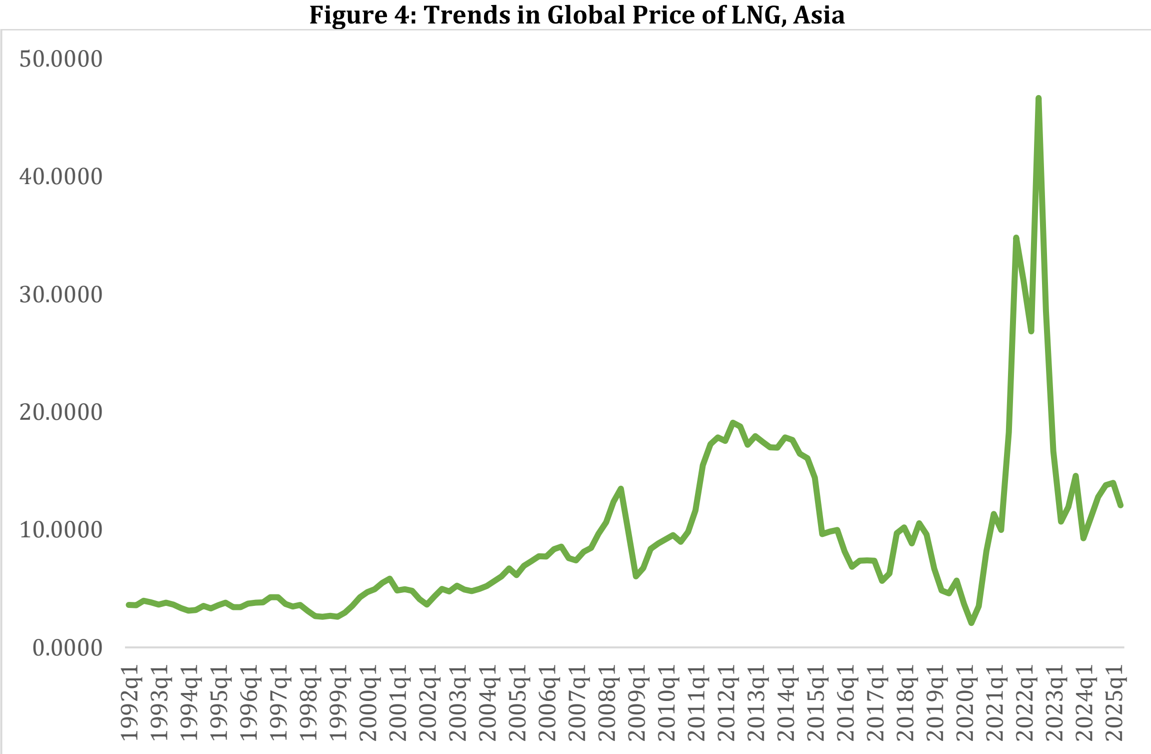


Source: Primary Commodity Prices, IMF

Meanwhile, the U.S. domestic gas market follows a notably different trajectory. Because abundant shale gas production provides a largely self-sufficient supply base, U.S. natural gas prices have remained relatively low and stable compared to international benchmarks. Although some moderate fluctuations are noticeable, particularly during the early 2000s, mid-2008, and 2021-2022, the U.S. avoided the extreme spikes observed in Asia and Europe. U.S. natural gas prices remained high in 2021-2022 due to the Russia–Ukraine war, then followed a moderate, stable trajectory. This divergence highlights the importance of domestic energy independence and supply security in protecting markets from global shocks. When combined, these trends form the average global natural gas price, which closely mirrors international benchmarks rather than the U.S. market, depicting the dominance of import-dependent regions in setting global averages. The contrast between stability in the U.S. and volatility in Japan and Europe highlights structural differences in market integration, trade dependence, and exposure to geopolitical risks.

Figure 4 depicts the long-term trajectory of LNG prices in Asia from 1992 to 2025, analyzing the gradual structural changes in the region's energy market. From 1992 through the mid-2000s, LNG prices remained relatively stable, indicating long-term supply contracts and moderate demand growth in East Asia, particularly in Japan, South Korea, and Taiwan. Energy prices started to rise steadily after the mid-2000s, coinciding with increasing demand in emerging Asian economies and tightening supply in global LNG markets. The dramatic surge in energy prices occurred between 2010 and 2014, largely driven by Japan's post-Fukushima nuclear shutdown, which increased reliance on LNG imports. However, between 2015 and 2019, prices declined due to an expansion of global LNG supply, particularly from the United States and Australia, and lower demand growth in some Asian markets.

Figure 4: Trends in Global Price of LNG, Asia

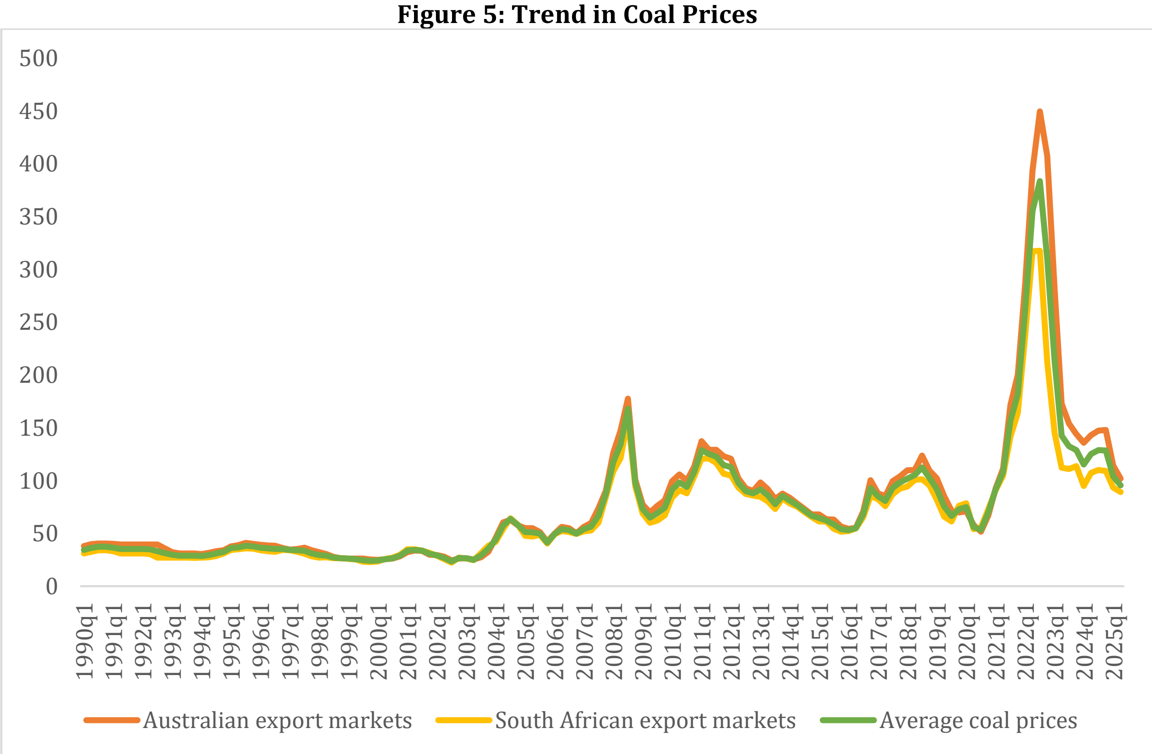


Source: Primary Commodity Prices, IMF

The post-2020 period witnessed unprecedented volatility in Asian LNG prices. Following a sharp decline during the COVID-19 pandemic, LNG prices escalated in 2021–2022, reaching record highs amid severe supply disruptions and increasing demand. The Russia–Ukraine war further aggravated global supply shortages, compelling Asia to compete aggressively with Europe for LNG cargoes, which boosted price pressures. A correction followed this price spike in 2023–2025, yet energy prices remained high compared to the pre-pandemic norm, indicating Asia's structural reliance on imported LNG.

Figure 5 shows the historical trend in global coal prices, focusing on the Australian and South African export markets from 1990 to 2025. Coal prices remained relatively stable throughout the 1990s, suggesting steady supply and demand. However, from the mid-2000s onward, prices rose significantly in both markets, driven by strong demand growth in China and India, coupled with supply constraints in key exporting countries. High peaks were also observed in both markets in 2008 and 2011 due to global commodity booms and tightening supply in Asian markets, after which coal prices corrected as production increased and global economic activity slowed. The Australian export market, often marked by a benchmark due to its dominance in high-quality thermal coal, shows sharper fluctuations during global demand booms in 2008 and 2011. On the contrary, the South African export market, which plays a key role in supplying Asia and Europe, generally followed similar trends but at a slightly lower price level, showing its sensitivity to regional transportation and infrastructure constraints as well as European market dynamics. Between 2014 and 2019, coal prices stabilized at lower levels, representing the gradual transition toward renewable energy, policy restrictions on coal use in some countries, and competition from cheaper natural gas.

Figure 5: Trend in Coal Prices



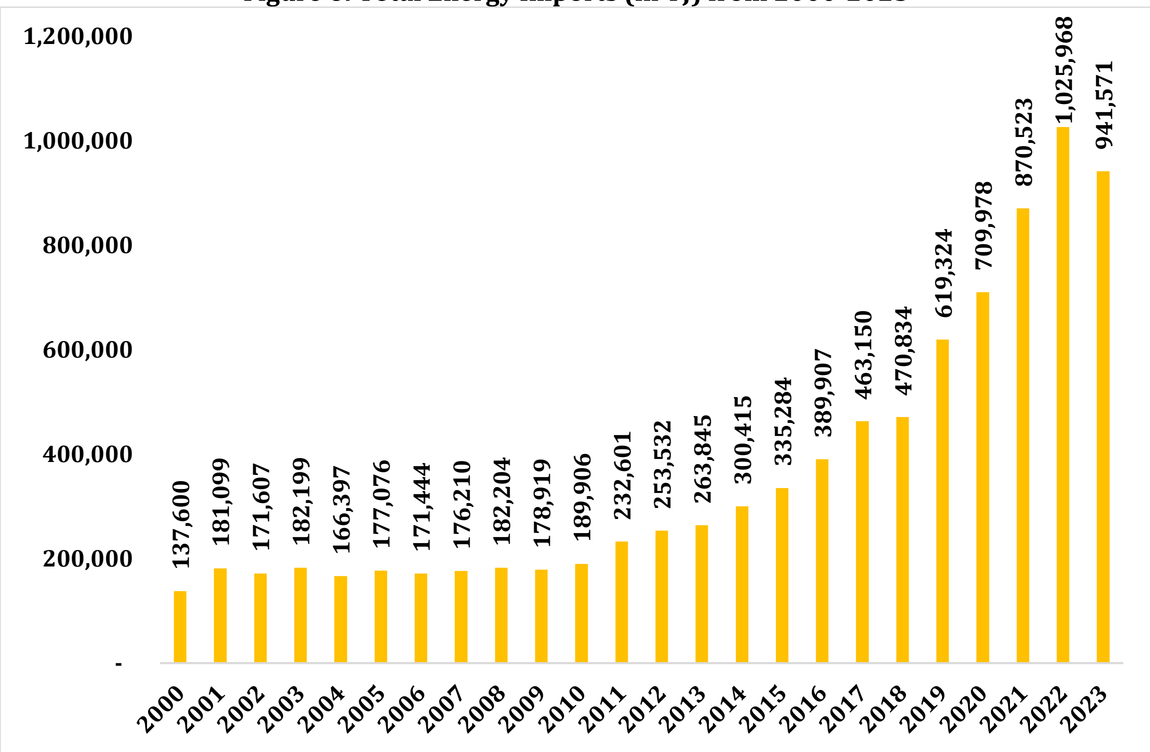
Source: Primary Commodity Prices, IMF

The post-2020 period depicts heightened, dramatic volatility in both markets. Coal prices initially fell during the COVID-19 pandemic as demand weakened. However, from late 2021 to 2022 they escalated to record highs due to the Russia–Ukraine war, with the Australian market reaching above 450 USD per ton due to global energy shortages, disruption of the supply chains, and the Russia–Ukraine war which shifted coal demand patterns as Europe and Asia scrambled to secure alternative supplies, while the South African market also rose steeply but at a lower peak, indicating logistical bottlenecks such as port and rail capacity issues in South Africa that limited export potential even during times of high demand. Following this sharp peak, coal prices declined substantially in both markets between 2023 and 2025 but remained above pre-pandemic levels, reflecting lingering supply constraints and persistent demand in energy-intensive economies. The average global coal price mirrors these two benchmarks, depicting the interconnectedness of coal markets worldwide, with strong upward shocks followed by a steep decline in 2023–2025 as supply recovered and demand adjusted. Overall, the trajectory demonstrates the cyclical and highly sensitive nature of coal prices to global shocks, policy changes, and the energy transition, highlighting coal's enduring—yet increasingly challenged—role in the global energy mix.

3.2 Bangladesh's Energy Import Dependence in a Volatile Global Market

Figure 6 shows a strong and sustained increase in Bangladesh's total energy imports over the past two decades, highlighting the country's growing dependence on external energy sources and rising exposure to global energy price volatility.

