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ENERGY SECURITY AND MACROECONOMIC STABILITY: THE ROLE OF SUPPLY RELIABILITY, AFFORDABILITY, AND DIVERSIFICATION IN CENTRAL ASIA

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Abstract. Energy security is usually treated as an energy-sector objective, yet its macroeconomic role in Central Asia, where five economies combine very different resource endowments and pricing regimes, is poorly documented. This article asks how supply reliability, energy affordability and diversification relate to macroeconomic stability in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, and through which mechanisms. Using a qualitative-comparative design, it synthesises ten peer-reviewed studies and several institutional reports located through scholarly search, compares the concentration of national power systems using 2026 Eurasian Development Bank figures, and examines four country cases. The evidence indicates that (i) unreliable supply imposes measurable real-economy costs, most visibly in hydropower-dependent Tajikistan and Kyrgyzstan; (ii) affordability achieved through below-cost tariffs shifts costs onto public budgets, as Uzbekistan's subsidy experience shows; and (iii) every country depends on a single source for 63–99% of its supply, which amplifies exposure to seasonal, price and import shocks. For the energy exporter, Kazakhstan, oil prices transmit to inflation through exchange rates. The article concludes that energy security supports macroeconomic stability chiefly when reliability and fiscally sustainable pricing are achieved together, and proposes a five-country panel design for formal testing.

Keywords: energy security, macroeconomic stability, Central Asia, supply reliability, energy subsidies, diversification

Introduction

Almost every economic activity, from manufacturing and irrigation to heating and public services, stops when energy stops. Since the oil shocks of the 1970s, economists have documented how disruptions and price swings in energy markets spill into output, inflation and external balances (Hamilton, 1983; Kilian, 2008). Whether secure energy therefore acts as a macroeconomic stabiliser is a question of direct policy relevance for developing and transition economies.

Central Asia is a revealing setting. The five republics inherited interconnected Soviet-era power systems but have since diverged sharply. According to Eurasian Development Bank figures reported in 2026, gas supplies 99% of Turkmenistan's energy balance and 74% of Uzbekistan's, coal supplies 63% of Kazakhstan's, and hydropower supplies 92% in Tajikistan and 91% in Kyrgyzstan (Kabylbayev, 2026). Some of these economies export hydrocarbons, others import fuel or electricity in winter, and Uzbekistan became a gas importer in 2023 (World Bank, 2024). The same energy-security problem therefore produces different macroeconomic risks.

The concept of energy security is itself multidimensional. It covers availability, affordability, technological development, sustainability and regulation (Sovacool & Mukherjee, 2011), and it can be read through the lenses of sovereignty, robustness and resilience (Cherp & Jewell, 2014). Measuring it with a single indicator is therefore misleading, and its effect on macroeconomic outcomes need not be uniform across dimensions.

A gap remains. Existing quantitative studies relate energy security to economic growth rather than to the stability of inflation and output; they typically use composite risk indices that hide which dimension matters; and the Central Asian states are pooled with Turkey and Azerbaijan (Kartal, 2022a) or covered one at a time (Amirov, Kozhukhova, et al., 2018). Turkmenistan is rarely covered at all. Reliability is seldom observed directly, and the fiscal cost of keeping energy affordable is not usually linked to macroeconomic outcomes.

This article therefore asks three questions. **RQ1:** How does supply reliability relate to macroeconomic stability in Central Asia? **RQ2:** How does energy affordability relate to it, once subsidies and fiscal costs are considered? **RQ3:** Does the concentration of national energy supply increase macroeconomic vulnerability? Corresponding propositions are tested qualitatively: **P1** greater reliability supports stability; **P2** affordability supports stability only when fiscally sustainable; **P3** concentration on one source increases exposure to shocks. The thesis is that energy security stabilises Central Asian economies conditionally, depending on the interaction of reliability, pricing policy and the country's exporter or importer position.