Figure 6: Total Energy Imports (in TJ) from 2000-2023



Source: International Energy Agency

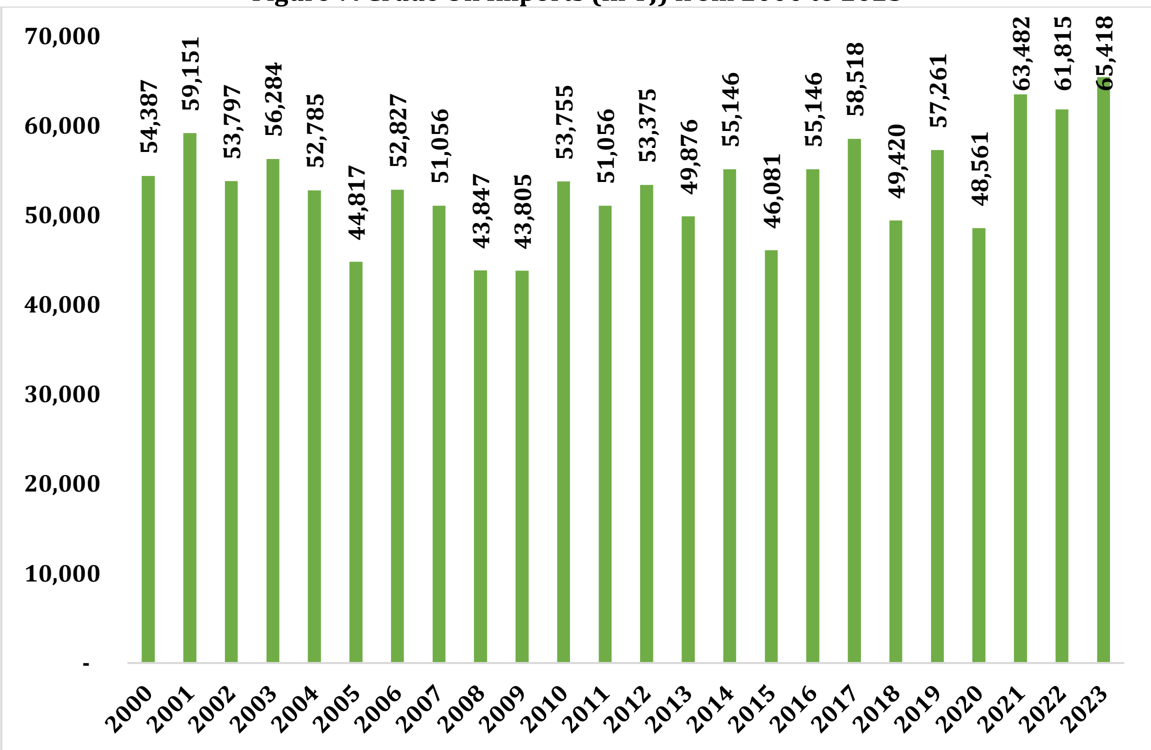
From 2000 to around 2009, energy imports increased gradually, fluctuating between about 138,000 TJ and 183,000 TJ. This period reflects relatively modest growth in energy demand, consistent with slower industrial expansion and a heavier reliance on domestic natural gas.

Beginning in 2010, energy imports rose sharply. Imports increased from 189,906 TJ in 2010 to 300,415 TJ by 2014, reflecting rapid economic growth, expanding electricity generation capacity, and rising energy demand from industry and transport. This upward trend intensified after 2015, coinciding with declining domestic gas reserves and increased reliance on imported oil, coal, and LNG.

The most pronounced growth occurred between 2017 and 2022, when energy imports more than doubled—from 463,150 TJ in 2017 to over 1,025,000 TJ in 2022. This surge underscores Bangladesh's structural shift toward imported fossil fuels, particularly LNG and coal, to support power generation and industrial activity.

In 2023, energy imports declined slightly to 941,571 TJ, likely reflecting a combination of high global energy prices, demand-side adjustments, fiscal pressures, and policy measures to curb imports. Nevertheless, import levels remain historically high, indicating persistent dependence on international energy markets.

Figure 7: Crude Oil Imports (in TJ) from 2000 to 2023



Source: International Energy Agency

Figure 7 on crude oil imports indicates that, unlike total energy imports, Bangladesh's oil imports have remained relatively stable over time, with moderate fluctuations rather than a sustained upward trend.

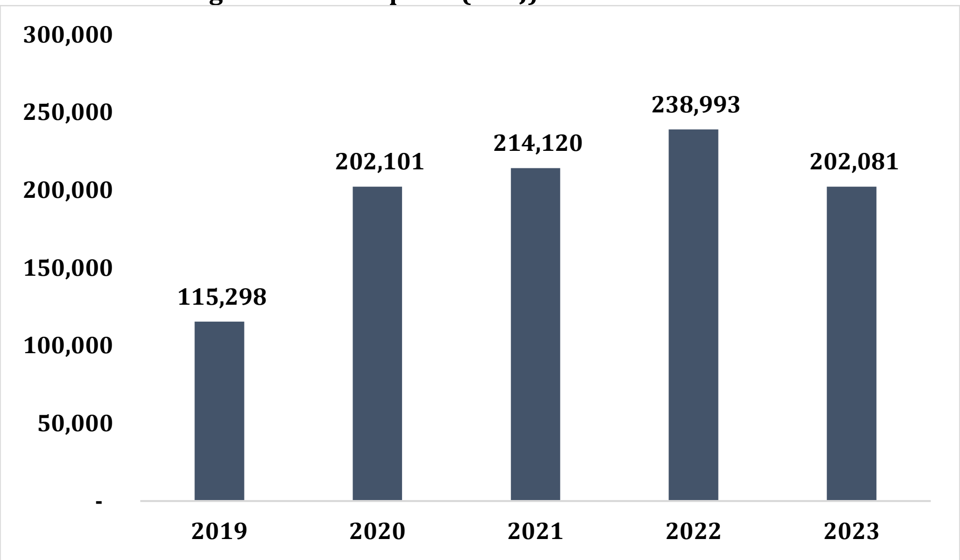
During 2000–2009, crude oil imports fluctuated within a narrow range of roughly 44,000–59,000 TJ, reflecting stable demand for oil mainly in transport, irrigation, and some industrial uses. There is no clear long-term increase during this period, suggesting that oil demand grew slowly and was partly offset by efficiency improvements and substitution toward domestic natural gas, especially in power generation.

From 2010 to 2019, crude oil imports fluctuated without a clear trend, generally ranging from 49,000 to 58,000 TJ. This period coincides with a policy shift toward using natural gas, coal, and later LNG for electricity generation, limiting the growth of oil imports despite rising overall energy demand.

In the post-2020 period, crude oil imports have increased modestly, rising from 48,561 TJ in 2020 to 65,418 TJ in 2023. This uptick likely reflects increased transport demand following the COVID-19 recovery, greater use of oil-based fuels in sectors facing gas shortages, and heightened reliance on imported fuels amid declining domestic gas production.

Overall, the pattern suggests that crude oil is not the primary driver of Bangladesh's rapidly growing energy import dependence. Instead, the sharp increase in total energy imports observed in recent years is more likely driven by LNG and coal imports, particularly for power generation. This distinction is important for policy analysis, as it implies that Bangladesh's vulnerability to global energy price shocks extends beyond oil markets and is increasingly shaped by price movements in gas and coal markets.

Figure 8: LNG Imports (in TJ) from 2019 to 2023



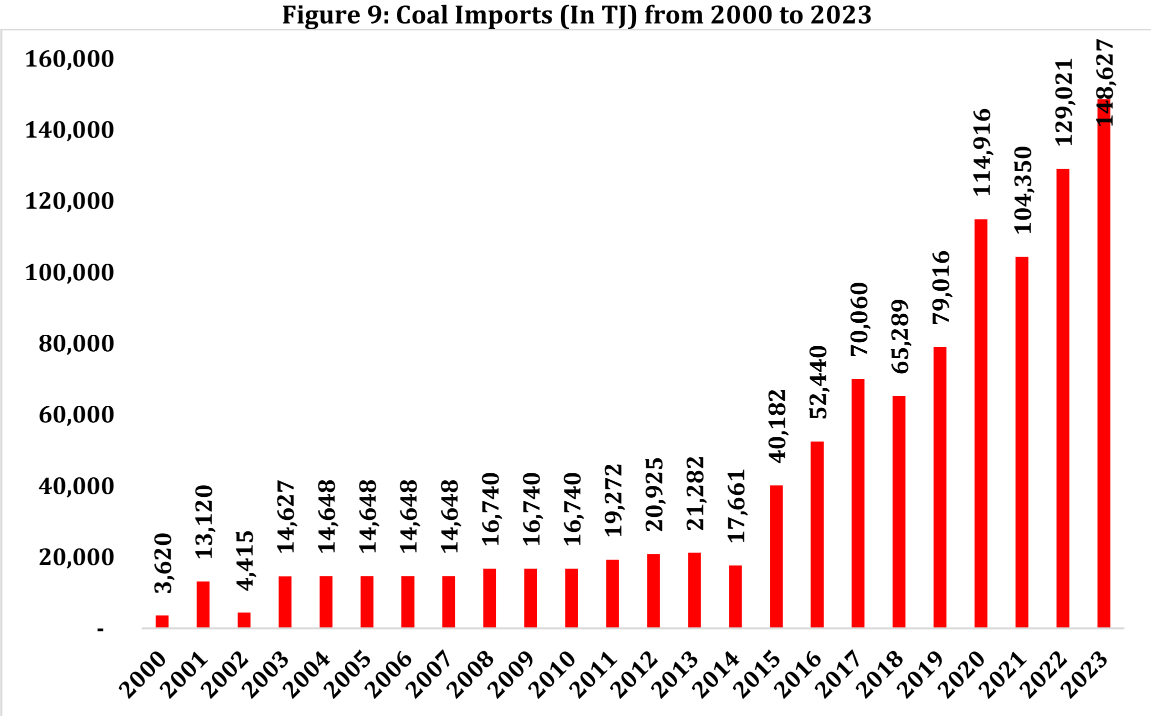
Source: International Energy Agency

Figure 8 shows a rapid and substantial increase in LNG over a short period, reflecting the country's growing reliance on imported gas to meet energy demand. In 2019, natural gas imports were 115,298 TJ, marking the beginning of significant imports. By 2020, imports nearly doubled to 202,101 TJ, likely driven by rising electricity demand, industrial expansion, and declining domestic gas production. Imports continued to grow in 2021 (214,120 TJ) and 2022 (238,993 TJ), highlighting Bangladesh's increasing dependence on imported LNG for power generation and other industrial uses. In 2023, imports fell slightly to 202,081 TJ, which may reflect temporary adjustments due to high global LNG prices, energy efficiency measures, or policy interventions aimed at reducing import costs.

This rapid growth in natural gas imports shows that Bangladesh is increasingly dependent on imported gas to meet its energy needs, especially for power generation (Raihan et al., 2024a). Combined with relatively stable crude oil imports, this trend indicates that the surge in total energy imports in recent years is largely driven by imported natural gas (LNG) rather than oil, making the economy more exposed to global gas market volatility. This also underscores the need for policies promoting energy diversification, domestic gas exploration, and renewable energy adoption to mitigate external shocks.

Figure 9 shows Bangladesh's coal import data, which indicates a clear, strong upward trend, particularly over the last decade, reflecting a growing reliance on imported coal for power generation and industrial use. During 2000–2010, coal imports remained relatively low, fluctuating between 3,620 TJ and 16,740 TJ, reflecting minimal reliance on coal in the energy mix. From 2011 to 2015, imports rose more consistently, reaching 40,182 TJ in 2015, as the government expanded coal-fired power generation to meet growing electricity demand. Between 2016 and 2023, coal imports accelerated sharply, increasing from 52,440 TJ in 2016 to 148,627 TJ in 2023. This period reflects the commissioning of large coal-fired power plants and growing industrial coal consumption. There were minor fluctuations, e.g., 104,350 TJ in 2021, likely due to global price volatility, shipping constraints, or temporary reductions in coal-based generation.

Figure 9: Coal Imports (In TJ) from 2000 to 2023



Source: International Energy Agency

The trend indicates that coal has become an increasingly important component of Bangladesh's energy import portfolio, contributing significantly to the overall surge in total energy imports in recent years. Combined with the rapid growth in imported LNG, coal imports highlight Bangladesh's growing exposure to global fossil fuel price shocks beyond crude oil. This highlights the importance of diversifying the energy mix, improving energy efficiency, and expanding renewable energy capacity to reduce vulnerability to international fuel market volatility.

4. Methodology: A Standard CGE Model for Bangladesh

4.1 Standard CGE Model

This paper employs a single-country, static CGE model developed according to the IFPRI standard (Lofgren et al., 2002) with subsequent modifications. The model follows the SAM disaggregation of factors, activities, commodities, and institutions. The model, therefore, captures the economy-wide interactions among producers, households, the government, and the rest of the world through a system of simultaneous equations based on neoclassical microeconomic theory.

Activities, Production, and Factor Markets: In the CGE model, a representative firm (represented by an activity) in each sector maximizes profits subject to its production technology. The sectoral output follows a Leontief production function of value-added and intermediate inputs, assuming no substitution between them. Each industry's value added is composed of composite labor and composite capital, following a CES specification. Different categories of labor are combined using a CES technology with imperfect substitutability across types. Composite capital is a CES combination of capital categories. It is assumed that intermediate inputs are perfectly complementary. They are combined following a Leontief production function.

Institutions: In the CGE model, institutions are represented by households, enterprises, the government, and the rest of the world. Household incomes come from labor income, capital income, and transfers received from other agents. Subtracting direct taxes yields a household's disposable income. Household savings are a linear function of disposable income, which allows the marginal propensity to save to differ from the average propensity.

Corporate income consists of its share of capital income and of transfers received from other agents. Deducting business income taxes from total income yields the disposable income of each type of business. Likewise, business savings are the residual that remains after subtracting transfers to other agents from disposable income.

The government draws its income from household and business income taxes, taxes on products and imports, and other production taxes. Income taxes for both households and businesses are described as a linear function of total income. The current government budget surplus or deficit (positive or negative savings) is the difference between its revenue and its expenditures. The latter consists of transfers to agents and current expenditures on goods and services.

The rest of the world receives payments for the value of imports, part of the income of capital, and transfers from domestic agents. Foreign spending in the domestic economy consists of the value of exports and transfers to domestic agents. The difference between foreign receipts and spending is the amount of rest-of-the-world savings, which equals the current account balance in absolute value but has the opposite sign.

Commodity Markets: The demand for goods and services, whether domestically produced or imported, consists of household consumption demand, investment demand, demand by government, and demand as transport or trade margins. It is assumed that households have Stone–Geary utility functions (which give rise to the Linear Expenditure System). Investment demand includes both gross fixed capital formation (GFCF) and changes in inventories. Nested constant-elasticity-of-substitution (CES) functions represent producers' supply behavior. On the upper level, aggregate output is allocated to individual products; on the lower level, the supply of each product is distributed between the domestic market and exports. The model departs from the pure form of the small-country hypothesis. A local producer can increase his share of the world market only by offering a price that is more advantageous than the (exogenous) world price. The ease with which his share can be increased depends on the degree of substitutability of the proposed product for competing products; in other words, it depends on the price-elasticity of export demand. Commodities demanded on the domestic market are composite goods, combinations of locally produced goods and imports. A CES aggregator function represents the imperfect substitutability between the two. Naturally, for goods with no import competition, the demand for the composite good is the same as the demand for the domestically produced good. The system requires equilibrium between supply and demand for each commodity in the domestic market. The sum of supplies of every commodity made by local producers must equal domestic demand for that locally produced commodity. Finally, supply to the export market of each good must be matched by demand. Also, there is an equilibrium between total capital demand and its available supply. However, the model assumes both fixed and flexible wage rates for labor under different closure conditions.

Macroeconomic Balances: The CGE model includes three macroeconomic balances: the (current) government balance, the external balance (the current account of the balance of payments, which includes the trade balance), and the Savings-Investment balance.

4.2 A Brief Description of the Social Accounting Matrix (SAM) 2022

The Social Accounting Matrix (SAM) used in this study is the 2022 Bangladesh SAM, developed by the International Food Policy Research Institute (IFPRI, 2024) as part of the Nexus Project. The SAM provides a comprehensive and internally consistent snapshot of the Bangladesh economy for the base year 2022, capturing the circular flow of income and expenditure across all major economic agents and markets. It encompasses 86 activities and 86 corresponding commodities, disaggregated into 35 agricultural activities, 39 industrial activities, including fossil fuel sectors such as coal, crude oil, and natural gas, and 12 service activities, thereby enabling a detailed sectoral analysis of the economy. The factors of production account distinguish 13 factor types, comprising eight labor categories differentiated by location (rural and urban) and education level (uneducated, primary, secondary, and tertiary), alongside five capital categories specific to crops, livestock, mining, and other sectors, as well as crop land. The household account is disaggregated into 15 representative household groups, classified by rural farm, rural nonfarm, and urban locations, and further divided into five expenditure quintiles within each group, allowing for a granular assessment of the distributional and welfare impacts of economic shocks across the income spectrum. The remaining accounts cover transaction costs, enterprises, government, taxes, savings and investment, changes in stocks, and the rest of the world. This rich disaggregation of sectors, factors, and households makes the 2022 Bangladesh SAM particularly well-suited for analyzing the economy-wide, sectoral, and household welfare effects of fossil-fuel price shocks within the CGE modeling framework employed in this study.

Table 1: Description of Bangladesh SAM for 2022

Set	Description of Elements
Activity (86)	**Agricultural Activities (35):** Maize, Sorghum + millet, Rice, Wheat + barley, Other cereals, Pulses, Groundnuts, Other oilseeds, Cassava, Irish potatoes, Sweet potatoes, Other roots, Leafy vegetables, Other vegetables, Sugarcane, Tobacco, Cotton + fibers, Nuts, Bananas + plantains, Other fruits, Tea, Coffee, Cocoa, Cut flowers, Rubber, Other crops, Cattle, Raw milk, Poultry, Eggs, Sheep + goats, Other livestock, Forestry, Aquaculture, Capture fisheries **Industrial Activities (39):** Coal, Crude oil, Natural gas, Other mining, Meat, Fish + seafood, Dairy, Fruits + vegetables, Fats + oils, Maize milling, Sorghum + millet milling, Rice milling, Wheat + barley milling, Other grain milling, Sugar refining, Coffee processing, Tea processing, Other foods, Animal feed, Beverages, Tobacco, Cotton yarn, Textiles, Clothing, Leather + footwear, Wood, Paper, Petroleum, Chemicals, Non-metal minerals, Metals + metal products, Machinery, Equipment, Vehicles, Other manufacturing, Electricity + gas, Water supply + sewage, Construction **Services Activities (12):** Wholesale + retail trade, Transportation + storage, Accommodation, Food services, Information + communication, Finance + insurance, Real estate activities, Business services, Public administration, Education, Health + social work, Other services
Commodity (86)	**Agricultural Commodities (35):** Maize, Sorghum + millet, Rice, Wheat + barley, Other cereals, Pulses, Groundnuts, Other oilseeds, Cassava, Irish potatoes, Sweet potatoes, Other roots, Leafy vegetables, Other vegetables, Sugarcane, Tobacco, Cotton + fibers, Nuts, Bananas + plantains, Other fruits, Tea, Coffee, Cocoa, Cut flowers, Rubber, Other crops, Cattle, Raw milk, Poultry, Eggs, Sheep + goats, Other livestock, Forestry, Aquaculture, Capture fisheries **Industrial Commodities (39):** Coal, Crude oil, Natural gas, Other mining, Meat, Fish + seafood, Dairy, Fruits + vegetables, Fats + oils, Maize milling, Sorghum + millet milling, Rice milling, Wheat + barley milling, Other grain milling, Sugar refining, Coffee processing, Tea processing, Other foods, Animal feed, Beverages, Tobacco, Cotton yarn, Textiles, Clothing, Leather + footwear, Wood, Paper, Petroleum, Chemicals, Non-metal minerals, Metals + metal products, Machinery, Equipment, Vehicles, Other manufacturing, Electricity + gas, Water supply + sewage, Construction **Services Commodities (12):** Wholesale + retail trade, Transportation + storage, Accommodation, Food services, Information + communication, Finance + insurance, Real estate activities, Business services, Public administration, Education, Health + social work, Other services
Factors of Production (13)	Labor - rural uneducated, Labor - rural primary, Labor - rural secondary, Labor - rural tertiary, Labor - urban uneducated, Labor - urban primary, Labor - urban secondary, Labor - urban tertiary, Crop land, Capital – crops, Capital – livestock, Capital – mining, Capital - other
Households (15)	Rural - farm q1, Rural - farm q2, Rural - farm q3, Rural - farm q4, Rural - farm q5, Rural - nonfarm q1, Rural - nonfarm q2, Rural - nonfarm q3, Rural - nonfarm q4, Rural - nonfarm q5, Urban - q1, Urban - q2, Urban - q3, Urban - q4, Urban - q5
Other Accounts (7)	Transaction costs, Enterprises, Government, Taxes, Savings-investment, Change in stocks, Rest of world

Source: International Food Policy Research Institute (2024), 2022 Social Accounting Matrix for Bangladesh: A Nexus Project SAM

4.3 The Structure of the Bangladesh Economy

Table 2 presents the structure of production and trade in Bangladesh in 2022, highlighting the relative importance of different sectors in GDP, exports, and imports, as well as their trade intensities. Services dominated the economy, accounting for 53% of GDP, but played a limited role in external trade, contributing only 13.2% of total exports and 16.4% of total imports. This indicates that most service activities were domestically oriented, with relatively low export and import penetration. Within services, transportation and storage stood out as the most trade-exposed subsector, accounting for

12.8% of total imports and recording an imports-to-demand ratio of 18.7%, reflecting Bangladesh's significant dependence on imported transport services.

Table 2: Structure of Production and Trade in Bangladesh (2022)

	Share of total (%)			Exports/output (%)	Imports/demand (%)
	GDP	Exports	Imports		
All sectors or commodities	100	100	100	6.8	8.6
Agriculture	11.5	0.7	13.9	0.5	10.1
Crops	5.7	0.2	13.8	0.4	22.4
Livestock	1.8	0	0	0	0.1
Forestry	1.5	0	0	0	0
Fisheries	2.6	0.5	0.1	1.3	0.4
Industry	35.5	86.1	69.7	10.8	10.7
Mining	1.6	0	5.1	0	22.8
Manufacturing	22.9	86.1	64	16.1	13.8
Processed foods	2.8	0.2	10.4	0.2	12.8
Beverage and tobacco	0.5	0.3	0.1	1.5	0.6
Textiles, clothing, and footwear	8	67.7	13.8	44.3	16.4
Wood and paper products	0.7	0	1.3	0.2	6.4
Chemicals and petroleum	0.7	0	18.6	0	32.3
Non-metal minerals	3.1	10.7	0	15.6	0
Metals and metal products	1.7	3.7	0	5.8	0
Machinery, equipment, and vehicles	2.5	0	18.5	0	28.9
Other manufacturing	2.8	3.5	1.3	7.5	3.7
Electricity, gas, and steam	1.3	0	0.6	0	2
Water supply and sewage	0.1	0	0	0	0
Construction	9.7	0	0	0	0
Services	53	13.2	16.4	2.4	4.3
Wholesale and retail trade	14.9	0	0	0	0
Accommodation and food services	1.2	1	1.8	3.2	8.1
Transportation and storage	7.5	3.3	12.8	3.9	18.7
Information and communication	1.1	0	0	0	0
Finance and insurance	3.1	0.5	0	1.1	0
Real estate activities	8.5	0	0	0	0
Business services	1.6	1.3	1.4	9.6	13.7
Public administration	2.9	7.2	0.5	22.5	2.7
Education	3.2	0	0	0	0
Health and social work	3.8	0	0	0	0
Other services	5.3	0	0	0	0

Source: International Food Policy Research Institute (2024), 2022 Social Accounting Matrix for Bangladesh: A Nexus Project SAM

In contrast, industry accounted for 35.5% of GDP but 86.1% of exports and 69.7% of imports, underscoring its central role in Bangladesh's integration into global markets. Within the industry, manufacturing was the key driver, accounting for 22.9% of GDP, generating 86.1% of total exports, and absorbing 64% of imports. Textiles, clothing, and footwear alone accounted for 67.7% of exports and exhibited a very high export intensity of 44.3%, reflecting Bangladesh's strong specialization in this subsector. Non-metal minerals emerged as the second-largest export subsector, accounting for 10.7% of total exports and an export intensity of 15.6%. Several manufacturing activities were highly import-dependent: chemicals and petroleum accounted for 18.6% of total imports with an imports-to-demand ratio of 32.3%, while machinery, equipment, and vehicles accounted for 18.5% of total imports with an imports-to-demand ratio of 28.9%. Mining, which includes coal and crude oil, contributed nothing to exports but accounted for 5.1% of total imports, with an imports-to-demand ratio of 22.8%, indicating a structural dependence on imported fossil fuels that is directly relevant to the present study.

Electricity, gas, and steam also recorded a modest but non-trivial import-to-demand ratio of 2%.

Agriculture contributed 11.5% of GDP but accounted for only 0.7% of export earnings, while accounting for 13.9% of total imports; crops were particularly exposed, with an imports-to-demand ratio of 22.4%, indicating limited international competitiveness. Overall, the table reveals a dual structure in which a service-led domestic economy coexists with an industry-led external sector, with exports heavily concentrated in a narrow range of manufacturing activities and imports dominated by fossil fuels, chemicals, and capital-intensive goods, a structural configuration that renders Bangladesh notably vulnerable to external fossil fuel price shocks.

Table 3 summarises the composition of household income in Bangladesh in 2022, revealing clear differences across income quintiles and between rural and urban households. Overall, capital income was the dominant source, accounting for 52.5% of total household income, with non-agricultural capital alone contributing 51%. Labor income accounted for 38.3% of total household income, with the largest share coming from low-educated workers at 18.8%, followed by highly educated workers at 12.4% and medium-educated workers at 7.1%. Crop land income accounted for 3.2% of total household income. This share was notably higher among the poorest households, reaching 6.4% in Quintile 1 and 6.6% in Quintile 2, reflecting the dependence of low-income rural households on land as a productive asset. Transfer income played a relatively minor role at the aggregate level, with government transfers accounting for 0.9% and remittances from the rest of the world accounting for 5% of total household income.

Across income quintiles, pronounced differences in income composition are evident. Poorer households were far more dependent on labor income, particularly low-skilled labor, which accounted for 44% of income in the lowest quintile, compared with only 8.9% in the richest quintile. As household income increased, reliance on labor income declined sharply, while capital income rose, reaching 63.6% in the top quintile, indicating strong asset-based income concentration among richer households. The share of highly educated labor income also increased with income, from 5.3% in Quintile 1 to 14.6% in Quintile 5, reflecting the close association between higher education and higher household income (Ahmed & Zubayer, 2024; Zubayer et al., 2025).

Rural and urban households exhibited distinct income structures. Rural households derived 21.7% of income from low-educated labor and 2.3% from agricultural capital, compared with 14.6% and 0.3%, respectively, for urban households, reflecting the more agrarian character of rural income sources. Urban households, by contrast, derived 17.4% of income from highly educated labor, nearly double the rural share of 8.9%, and 57.2% from non-agricultural capital, compared with 46.8% for rural households, indicating the greater importance of skilled employment and non-farm capital in urban income generation. Remittances from abroad were more significant for rural households, accounting for 6.3% of rural household income, compared with 3.2% for urban households.

Overall, Table 3 highlights pronounced inequality in income sources, with poorer households depending mainly on low-skill labor and crop land, and richer households benefiting disproportionately from non-agricultural capital income and higher-skill employment (see Ahmed & Chowdhury, 2024). These structural differences in income composition have important implications for the distributional consequences of fossil fuel price shocks, as households with different income sources are likely to be affected through distinct transmission channels.