The paper proceeds as follows: Section 2 reviews the literature, Section 3 describes the methods, Section 4 reports the results, Section 5 discusses them, and Section 6 concludes.

Literature Review

2.1 From a single indicator to a multidimensional concept

Early definitions equated energy security with physical availability. Sovacool and Mukherjee (2011) synthesised the literature into five dimensions, which implies that availability, cost and regulation must be assessed together. Cherp and Jewell (2014) argued that the familiar "four As" (availability, accessibility, affordability, acceptability) should be complemented by an analysis of sovereignty, robustness and resilience, shifting attention from what is supplied to how systems withstand shocks. Both contributions justify treating reliability, affordability and diversification as separate, potentially conflicting dimensions.

2.2 Energy shocks and macroeconomic transmission

Hamilton (1983) showed that US recessions after the Second World War were typically preceded by sharp oil price increases, launching a large empirical literature. Kilian (2008) refined the picture by showing that the economic effect of an energy price shock depends on what caused it and on how it transmits to output and prices. For Central Asia the direction of the effect also depends on whether a country exports or imports energy. Mukhiyayeva et al. (2026), using Kazakh data for 2015–2025 and nonlinear lagged models, find that a USD 1 per barrel rise in oil prices raises inflation by 0.27% within six months, that currency depreciation intensifies inflationary pressure, and that exchange-rate volatility has threshold effects. An exporter can thus be hit through prices even while it gains revenue.

2.3 Reliability and the real economy

The most credible evidence on reliability comes from outside the region. Allcott, Collard-Wexler and O'Connell (2016), instrumenting shortages with hydroelectric availability, estimate that India's average level of shortages reduced plant revenues and producer surplus by 5–10%. Productivity losses were smaller because inputs can be stored, and plants without generators suffered most. The result is directly relevant to hydropower-dependent economies, but its magnitude cannot be transferred to Central Asia without local evidence.

2.4 Energy security and growth: evidence for the region

Kartal (2022a) studies Turkey, Azerbaijan, Kazakhstan, Turkmenistan and Uzbekistan for 1992–2016 with second-generation panel methods and finds that a 1% rise in the energy-security risk level reduces growth by roughly 0.95%. In a 74-country sample, Kartal (2022b) finds that the direction of causality differs across countries, running from risk to GDP in 14 countries, from GDP to risk in 20 and in both directions in 22, and that causal links are detected more often among lower-middle-income countries. This is an important warning: richer economies may buy more security, so correlation does not establish that security causes stability. Country work for Kazakhstan constructs an energy-security performance index from ten indicators across four dimensions for 2000–2015 and reports a significant improvement (Amirov, Kozhukhova, et al., 2018). The dataset of Lobova et al. (2019) extends this approach to nine CIS members for 2000–2014 using twelve indicators, but omits Turkmenistan. For Tajikistan, a World Bank study documents recurring winter shortages equal to about 24% of winter demand, in a system whose electricity underpins aluminum and agriculture (Fields et al., 2012).

2.5 Research gap

The literature is strong on growth and on single-country indices, but weak in four respects: the outcome is growth rather than stability; the three dimensions are rarely separated; reliability and fiscal costs are rarely observed; and a regional comparison covering all five countries is missing. This article addresses these gaps by comparing all five economies dimension by dimension and by linking each dimension to a transmission channel.

Methods

Research design. The study uses a qualitative-comparative evidence synthesis with three components: (1) a structured review of published research and institutional documents; (2) an indicator comparison of the concentration of national energy systems; and (3) four country cases (Kazakhstan, Kyrgyzstan–Tajikistan as a hydropower pair, Uzbekistan, Turkmenistan) selected because they represent contrasting energy-system types. A formal panel regression was considered but rejected at this stage: with five countries, annual observations and no harmonised annual reliability or affordability series, conventional inference would be unreliable.