Table 3: Household Income Sources in Bangladesh (2022)

	Share of total household income (%)									
	Labor by education level				Crop land	Capital			Transfers	
	All workers	Low educated	Medium educated	High educated		All	Agriculture	Non-agriculture	Government	World
All households	38.3	18.8	7.1	12.4	3.2	52.5	1.5	51	0.9	5
Quantile 1	56.8	44	7.4	5.3	6.4	31.7	3.4	28.4	3	2.1
Quantile 2	53.7	36.6	9.4	7.7	6.6	33.9	2.8	31.2	2.5	3.2
Quantile 3	48.3	27	9.7	11.7	4.8	40.4	2.1	38.3	1.4	5.1
Quantile 4	38.9	19.5	7	12.4	3.4	51.2	1.4	49.8	0.8	5.6
Quantile 5	29.3	8.9	5.8	14.6	1.4	63.6	0.8	62.8	0.3	5.5
Rural households	38.1	21.7	7.4	8.9	5.1	49	2.3	46.8	1.4	6.3
Urban households	38.7	14.6	6.6	17.4	0.3	57.5	0.3	57.2	0.3	3.2

Source: International Food Policy Research Institute (2024), 2022 Social Accounting Matrix for Bangladesh: A Nexus Project SAM

Table 4 provides an overview of household populations, consumption, and spending patterns in Bangladesh in 2022, highlighting disparities across income quintiles and between rural and urban households. The total population was approximately 167.9 million, with rural households comprising 72.8% and urban households 27.2%. Average per capita consumption spending was 172 thousand Taka, with food accounting for 34.8% of this expenditure. In comparison, total per capita spending was higher at 220 thousand Taka, reflecting a national savings rate of 21.2%.

There were marked differences across income quintiles. The poorest quintile accounted for 20% of the population but only 6.4% of total consumption, with a per capita consumption spending of 55 thousand Taka and a high food share of 42.9%, reflecting severely limited purchasing power. Total per capita spending for this group was 65 thousand Taka, with a savings rate of only 15.8%, the lowest among all quintiles, indicating that the poorest households have virtually no financial buffer against income or price shocks. In contrast, the richest quintile also comprised 20% of the population. However, it accounted for 46.9% of total consumption, with per capita consumption spending of 404 thousand Taka, total per capita spending of 520 thousand Taka, and a lower food share of 33.3%, indicating considerably higher discretionary income. The savings rate generally rose with income, from 15.8% in Quintile 1 to a peak of 22.9% in Quintile 3, before stabilizing at around 21–22% in the upper quintiles, suggesting that middle- and upper-income households have greater capacity to absorb economic shocks through savings.

Rural and urban households exhibited distinct consumption and spending profiles. Rural households had a lower per capita consumption spending of 148 thousand Taka and a higher food share of 37% compared with urban households, which recorded per capita consumption spending of 236 thousand Taka and a food share of 31.1%, reflecting lower incomes and a greater proportion of budgets devoted to essential food expenditure in rural areas. Total per capita spending was 178 thousand Taka for rural households and 333 thousand Taka for urban households. The rural savings rate of 16.5% was considerably lower than the urban rate of 27.7%, indicating that rural households face significantly tighter budget constraints and are more financially exposed to adverse price shocks.

Overall, Table 4 highlights pronounced inequality in consumption and spending, with wealthier urban households enjoying higher living standards, lower relative food expenditures, and higher savings rates. In comparison, rural and poorer households face tighter budget constraints and greater vulnerability to fossil fuel price shocks that raise the cost of food and other essential goods.

Table 4: Household Populations and Expenditures in Bangladesh (2022)

	Population		Consumption spending			Total spending	
	Millions of people	Share of total (%)	Share of total (%)	Per capita (1000 Taka)	Food share (%)	Per capita (1000 Taka)	Savings rate (%)
All households	167.9	100	100	172	34.8	220	21.2
Quantile 1	33.6	20	6.4	55	42.9	65	15.8
Quantile 2	33.5	20	10.3	89	38.6	111	20.1
Quantile 3	33.6	20	14.8	127	35.1	165	22.9
Quantile 4	33.6	20	21.6	185	33.5	238	21.5
Quantile 5	33.5	20	46.9	404	33.3	520	21.2
Rural households	122.2	72.8	62.7	148	37	178	16.5
Urban households	45.7	27.2	37.3	236	31.1	333	27.7

Source: International Food Policy Research Institute (2024), 2022 Social Accounting Matrix for Bangladesh: A Nexus Project SAM

5. Model Simulation and Results

5.1 Simulation Scenario

The study considers three energy price shock scenarios: short-term, medium-term, and long-term to capture the differential impacts of global fossil fuel price fluctuations across different time horizons (Table 5). The short-term energy price (STEP) shock reflects the sharp surge in crude oil, natural gas, and coal prices observed in 2022 following the Russia–Ukraine war, relative to 2021 levels, involving increases of 39.15% in crude oil, 102.32% in natural gas, and 143.28% in coal prices. The medium-term energy price (MTEP) shock represents the persistence of elevated energy prices two years after the onset of the conflict, measured as the average annual price increase in 2024 compared with the pre-crisis baseline year of 2019, involving increases of 22.39% in crude oil, 39.65% in natural gas, and 23.92% in coal prices. The long-term energy price (LTEP) shock captures structural trends in global energy markets, operationalized as the average annual growth in global energy prices over the decade from 2015 to 2025, incorporating increases of 3.83% in crude oil, 4.29% in natural gas, and 6.64% in coal prices. Although this decade encompasses the COVID-19 demand collapse of 2020 and the Russia–Ukraine price spike of 2022, the ten-year average nonetheless provides a meaningful benchmark for the underlying long-run trend in fossil fuel prices. It reflects the cumulative price pressures to which the Bangladeshi economy is structurally exposed. Together, these three scenarios enable a systematic assessment of how energy price shocks of varying magnitudes and durations transmit through Bangladesh's macroeconomy, affect sectoral performance, and generate distributional welfare consequences across household groups.

Table 5: Simulation Scenarios and Rationale

Simulations	Descriptions	Assumptions	Rationale
Short-Term Energy Price (STEP) Shocks	Increase in global energy prices	39.15% increase in crude oil price; 102.32% increase in natural gas price; 143.28% increase in coal price	These price increases were observed in 2022 following the Russia–Ukraine war, compared with 2021.
Medium Term Energy Price (MTEP) Shocks	Increase in global energy prices	22.39% increase in crude oil price; 39.65% increase in natural gas price; 23.92% increase in coal price	Elevated energy prices (average annual increases) persisted in 2024, two years after the Russia–Ukraine war, compared with a normal year such as 2020.
Long-Term Energy Price (LTEP) Shocks	Increase in global energy prices	3.83% increase in crude oil price; 4.29% increase in natural gas price; 6.64% increase in coal price	These increases reflect the average annual growth in global energy prices over the last decade (2015–2025).

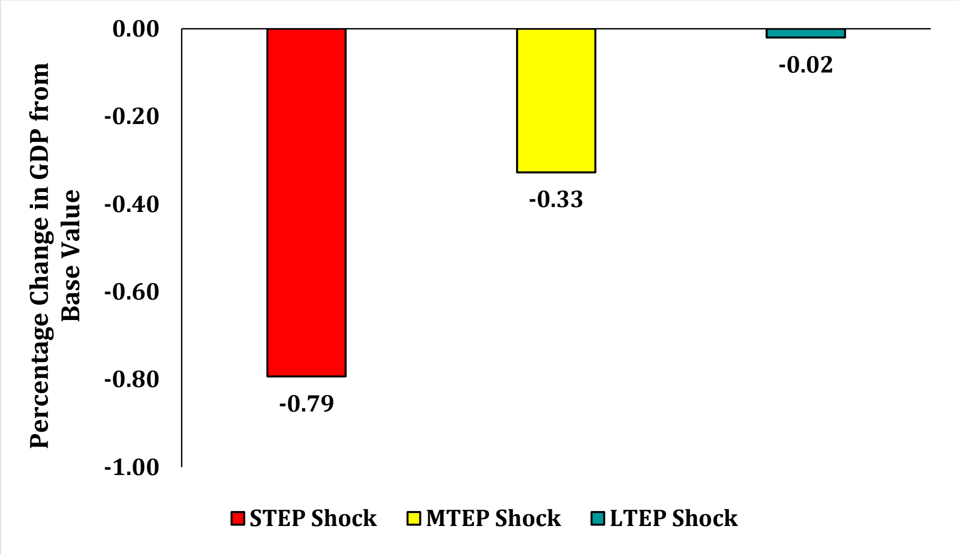
Source: Authors' design based on observed data

5.2 Macroeconomic Impacts of Global Energy Price Shocks

Figure 10 shows that higher global fossil fuel prices lead to significant GDP contractions. The impact's magnitude decreases over time. A short-term energy price shock (STEP) reduces GDP by 0.79% from the baseline, indicating that sudden energy price increases impose immediate costs on production and consumption. In the medium term (MTEP), GDP falls by 0.33%, reflecting partial economic adjustment through measures such as input substitution, efficiency improvements, and policy responses. In the long term

(LTEP), the impact is almost negligible at -0.02%, suggesting that the economy can largely adapt to persistent energy price changes through structural adjustments and longer-term efficiency gains. Overall, these results highlight that the economy is most vulnerable to short-term shocks but demonstrates resilience as adjustments occur over time.

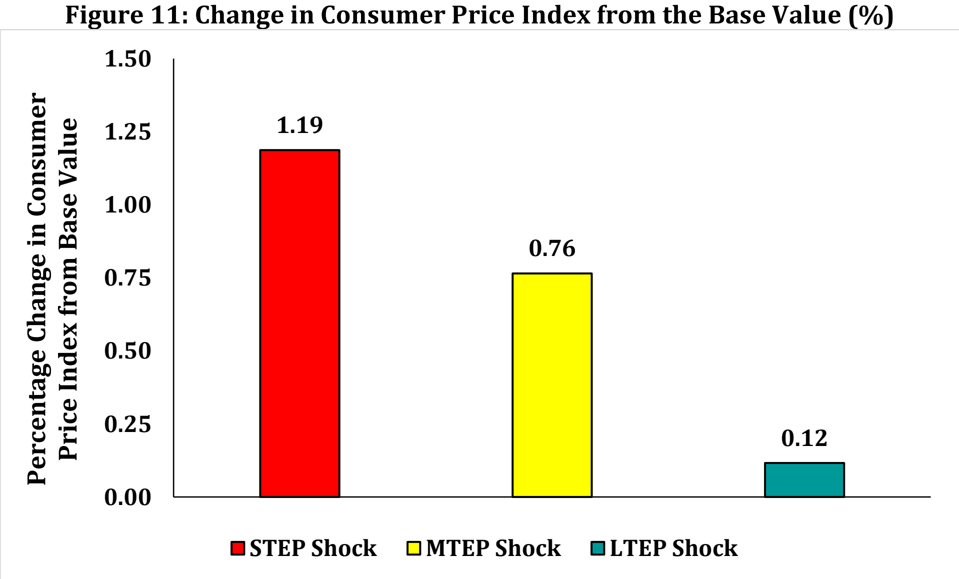
Figure 10: Change in GDP at Market Prices from the Base Value (%)



Source: Static CGE Model Simulation

Figure 11 indicates that energy price shocks generate inflationary pressure, with the impact on consumer prices strongest in the short term and gradually declining over time. Following a short-term shock (STEP), the CPI increases by 1.19% relative to the baseline, reflecting the immediate pass-through of higher energy and production costs to consumer prices. In the medium term (MTEP), the CPI rise moderates to 0.76% as producers and consumers partially adjust through substitution and demand responses. In the long term (LTEP), the CPI increases only slightly by 0.12%, suggesting that longer-term adjustments, efficiency gains, and structural changes substantially dampen the inflationary effects of energy price shocks.

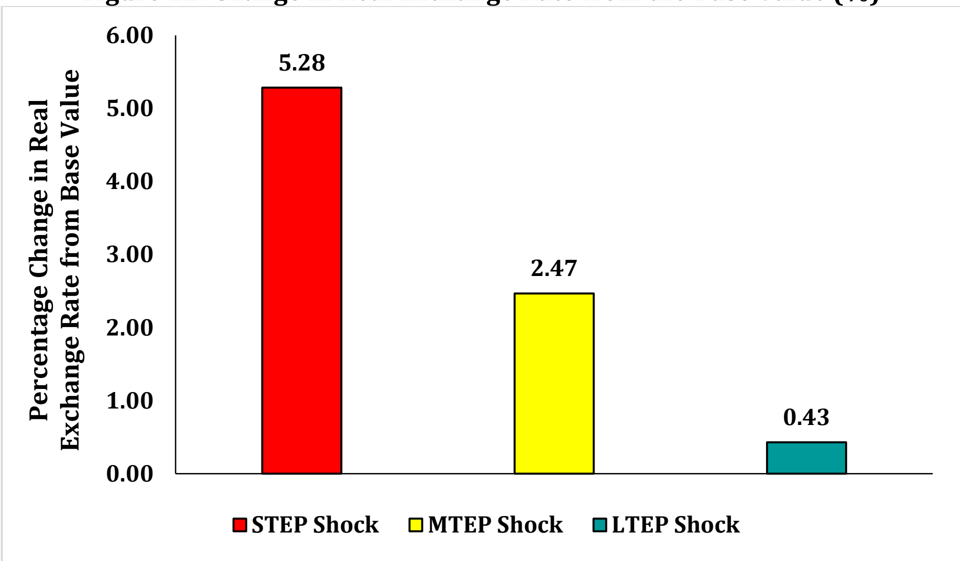
Figure 11: Change in Consumer Price Index from the Base Value (%)



Source: Static CGE Model Simulation

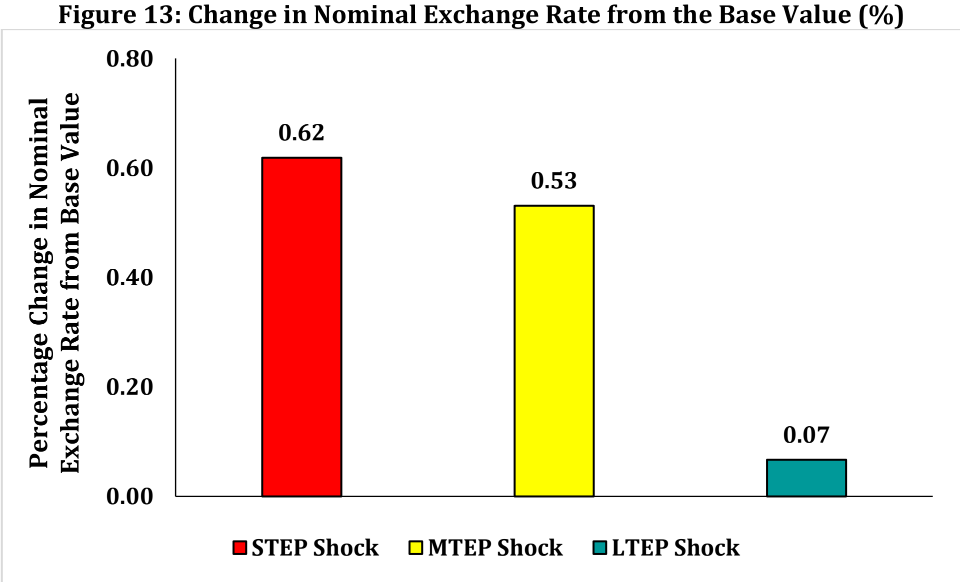
An energy price shock leads to a real depreciation of the domestic currency, with the effect being strongest in the short term and gradually fading over time (Figure 12). In the short term (STEP), the real exchange rate increases by 5.28% relative to the baseline, reflecting higher import costs and inflationary pressures following the shock. In the medium term (MTEP), the depreciation moderates to 2.47% as the economy partially adjusts through price and trade responses. In the long term (LTEP), the real exchange rate rises only slightly by 0.43%, suggesting that most of the depreciation pressure dissipates once full adjustment and structural changes take place.

Figure 12: Change in Real Exchange Rate from the Base Value (%)



Source: Static CGE Model Simulation

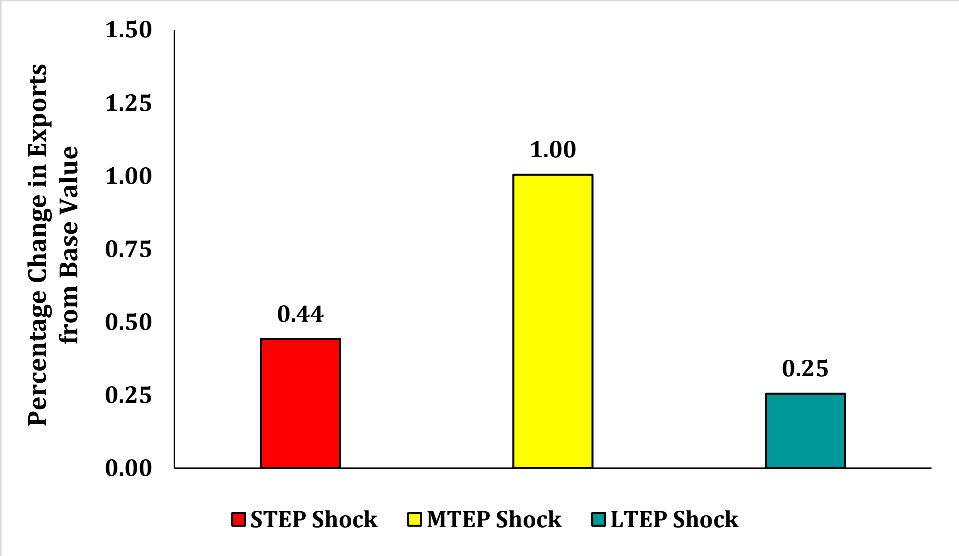
Figure 13: Change in Nominal Exchange Rate from the Base Value (%)



Source: Static CGE Model Simulation

Figure 13 shows that energy price shocks lead to a moderate depreciation of the nominal exchange rate, with the effect strongest in the short term and diminishing over time. Following a short-term shock (STEP), the nominal exchange rate increases by 0.62% relative to the baseline, indicating an immediate depreciation driven by higher import costs and inflationary pressures. In the medium term (MTEP), the depreciation persists but weakens to 0.53% as partial macroeconomic and trade adjustments take place. In the long term (LTEP), the nominal exchange rate rises only marginally by 0.07%, suggesting that most of the initial depreciation pressure is absorbed as the economy gradually stabilizes and adjusts to the shock.

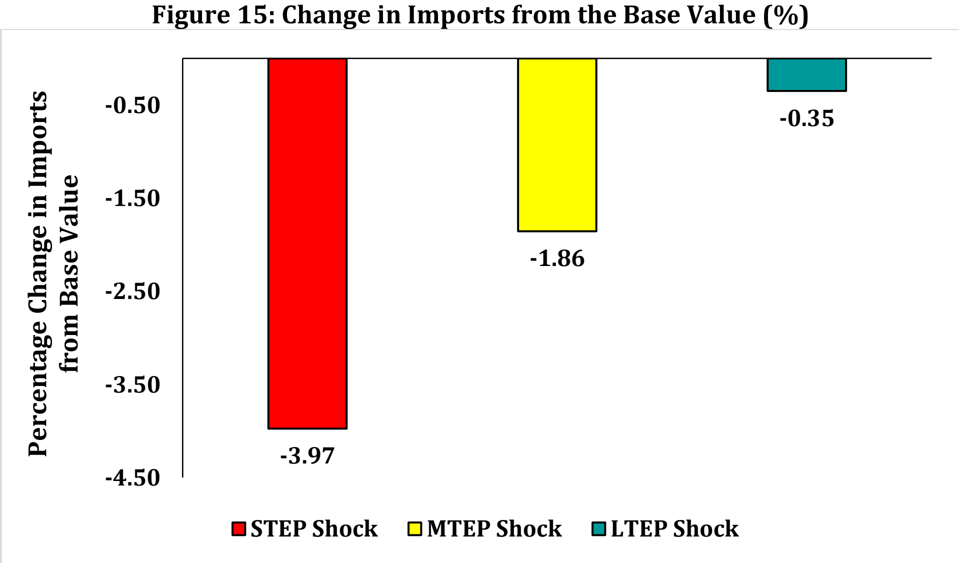
Figure 14: Change in Exports from the Base Value (%)



Source: Static CGE Model Simulation

Figure 14 shows that energy price shocks increase exports, with the response varying across time horizons. In the short term (STEP), exports rise by 0.44% relative to the baseline, reflecting an initial competitiveness gain likely driven by currency depreciation effects. In the medium term (MTEP), exports increase more strongly by 1.00%, suggesting that firms adjust production and reorient output toward external markets as relative prices and trade incentives improve. In the long term (LTEP), the export increase moderates to 0.25%, indicating that as the economy fully adjusts and domestic cost pressures stabilize, the export response remains positive but weaker. Overall, the results imply that exchange rate movements and adjustment mechanisms partially offset the adverse effects of energy price shocks on external trade performance.

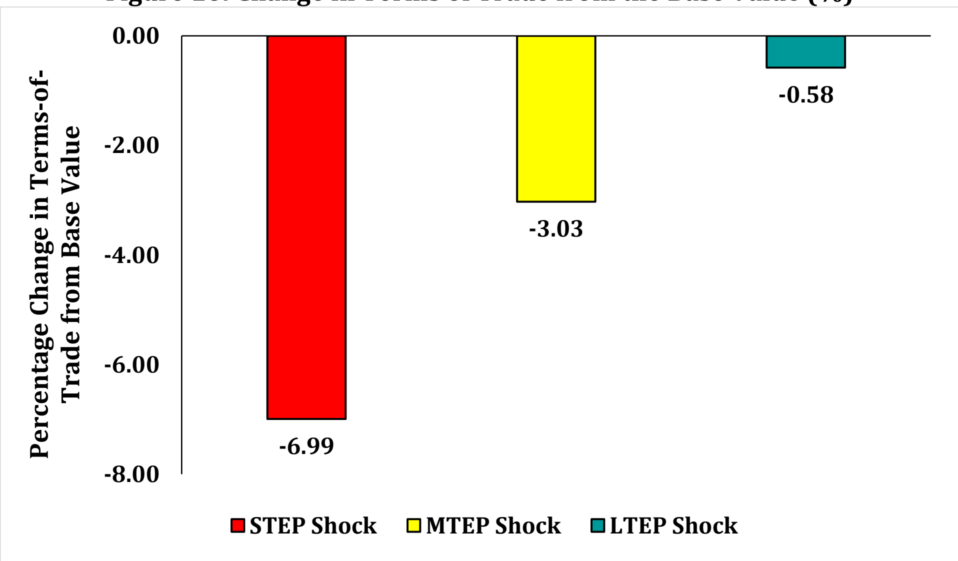
Figure 15: Change in Imports from the Base Value (%)



Source: Static CGE Model Simulation

Figure 15 indicates that energy price shocks lead to a decline in imports, with the contraction strongest in the short term and gradually easing over time. Following a short-term shock (STEP), imports fall by 3.97% relative to the baseline, reflecting higher import costs from currency depreciation and reduced domestic demand. In the medium term (MTEP), imports remain below the baseline, but the decline moderates to 1.86% as partial adjustment in consumption and production takes place. In the long term (LTEP), imports decrease only slightly by 0.35%, suggesting that as the economy adapts through substitution toward domestic production and price stabilization, the initial compression of imports largely dissipates.

Figure 16: Change in Terms of Trade from the Base Value (%)



Source: Static CGE Model Simulation

Figure 16 shows that energy price shocks cause a deterioration in the terms of trade, with the adverse effects strongest in the short term and diminishing over time. In the short term (STEP), the terms of trade decline sharply by 6.99% relative to the baseline, indicating that import prices rise faster than export prices, largely due to higher energy costs and exchange rate depreciation. In the medium term (MTEP), the deterioration moderates to 3.03% as partial price and trade adjustments occur. In the long term (LTEP), the terms of trade fall only marginally by 0.58%, suggesting that structural adjustments and substitution effects help alleviate the initial external price disadvantage.

Table 6: Various Macroeconomic Variables (% of GDP)

		STEP Shocks	MTEP Shocks	LTEP Shocks
Share	**Base Value**	**Change from the Base value (%)**		
Investment / GDP	32.01	0.21	0.13	0.03
Private savings / GDP	31.19	-0.10	-0.06	0.03
Foreign savings / GDP	3.31	0.07	0.04	0.01
Trade deficit / GDP	11.27	0.15	0.09	0.01
Public savings / GDP	-1.36	0.27	0.16	0.00
Import taxes / GDP	0.61	0.02	0.01	0.00
Direct taxes / GDP	2.17	-0.01	0.00	-0.03

Source: Static CGE Model Simulation

Table 6 shows that energy price shocks lead to modest adjustments in macroeconomic balances relative to GDP, with the effects strongest in the short term and gradually diminishing over time. The investment–GDP ratio increases slightly across all horizons, rising by 0.21% under the STEP shock, 0.13% in the MTEP, and 0.03% in the LTEP, suggesting a limited reallocation of resources toward capital formation despite higher energy costs. In contrast, private savings as a share of GDP decline in the short and medium term (−0.10% and −0.06%), reflecting reduced household real income, before marginally increasing in the long term as adjustment takes place. Foreign savings and the trade deficit as shares of GDP increase modestly in the short and medium term, indicating a slightly greater reliance on external financing following the shock. However, these effects nearly vanish in the long run. Public savings improve in the short and medium term, consistent with higher nominal revenues. At the same time, changes in import and direct tax shares are very small, suggesting a limited overall fiscal response. Taken together, the results imply that energy price shocks induce short-run pressure on savings and external balances, but these macroeconomic distortions largely dissipate as the economy adjusts over time.

5.3 Sectoral Impacts for World Energy Price Shocks

Figure 17 presents the simulated changes in sectoral GDP from the baseline across the three energy price shock scenarios. The results reveal pronounced heterogeneity in sectoral responses, reflecting differences in energy intensity, import dependence, and exposure to fossil-fuel price changes.

The most striking result is the strong expansion of the mining sector, which records GDP gains of 9.86% under the STEP shock, 2.15% under the MTEP shock, and 0.68% under the LTEP shock. This outcome is consistent with standard CGE model behavior: as global fossil fuel prices rise, the domestic value of coal, crude oil, and natural gas extraction increases, thereby raising output value and returns to capital in the mining sector. This finding aligns with the broader literature on resource sector responses to commodity price shocks in energy-exporting and mixed economies. Similarly, the solar electricity sector records notable output gains of 5.80% under STEP, 1.20% under MTEP, and 0.46% under LTEP. This result reflects the improved relative competitiveness of solar power as fossil-fuel-based electricity generation becomes more expensive, suggesting that energy price shocks create structural incentives for substitution toward renewable energy sources, an important finding from a long-run energy transition perspective (Raihan et al., 2024b).