Sample. The geographical sample is all five Central Asian republics. Sources were included if they (a) addressed at least one of the three dimensions or its macroeconomic transmission; (b) were peer-reviewed, or issued by a recognised international or national institution; and (c) concerned Central Asia or established a mechanism that transfers to it. Master's theses and unsourced commentary were not used as evidence of effects.

Data collection. Searches in October 2026 combined the terms energy security, economic growth, macroeconomic stability, oil price shock, electricity shortages, energy subsidies and each country name, using web searches of publisher and repository records; each study used is listed with full bibliographic details so that it can be located on Google Scholar. Policy facts (tariffs, subsidies, budget figures) were taken from institutional sources and from official statements reported by Kun.uz, and are flagged as such. Concentration was measured with a simple indicator: the share of the single largest source in the energy or power balance, as reported by the Eurasian Development Bank (Kabylbayev, 2026). A Herfindahl–Hirschman index would be preferable but requires full source-by-source shares that were not available for all five countries.

Analysis. Evidence was coded against the three dimensions (reliability, affordability, diversification) and the four transmission channels (real economy, prices, fiscal position, external position). Each proposition was then rated as supported, partly supported or not testable according to the number, quality and consistency of the evidence. **Ethics.** No human participants were involved and all data are secondary and public, so ethical approval and informed consent were not required. **Limitations** are discussed in Section 5.3.

Results

4.1 Studies used

Table 1 lists the studies that form the evidence base. The ten peer-reviewed studies are complemented by the World Bank sector study on Tajikistan and by the institutional reports cited in Sections 4.2 and 4.3.

Table 1. Research used in this article (author's synthesis)

Study	Context and method	Main finding	Dimension
Sovacool & Mukherjee (2011)	Conceptual synthesis	Energy security has five dimensions, including availability, affordability and regulation	All
Cherp & Jewell (2014)	Conceptual critique	Adds sovereignty, robustness and resilience perspectives to the "four As"	All
Hamilton (1983)	US time series	Post-war recessions typically preceded by sharp oil price rises	Price
Kilian (2008)	Literature review	Effects of energy price shocks depend on their cause and transmission	Price
Allcott et al. (2016)	Indian plants; hydro-based instrument	Average shortages cut plant revenue and producer surplus by 5–10%	Reliability
Kartal (2022a)	Panel of five Turkic states, 1992–2016	1% more energy-security risk lowers growth by about 0.95%	Composite
Kartal (2022b)	74 countries; bootstrap Granger tests	Causal direction varies; more links in lower-middle-income countries	Composite

Study	Context and method	Main finding	Dimension
Amirov, Kozhukhova et al. (2018)	Kazakhstan; index of ten indicators, 2000–2015	Energy-security performance rose significantly	Composite
Lobova et al. (2019)	CIS dataset; twelve indicators, 2000–2014	Index data for four dimensions; Turkmenistan not covered	Composite
Fields et al. (2012)	World Bank sector study, Tajikistan	Winter shortages about 24% of winter demand	Reliability
Mukhiyayeva et al. (2026)	Kazakhstan, 2015–2025; nonlinear lagged models	USD 1/bbl rise in oil raises inflation 0.27% within six months	Price / exporter

4.2 Concentration of national energy systems

Figure 1 shows that every Central Asian economy depends on one source for more than 60% of its supply. The two upstream states are almost wholly hydropower-based, while Turkmenistan is a near single-fuel gas system. Table 2 combines this with each country's macroeconomic position and the exposure documented in the sources.

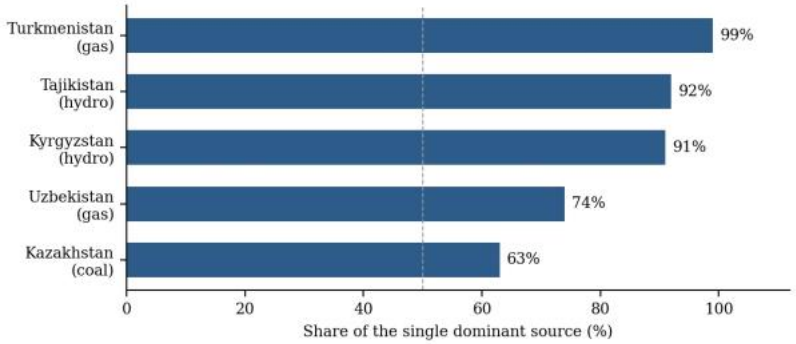

Figure 1. Share of the dominant source in the energy or power balance (Kabylbayev, 2026). Definitions differ slightly by country, so values are indicative.