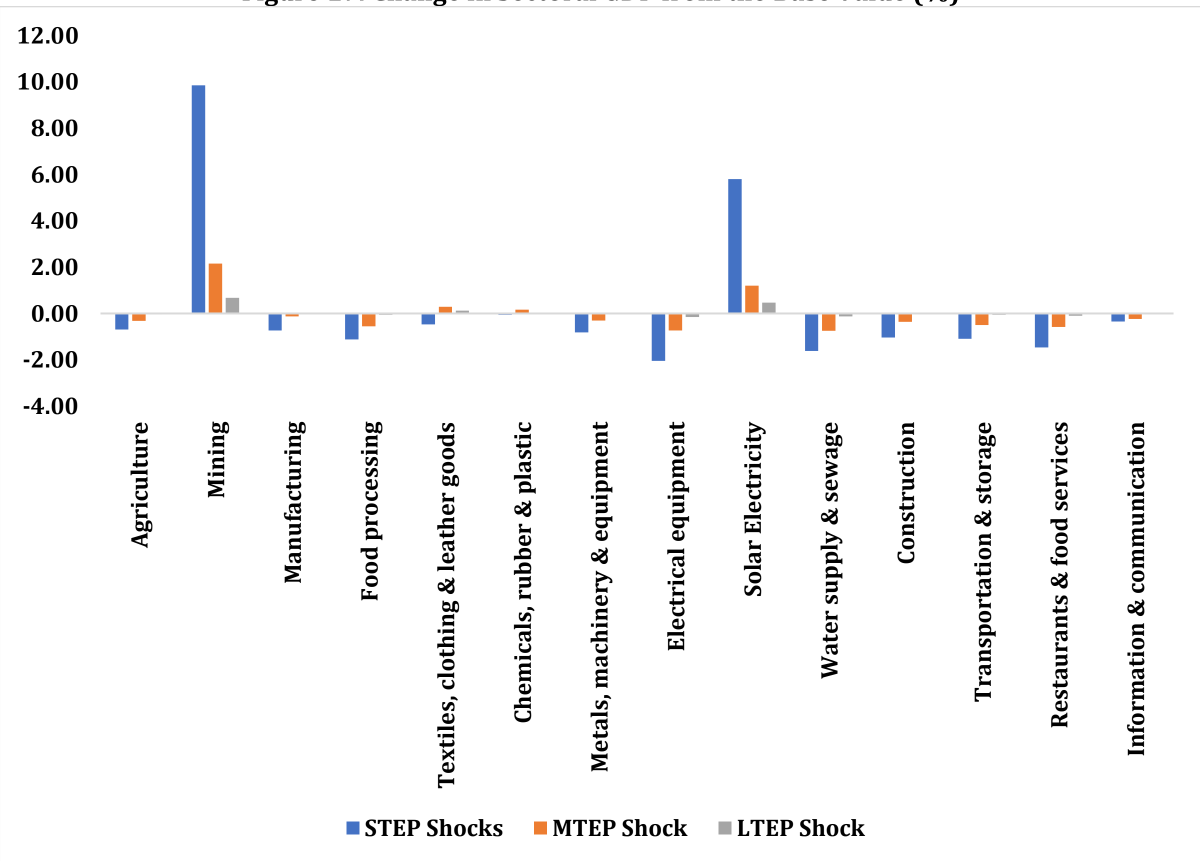
Among the sectors experiencing output contractions, electrical equipment records the largest decline under the STEP shock at -2.04%, followed by water supply and sewage at -1.62%, restaurants and food services at -1.46%, and construction at -1.04%. The sharp contraction in electrical equipment reflects its high reliance on energy-intensive intermediate inputs, making it particularly sensitive to increases in fossil fuel prices. The contraction of the water supply and sewage sector is similarly explained by its significant energy requirements for pumping, treatment, and distribution. Restaurants and food services face a dual burden: higher energy costs for food preparation and heating, combined with compressed household real incomes that reduce demand for discretionary food services.

The transportation and storage sector contracts by 1.09% under STEP, 0.49% under MTEP, and 0.06% under LTEP. This result is particularly significant in the context of

Bangladesh, given the sector's central role in the economy's supply chain linkages. As fossil fuel prices rise, transportation costs increase, with adverse knock-on effects on the competitiveness of downstream sectors that rely on affordable logistics. Food processing also contracts by 1.12% under STEP, reflecting higher energy input costs and elevated raw material prices transmitted from upstream agricultural production. The agriculture sector contracts by 0.69% under STEP and 0.33% under MTEP, reflecting increased costs of energy-dependent inputs such as irrigation, mechanization, and fertilizers, with the effect largely dissipating in the long run to -0.03%.

Manufacturing as a whole contracts by 0.73% under STEP and 0.13% under MTEP, though the aggregate figure masks important within-sector heterogeneity. Textiles, clothing, and leather goods-Bangladesh's dominant export subsector - contract by 0.47% in the short term but recover to modest positive territory in the medium and long term (0.29% and 0.13%, respectively), suggesting that the real exchange rate depreciation identified in the macroeconomic results partially restores export competitiveness of this subsector over time. Chemicals, rubber, and plastics follow a similar pattern, contracting marginally in the short term (-0.06 percent) before registering modest positive responses in the medium and long term (0.17% and 0.04%), which may reflect import-substitution effects as domestically produced chemicals become relatively more competitive with higher-priced imports. Metals, machinery, and equipment, by contrast, contract across all horizons (-0.81%, -0.31%, and -0.02%), reflecting persistent import dependence and high capital intensity that limit the scope for substitution.

Figure 17: Change in Sectoral GDP from the Base Value (%)



Source: Static CGE Model Simulation

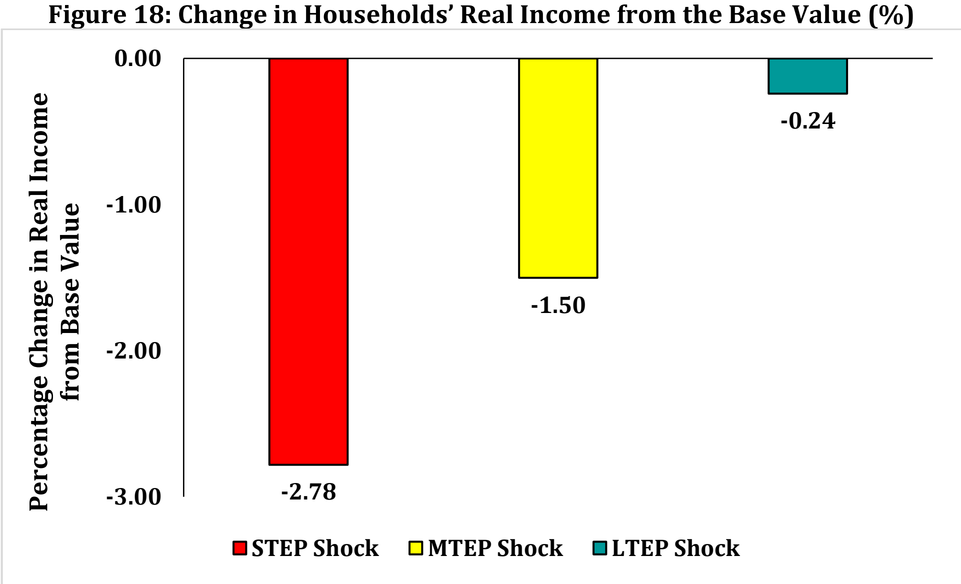
The information and communication sector records relatively modest contractions across all scenarios (-0.35%, -0.23%, and -0.01%), consistent with its comparatively lower direct energy intensity compared with the manufacturing and industrial sectors. However, indirect cost pressures through transportation and utilities still have some adverse effects.

Overall, the sectoral results reveal a clear divide between energy-producing and energy-intensive sectors. While mining and solar electricity benefit from higher fossil fuel prices through increased output values and improved relative competitiveness, respectively, the vast majority of sectors - particularly those with high energy intensity, significant transportation dependence, or strong linkages to imported inputs - experience output contractions. The short-term effects are most severe, with gradual recovery in most sectors over the medium and long term as relative price adjustments and substitution effects take hold. These findings highlight the asymmetric sectoral incidence of fossil fuel price shocks in Bangladesh and underscore the importance of targeted sectoral policies, particularly for energy-intensive industries, food processing, and transportation, to mitigate the adverse output effects of global energy price volatility.

5.4 Household Welfare Impacts of Global Energy Price Shocks

5.4.1 Impacts on Households' Real Income

Figure 18: Change in Households' Real Income from the Base Value (%)

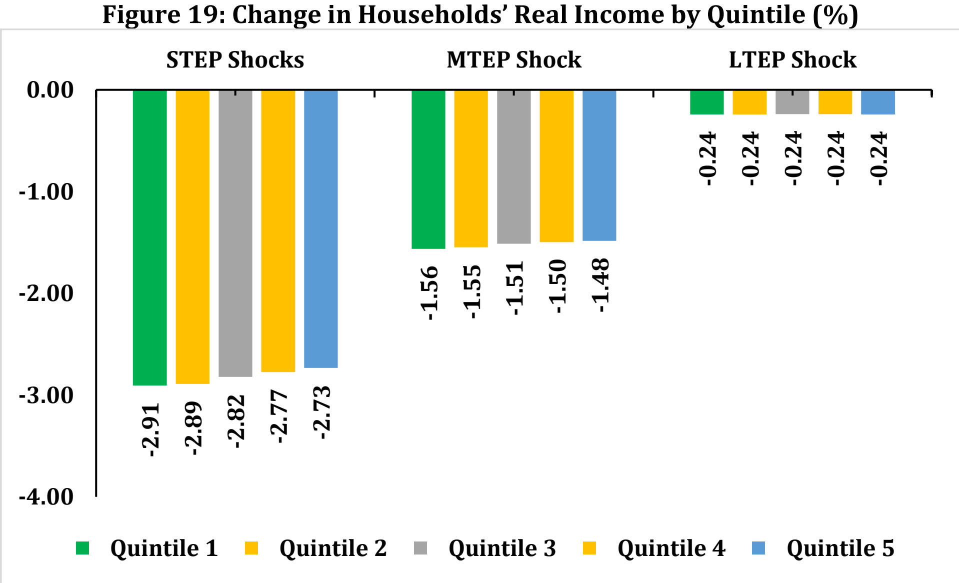


Source: Static CGE Model Simulation

Figure 18 indicates that energy price shocks lead to a decline in households' real income, with the impact strongest in the short term and gradually weakening over time. In the short term (STEP), households' real income falls by 2.78% relative to the baseline, reflecting higher consumer prices, increased energy costs, and reduced purchasing power. In the medium term (MTEP), the decline moderates to 1.50% as households partially adjust through consumption smoothing and labor market responses. In the long term (LTEP), real income decreases only slightly by 0.24%, suggesting that longer-term adjustments in prices, production, and income sources help absorb most of the initial welfare loss. Overall, the results highlight that households bear substantial short-run welfare costs from energy price shocks, while the adverse effects diminish as the economy adapts over time.

Figure 19 indicates that energy price shocks reduce households' real income across all income quintiles, with the short-term impact slightly larger for lower-income households and diminishing over time. In the short term (STEP), the poorest quintile (Quintile 1) experiences the largest decline (−2.91%), while the richest quintile (Quintile 5) sees a slightly smaller loss (−2.73%), suggesting that energy price shocks disproportionately affect lower-income households. In the medium term (MTEP), the losses narrow, ranging from −1.56% for Quintile 1 to −1.48% for Quintile 5, reflecting partial adjustments in consumption and income sources. In the long term (LTEP), all quintiles experience the same decline of −0.24%, indicating that the initial income disparities in vulnerability largely disappear as the economy fully adapts. Overall, the results highlight that energy price shocks impose greater short-run welfare costs on poorer households, though these differences are largely mitigated over the long run.

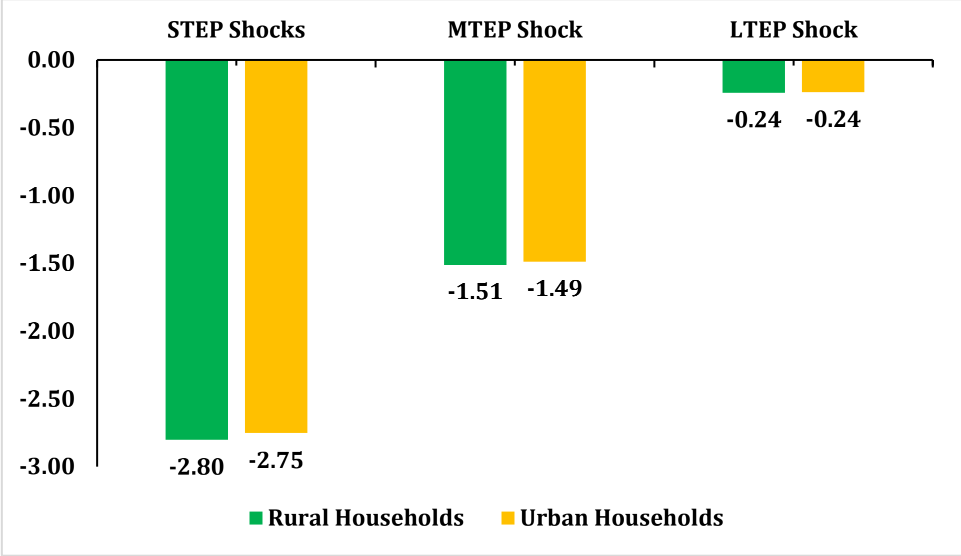
Figure 19: Change in Households' Real Income by Quintile (%)



Source: Static CGE Model Simulation

Figure 20 shows that energy price shocks reduce households' real income in both rural and urban areas, with very similar magnitudes across regions and diminishing effects over time. In the short term (STEP), rural households experience a slightly larger decline in real income (−2.80%) than urban households (−2.75%), indicating marginally higher short-run vulnerability in rural areas, likely due to greater exposure to energy-intensive consumption and limited adjustment capacity. In the medium term (MTEP), real income losses narrow to −1.51% for rural households and −1.49% for urban households as partial economic adjustments take place. In the long term (LTEP), real income falls by an identical 0.24% for both groups, suggesting that regional differences largely disappear once the economy fully adjusts. Overall, the results imply that energy price shocks impose broadly comparable welfare losses across rural and urban households, with only minor short-term disparities.

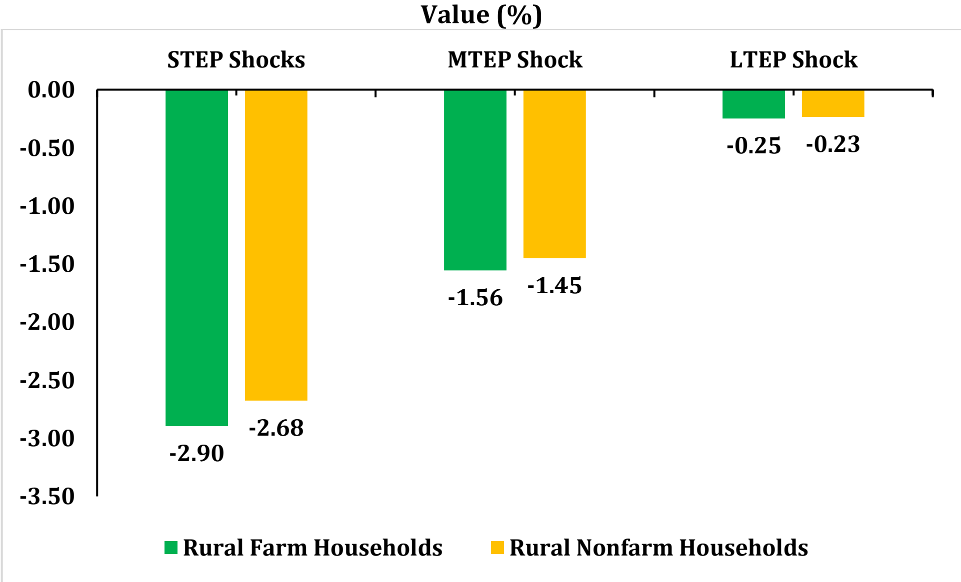
Figure 20: Change in Households' Real Income by Region from the Base Value (%)



Source: Static CGE Model Simulation

Figure 21 indicates that energy price shocks reduce real income for both rural farm and nonfarm households, with farm households experiencing slightly larger short-term losses. In the short term (STEP), rural farm households see a decline of −2.90%, compared to −2.68% for rural nonfarm households, suggesting that farm households are marginally more vulnerable to energy price shocks, likely due to higher exposure to fuel and input costs. In the medium term (MTEP), losses narrow to −1.56% for farm households and −1.45% for nonfarm households as partial adjustments in production, consumption, and income sources occur. By the long term (LTEP), declines are small and nearly equal (−0.25% for farm and −0.23% for nonfarm households), indicating that long-run structural and economic adjustments largely mitigate the initial disparities. Overall, the results suggest that energy price shocks impose slightly higher short-run welfare costs on rural farm households. However, the long-term impact is broadly similar across rural household types.

Figure 21: Change in Rural Households' Real Income by Farm versus Nonfarm Status from the Base Value (%)

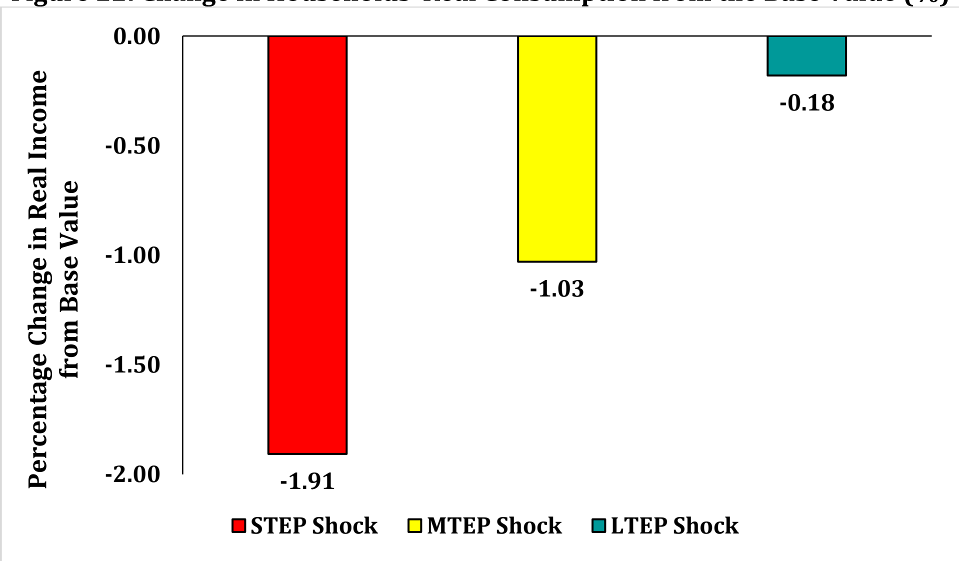


Source: Static CGE Model Simulation

5.4.2 Impacts on Households' Real Consumption

Figure 22 shows that energy price shocks reduce households' real consumption, with the effect strongest in the short term and gradually diminishing over time. Following a short-term shock (STEP), real consumption falls by 1.91% relative to the baseline, reflecting higher prices and reduced purchasing power. In the medium term (MTEP), the decline moderates to 1.03% as households adjust their consumption patterns, partially offsetting higher costs. By the long term (LTEP), real consumption decreases only slightly by 0.18%, indicating that longer-term adjustments in prices, income, and consumption behavior largely mitigate the initial welfare loss. Overall, the results highlight that energy price shocks impose the greatest short-run reduction in household consumption, while the long-term impact is minimal.

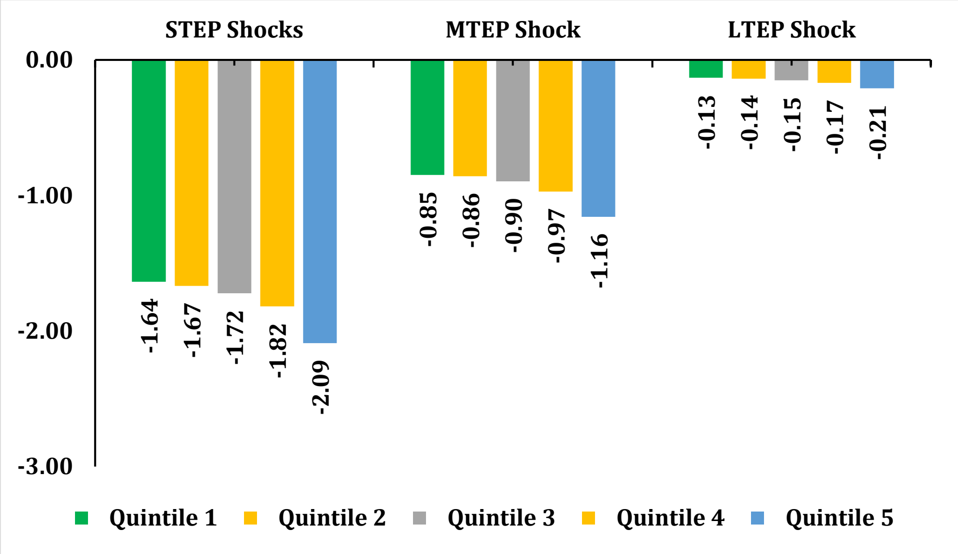
Figure 22: Change in Households' Real Consumption from the Base Value (%)



Source: Static CGE Model Simulation

Figure 23 indicates that energy price shocks reduce households' real consumption across all income quintiles, with the short-term impact being largest for higher-income households. In the short term (STEP), real consumption declines range from −1.64% for the poorest quintile (Quintile 1) to −2.09% for the richest quintile (Quintile 5), suggesting that higher-income households face larger nominal consumption losses, likely due to their greater expenditure on energy-intensive goods. In the medium term (MTEP), the reductions narrow to −0.85% for Quintile 1 and −1.16% for Quintile 5, reflecting partial adjustments in spending patterns and substitution effects. By the long term (LTEP), consumption declines are small across all quintiles (−0.13% to −0.21%), indicating that longer-term economic adjustments, such as income stabilization and price moderation, largely mitigate the initial consumption losses. Overall, the results show that energy price shocks reduce real consumption across all households, with short-term impacts slightly more pronounced among higher-income groups, while long-term effects are minimal.

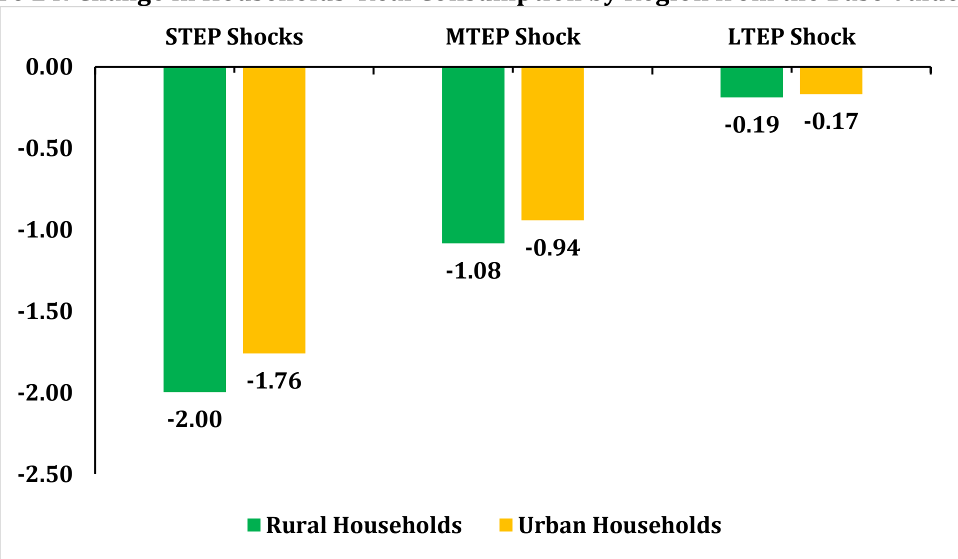
Figure 23: Change in Households' Real Consumption by Quintile from the Base Value (%)



Source: Static CGE Model Simulation

Figure 24 shows that energy price shocks reduce real consumption for both rural and urban households, with the short-term impact slightly larger in rural areas. In the short term (STEP), rural households' consumption falls by 2.00%, compared with 1.76% for urban households, reflecting greater vulnerability in rural areas due to higher energy costs relative to income. In the medium term (MTEP), the reductions moderate to −1.08% for rural and −0.94% for urban households as partial adjustments in consumption and income sources occur. By the long term (LTEP), declines are small and nearly equal (−0.19% for rural and −0.17% for urban households), indicating that longer-term economic adjustments largely mitigate the initial consumption losses. Overall, the results suggest that energy price shocks impose slightly higher short-run consumption costs on rural households, while the long-term impacts are minimal across both regions.

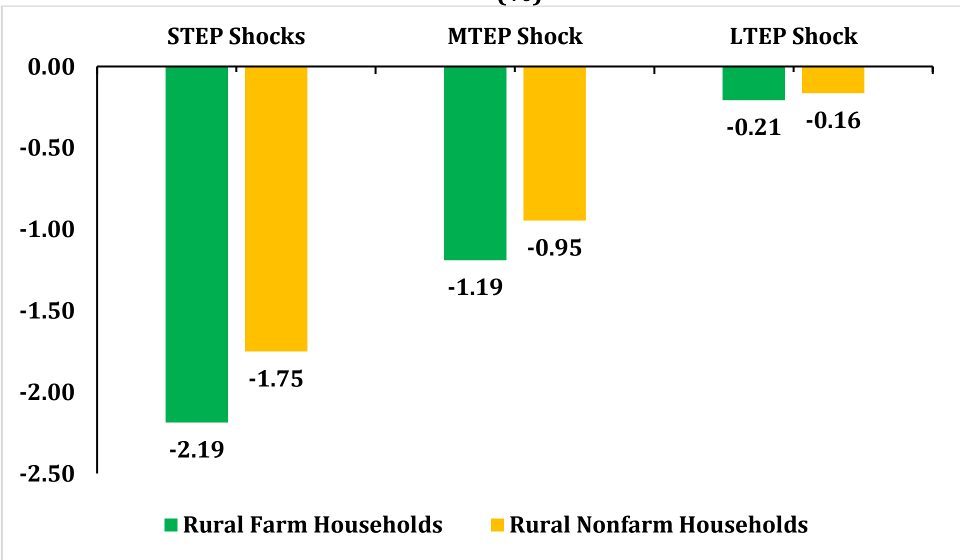
Figure 24: Change in Households' Real Consumption by Region from the Base Value (%)



Source: Static CGE Model Simulation

Figure 25 indicates that energy price shocks reduce real consumption for both rural farm and nonfarm households, with farm households experiencing slightly larger short-term losses. In the short term (STEP), rural farm households' consumption declines by 2.19%, compared to 1.75% for rural nonfarm households, reflecting greater exposure of farm households to energy costs in production and daily activities. In the medium term (MTEP), the declines moderate to −1.19% for farm and −0.95% for nonfarm households as households partially adjust their consumption and income sources. By the long term (LTEP), reductions are small (−0.21% for farm and −0.16% for nonfarm households), indicating that structural and economic adjustments largely mitigate the initial losses. Overall, the results suggest that rural farm households are slightly more vulnerable to energy price shocks in terms of consumption, but the long-term impacts are minimal for both groups.

Figure 25: Change in Rural Households' Real Consumption by Farm versus Nonfarm from the Base Value (%)



Source: Static CGE Model Simulation

6. Conclusion and Policy Implications

6.1 Conclusions

This study examined the economy-wide effects of fossil-fuel price shocks on macroeconomic performance, sectoral output, and household welfare in Bangladesh, a country structurally dependent on imported oil, coal, and liquefied natural gas and therefore acutely vulnerable to global energy price volatility. While a substantial body of literature exists on the macroeconomic and welfare consequences of energy price shocks, no prior study has simultaneously examined all three dimensions, macroeconomic, sectoral, and distributional, within a unified analytical framework for Bangladesh. This study addressed that gap by employing a single-country, static Computable General Equilibrium (CGE) model developed according to the IFPRI standard framework (Lofgren et al., 2002) and calibrated using a highly disaggregated 2022 Social Accounting Matrix. Three simulation scenarios were designed to capture the differential impacts of fossil fuel price shocks across time horizons: a short-term energy price shock (STEP) reflecting the 2022 Russia–Ukraine war price surge, a medium-term shock (MTEP) capturing the persistence of elevated prices in 2024 relative to the pre-crisis baseline of 2019, and a long-term shock (LTEP) representing the average annual growth in global fossil fuel prices over the decade 2015–2025.