Table 2. Energy-system profiles of the five economies

Country	Dominant source (share)	Macroeconomic position	Main exposure documented
Kazakhstan	Coal (63% of power)	Raw-material exporter	Oil price and exchange-rate transmission to inflation (Mukhiyayeva et al., 2026)
Kyrgyzstan	Hydro (91%)	Seasonal electricity importer	Imported about 20% of electricity in winter 2024 (FES, 2025)
Tajikistan	Hydro (92%)	Hydropower-dependent; winter deficit	Winter shortages about 24% of winter demand (Fields et al., 2012)
Turkmenistan	Gas (99%)	Gas exporter; grid isolated from the regional system	Exports handled bilaterally outside the regional grid; macroeconomic data scarce (FES, 2025)

Country	Dominant source (share)	Macroeconomic position	Main exposure documented
Uzbekistan	Gas (74%)	Became a gas importer in 2023	Subsidy burden and fuel-import growth (EBRD, 2024; World Bank, 2024)

4.3 Evidence by dimension

Reliability. The clearest evidence concerns the hydropower pair. Fields et al. (2012) report that Tajikistan's recurring winter shortages equal about 24% of winter demand, and that electricity powers aluminium and agricultural production, which together account for about 30% of GDP and nearly 45% of export earnings. Kyrgyzstan imported about 20% of its electricity in winter 2024 (FES, 2025). Across the region, ageing infrastructure produces grid losses that in some cases reach 20% (Kabylbayev, 2026). Evidence on the effect of these interruptions on inflation or output volatility is not available at national level, so the link to macroeconomic stability rests on firm-level analogies (Allcott et al., 2016).

Affordability. Uzbekistan offers the most documented case. In 2023 the Ministry of Energy put the net cost of electricity at 970 soums per kWh against a household tariff of 295, and of gas at 1,890 soums per cubic metre against 380, implying household subsidies above 14 trillion soums (Kun.uz, 2023). Two tariff rounds in 2018–2019 raised the weighted-average tariff by about 70%, yet electricity tariffs stood at about 70% and gas tariffs at about 50% of cost recovery in 2023, with cost recovery targeted for 2026 (ERRA, 2023). The EBRD (2024) notes that more than 70% of subsidies went to energy and that business tariffs were raised in October 2023 and household tariffs in May 2024, the first household increase since August 2019. The World Bank (2024) shows the fiscal deficit widening from 4.1% of GDP in 2022 to 5.8% in 2023. Energy subsidies were reported at 12 trillion soums in 2024, with 7.5 trillion planned for 2025 and an end to energy subsidies announced for 2028 (Kun.uz, 2024). Cheap energy was therefore affordable to consumers but costly to the budget.

Diversification. The Eurasian Development Bank describes a generation mix that has stayed virtually unchanged for thirty years because of inertia and structural barriers (Kun.uz, 2026). Where concentration met limited supply, adjustment was costly: the EBRD (2024) links lower gas extraction in Uzbekistan to energy shortages and a 78.1% year-on-year rise in mineral fuel imports in the period it reports, and Uzbekistan began importing Russian gas in 2023 (World Bank, 2024). Diversification is under way: renewables supplied over 22% of Uzbek electricity in the first half of 2025 (Kun.uz, 2026).

Exporter channel. For Kazakhstan, the evidence points to price and exchange-rate transmission rather than physical shortage: a USD 1 per barrel rise in oil raises inflation by 0.27% within six months, and effects become nonlinear when exchange-rate volatility is high (Mukhiyayeva et al., 2026). Table 3 summarises the assessment of the propositions.

Table 3. Assessment of the propositions

	Proposition	Evidence	Assessment
P1	Greater reliability supports stability	Costs of shortages shown for firms (Allcott et al., 2016) and for Tajikistan (Fields et al., 2012); no region-wide stability estimate	Partly supported
P2	Affordability supports stability only if fiscally sustainable	Uzbekistan: tariffs below cost, large subsidies, later tariff reform (Section 4.3)	Supported (one case)
P3	Concentration increases exposure to shocks	All five systems rely on one source for 63–99%; concentration linked to shortages in Uzbekistan and Kyrgyzstan	Partly supported

Discussion

5.1 Interpretation

The evidence answers the research questions in a qualified way. On RQ1, reliability matters most where the energy system is seasonal: in Tajikistan and Kyrgyzstan, winter shortages affect the sectors that generate much of GDP and export earnings. On RQ2, affordability is a fiscal as well as a social variable. Uzbekistan's experience shows that holding prices below cost protects households in the short run but moves the burden to the budget, and the deficit data are consistent with this pressure, although they do not isolate energy as its cause. On RQ3, concentration is universal in the region, so it cannot by itself explain differences in stability across countries; what differs is whether the dominant source is exposed to seasonal supply, import dependence or price volatility. The exporter case, Kazakhstan, shows that energy affects stability through prices and exchange rates rather than shortages.

5.2 Comparison with the literature and implications

The results agree with Kartal (2022a) that energy-security risk is associated with weaker growth in the region, but they add a distinction his composite measure cannot show: different dimensions work through different channels. They also support the warning in Kartal (2022b) about two-way causality; Uzbekistan's tariff reform illustrates this, since adjustments were paused in 2020–2021 because of COVID-19 and the war in Ukraine (ERRA, 2023), so the pace of reform was itself shaped by external shocks. Allcott et al. (2016) suggest that the cost of shortages depends on firms' ability to cope, which implies that targeted measures such as interruptible contracts or backup capacity for small firms could reduce losses, although this has not been tested for Central Asia. The policy implications are threefold:

sequence tariff reform with targeted social protection so that affordability does not depend on open-ended subsidies; reduce winter exposure of the hydropower states through regional electricity trade and storage; and treat diversification as a reduction of exposure to specific shocks, not as a numerical target.

5.3 Limitations and future research

Several limitations qualify these conclusions. The article relies on secondary evidence and does not estimate causal effects; no study directly measures the effect of reliability on inflation or output volatility in Central Asia. Sources differ in definition and date: Fields et al. (2012) is more than a decade old, and the dominant-source shares mix energy-balance and electricity data. The concentration indicator is cruder than an HHI. Turkmenistan's data are scarce, and some policy facts rest on official statements reported by the media. Future research should build the panel proposed in the project framework: a stability index based on rolling standard deviations of inflation and GDP growth, separate indicators of reliability, affordability and concentration, interactions with external energy shocks, and inference suited to five clusters, such as a wild cluster bootstrap. Interviews with regulators and utilities would help explain the mechanisms.

Conclusion

Energy security in Central Asia is best understood as a set of distinct conditions with different macroeconomic consequences. Unreliable supply imposes real costs where hydropower dominates, below-cost pricing converts affordability into a fiscal liability, and heavy dependence on a single source leaves each economy exposed to a different kind of shock. For the energy exporter, the main channel is prices and exchange rates. These findings support the thesis that energy security stabilises Central Asian economies conditionally, when reliability and fiscally sustainable pricing are pursued together.

The wider lesson is that policies which merely transfer energy costs between households, firms and the budget do not create security. Measurement and transparency matter as much as investment: until annual reliability and loss data are published, the stabilising role of energy security in Central Asia can be argued but not fully tested.

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