The macroeconomic results confirm that fossil fuel price shocks have significant adverse effects in the short term, with these effects moderating over time. Under the STEP shock, GDP contracts by 0.79%, driven by higher intermediate input costs across production sectors, compressed real household incomes, and reduced consumption demand. The CPI rises by 1.19%, reflecting the immediate pass-through of energy costs into consumer prices. In comparison, the real exchange rate depreciates by 5.28%, and the terms of trade deteriorate by 6.99%, signaling a worsening of Bangladesh's external price position. Exports increase modestly by 0.44%, driven by the competitiveness effect of real exchange rate depreciation, while imports contract by 3.97% as higher import costs and reduced domestic demand compress external purchases. These macroeconomic disruptions moderate substantially under the MTEP shock and become negligible under the LTEP shock, suggesting that the economy possesses sufficient structural flexibility to absorb gradual and persistent energy price increases over the long run, while remaining acutely vulnerable to sudden and large price spikes of the kind observed in 2022.

The sectoral results reveal pronounced heterogeneity in responses across the economy. The mining sector expands by 9.86% under STEP, as rising global fossil fuel prices boost the domestic value of coal, crude oil, and natural gas extraction. The solar electricity sector also expands notably by 5.80% under STEP, reflecting the improved relative competitiveness of renewable energy as fossil-fuel-based generation becomes more expensive, an important structural signal for Bangladesh's energy transition agenda. In contrast, the majority of sectors experience output contractions under the STEP shock, with electrical equipment (-2.04 percent), water supply and sewage (-1.62 percent), restaurants and food services (-1.46 percent), transportation and storage (-1.09 percent), construction (-1.04 percent), and food processing (-1.12 percent) recording the largest declines. Agriculture contracts by 0.69% under STEP, reflecting higher costs for energy-intensive inputs such as irrigation, mechanization, and fertilizers. Within manufacturing, textiles, clothing, and leather goods, Bangladesh's dominant export subsector contracts by 0.47% in the short term but recovers to positive territory in the medium and long term, as real exchange rate depreciation partially restores export competitiveness. Sectoral impacts diminish progressively across all three scenarios, with most sectors either recovering or posting minimal changes under the LTEP shock.

At the household level, fossil fuel price shocks generate regressive welfare losses, with poorer, rural, and farm households bearing a disproportionately large burden. Under the STEP shock, aggregate real household income declines by 2.78%, while real consumption falls by 1.91%. Across income quintiles, the poorest households (Quintile 1) experience the largest real income loss (-2.91%), compared with -2.73% for the richest quintile (Quintile 5), confirming the regressive distributional character of energy price shocks. However, the pattern reverses for real consumption losses, where higher-income households experience slightly larger declines (-2.09% for Quintile 5 versus -1.64% for Quintile 1 under STEP), reflecting their greater expenditure on energy-intensive goods and services. Rural households experience marginally larger real income and consumption losses than urban households in the short term. In contrast, rural farm households suffer greater welfare losses than rural nonfarm households across both income and consumption dimensions, driven by higher exposure to fuel and agricultural input costs. These distributional disparities moderate in the medium term and largely converge across household groups in the long term. However, real consumption losses remain more pronounced for rural and farm households across all time horizons. Taken together, the findings underscore the importance of integrated, forward-looking policy frameworks that simultaneously address macroeconomic stability, sectoral resilience, and household welfare protection amid global volatility in fossil fuel prices.

6.2 Policy Recommendations

The CGE simulation results demonstrate that fossil fuel price shocks generate significant short-term risks to Bangladesh's macroeconomic stability, sectoral performance, and household welfare. Although structural adjustment mechanisms moderate these effects over time, proactive and well-coordinated policy interventions are necessary to reduce vulnerability, smooth the adjustment process, and protect the most adversely affected groups. The following recommendations are grounded directly in the simulation findings and are structured around three complementary policy dimensions: macroeconomic stability, sectoral resilience, and household welfare protection.

6.2.1 Macroeconomic Policies

Coordinated Inflation and Output Stabilization

The STEP shock shows a GDP contraction of 0.79% and a CPI increase of 1.19%, demonstrating that fossil-fuel price shocks simultaneously generate inflationary pressures and output losses, creating a policy dilemma between tightening to contain inflation and easing to support growth. Bangladesh Bank should adopt a carefully calibrated monetary response that prioritizes containing second-round inflationary effects, particularly through energy price pass-through to food and transport, while avoiding excessive interest rate increases that would further compress investment and output. Simultaneously, the Ministry of Finance should deploy counter-cyclical fiscal measures, such as temporary reductions in energy-related indirect taxes or targeted expenditure increases, to partially offset the output contraction without undermining fiscal sustainability. Given that macroeconomic effects diminish significantly under the MTEP and LTEP scenarios, such stabilization measures should be designed as explicitly time-limited interventions rather than permanent structural commitments.

Exchange Rate Flexibility and Balance of Payments Management

The sharp 5.28% real exchange rate depreciation and the 6.99% terms-of-trade deterioration under the STEP shock highlight Bangladesh's external vulnerability to fossil-fuel price spikes. Bangladesh Bank should allow a degree of controlled exchange rate flexibility to absorb external shocks and support export competitiveness. The simulation results confirm that real depreciation partially offsets the competitiveness losses from higher energy costs, as evidenced by the modest 0.44% increase in exports under STEP. At the same time, the central bank should maintain adequate foreign exchange reserves to manage excessive nominal volatility and prevent disorderly currency depreciation. The government should also accelerate efforts to diversify energy import sources, negotiate long-term fossil fuel supply contracts at stable prices, and expand strategic petroleum reserves to reduce the balance of payments impact of sudden global price spikes.

Fiscal Space for Energy Transition Investment

The near-negligible macroeconomic effects under the LTEP scenario, the GDP impact of only -0.02%, demonstrate that the Bangladeshi economy can absorb gradual and persistent energy price increases with minimal disruption, provided structural adjustment proceeds. This finding provides a strong macroeconomic rationale for accelerating the energy transition. The government should establish a dedicated Energy Transition Fund, financed through a combination of redirected fossil fuel subsidies, green bonds, and concessional climate finance, to scale up investment in renewable energy infrastructure (Anika et al., 2025). Prioritizing solar energy is particularly warranted given the simulation finding that the solar electricity sector expands by 5.80% under STEP, confirming its role as a structural beneficiary of higher fossil fuel prices and a natural hedge against future energy price volatility.

6.2.2 Sectoral Policies

Emergency Cost Relief for Energy-Intensive Sectors

The sectoral results identify electrical equipment, water supply and sewage, food processing, transportation and storage, construction, and agriculture as the most severely affected sectors under the STEP shock. The government should establish a Sectoral Energy Shock Relief Facility providing time-limited, targeted support to firms in these sectors during periods of acute price spikes. Support instruments should include concessional short-term credit lines to manage liquidity pressures (see Raihan et al., 2024d; Raihan et al., 2022; Raihan et al., 2021a; Raihan et al., 2020b), temporary reductions in energy tariffs for high-intensity industrial users, and expedited customs clearance for energy-efficient capital goods and machinery imports. Critically, this support should be conditional on verifiable productivity improvements or energy efficiency commitments to avoid creating long-term subsidy dependencies.

Energy Efficiency and Technological Modernization Program

The persistent short- and medium-term contractions in the food processing, metals and machinery, and electrical equipment sectors, which show limited recovery even under the MTEP scenario, point to structural energy inefficiency as a key vulnerability. The government, in partnership with the Bangladesh Investment Development Authority (BIDA) and relevant industry associations, should launch a national Energy Efficiency and Industrial Modernization Program offering tax incentives, investment grants, and subsidized technical assistance to firms adopting energy-efficient technologies, cleaner production processes, and renewable energy self-generation (Raihan et al., 2026). In the agricultural sector, where the STEP shock reduces output by 0.69%, a shift toward solar-powered irrigation systems and precision agriculture technologies would lower energy input costs and enhance resilience to future fossil fuel price shocks.

Strategic Support for the Textile and RMG Sector

The simulation results show that Bangladesh's dominant export sector, such as textiles, clothing, and leather goods, contracts by 0.47% under STEP but recovers to positive territory in the medium and long term. To accelerate this recovery and protect the sector's international competitiveness during the transition period, the government should provide targeted export facilitation support, including temporary reductions in energy tariffs for export-oriented manufacturing, trade financing support through the Export Development Fund, and incentives for green certification of garment factories to access premium export markets. These measures would reinforce the competitiveness recovery already identified in the simulation results and reduce the sector's adjustment period following a price shock.

Leveraging Mining and Solar Expansion for Structural Transformation

The strong expansion of the mining sector (9.86% under STEP) and solar electricity (5.80% under STEP) represents a structural opportunity that policy should actively exploit (see Raihan et al., 2025c). For the mining sector, the government should ensure that higher revenues generated during periods of elevated fossil fuel prices are captured through appropriate fiscal instruments, including royalties, production-sharing arrangements, and windfall profit taxes, and channeled into a Sovereign Energy Stabilization Fund to buffer future shocks. In the solar electricity sector, the Bangladesh Energy Regulatory Commission (BERC) should accelerate the grid integration of solar capacity, streamline licensing procedures for private solar investment, and implement net metering regulations that incentivize household and commercial solar adoption, thereby locking in the competitiveness gains identified in the simulation results.

Protecting the Transportation Sector and Supply Chain Linkages

The transportation and storage sector contracts by 1.09% under STEP, with significant knock-on effects on downstream sectors that depend on affordable logistics. Given this sector's centrality to Bangladesh's supply chain connectivity, the government should introduce a Fuel Cost Stabilization Mechanism for commercial freight transport, such as a partial fuel subsidy or road freight tax rebate, that is automatically triggered when global oil prices exceed a defined threshold. Additionally, accelerating investment in mass rapid transit, inland waterway transport, and rail freight infrastructure would structurally reduce the economy's dependence on road-based, petroleum-powered logistics over the medium and long term.

6.2.3 Household Welfare Policies

Automatic Stabilizer for Energy Price Shock-Triggered Cash Transfers

The household results demonstrate that the STEP shock reduces aggregate real household income by 2.78%, with the poorest quintile suffering the largest income loss of -2.91%. To protect the most vulnerable households, the government should institutionalize an Automatic Social Protection Stabilizer, a pre-designed cash transfer mechanism linked to a global energy price trigger that automatically activates enhanced cash transfers to Quintile 1 and Quintile 2 households through the existing social safety net infrastructure when fossil fuel prices exceed a defined threshold. This approach would ensure that compensatory transfers reach vulnerable households rapidly, before the full welfare impact of a price shock materializes, without requiring lengthy parliamentary or bureaucratic approval processes.

Targeted Food Assistance for Rural Farm Households

The simulation results consistently show that rural farm households experience the largest welfare losses across both real income (-2.90% under STEP) and real consumption (-2.19% under STEP). Given that food constitutes 37% of rural household expenditure per the SAM data, and given the strong pass-through from energy prices to food prices through agricultural input and transportation cost channels, the government should expand the Open Market Sales (OMS) program and the Vulnerable Group Feeding (VGF) scheme, specifically in rural agricultural districts during periods of fossil fuel price spikes. Allocation criteria should explicitly prioritize rural farm households in the lowest two income quintiles, who face the compound burden of higher agricultural input costs and reduced real incomes.

Energy Affordability Support for Low-Income Households

The CPI increase of 1.19% under STEP, combined with real income declines disproportionately concentrated in lower quintiles, indicates that low-income households face significant energy affordability pressures following price shocks. The government should reform the existing lifeline electricity tariff structure to ensure that households in the bottom two income quintiles benefit from a meaningful tariff subsidy on their essential energy consumption. At the same time, cross-subsidization from higher-income users covers the fiscal cost. Simultaneously, a targeted LPG subsidy or cooking fuel voucher scheme for rural households that rely more heavily on fossil-fuel-based cooking would directly mitigate the welfare impact of higher gas and petroleum prices on daily household expenditure.

Skills Development and Rural Income Diversification

The finding that rural nonfarm households consistently experience smaller welfare losses than rural farm households across both income (-2.68% versus -2.90% under STEP) and consumption (-1.75% versus -2.19%) dimensions highlights the protective role of income diversification against energy price shocks. The government should therefore scale up investment in rural skills development programs (see Rahman et al., 2025), vocational training centers (see Hossain et al., 2026), and rural enterprise finance facilities (see Hasan et al., 2026) to facilitate the transition of farm-dependent households into nonfarm employment and income sources. Expanding the reach of digital financial services and mobile banking in rural areas would further support income diversification by connecting rural households to broader economic opportunities and reducing their structural vulnerability to energy price volatility.

Long-Term Energy Poverty Reduction Strategy

While the long-term welfare effects are modest across all household groups, real income declines of only -0.24% under LTEP, the simulation results nonetheless confirm that lower-income and rural households remain structurally more exposed to energy price pressures over the long run. The government should develop a comprehensive Energy Poverty Reduction Strategy, integrated into the broader poverty reduction framework, that combines household-level support for renewable energy adoption, such as subsidized solar home systems and clean cooking solutions, with income support measures and community-level investments in energy infrastructure. Prioritizing off-grid and rural energy solutions would simultaneously reduce energy poverty, lower household exposure to fossil-fuel price volatility, and support Bangladesh's national renewable energy and climate commitments.

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