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By *Oguzhan Cepni, Selçuk Gül, Abdullah Kazdal, and Muhammed Hasan Yılmaz*

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Energy Supply and Industrial Outcomes: A Quasi-Experimental Evidence from Recent Natural Gas Outage

Oguzhan Cepni[1,2], Selçuk Gül[3], Abdullah Kazdal[3], Muhammed Hasan Yılmaz[3,4]

[1] Copenhagen Business School, Department of Economics, Porcelænshaven 16A, Frederiksberg DK-2000, Denmark

[2] Ostim Technical University, Ankara, Turkiye

[3] Central Bank of the Republic of Türkiye, Ümraniye, Istanbul, 34768, Türkiye

[4] University of St Andrews Business School, Centre for Responsible Banking & Finance, The Gateway, St Andrews, Fife KY16 9RJ, UK

Abstract

Drawing on a large emerging market with a substantial reliance on natural gas as a primary energy source for industrial activities, this paper re-visits the relationship between energy supply conditions and industrial performance. By exploiting a widespread disruption of natural gas supply for industrial use in Türkiye in January 2022 as a quasi-experimental design, we compare the change in economic outcomes of highly gas-dependent industries with others characterized by lower intensity of natural gas use as energy input. Our difference-in-differences estimations show that affected industries experience depressed production, sales, employment and net importing performance relative to control industries in the post-gas outage period. Weakened economic performance is also reflected in amplified financial constraints in the form of lower level of borrowing via bank credits. The baseline results are robust to a myriad of additional analyses and validity checks. Our findings emphasize the importance of energy source diversification strategies and energy security policies in insulating the industrial performance against fluctuations in supply conditions.

Keywords: Natural Gas, Industrial Production, Energy Policies, Difference-in-Differences

JEL Classifications: Q43, O13, C31

1. Introduction and Related Literature

The intricate dynamics between energy supply reliability and industrial production continuity are increasingly recognized as pivotal for sustaining economic stability and fostering growth. Energy disruptions, stemming from various sources including equipment failures, natural disasters, and power outages, significantly obsruct economic processes across multiple sectors (Wu et al., 2023). These disruptions not only cause production halts, leading to delays in order fulfillment and subsequent ripple effects through supply chains but also incur additional costs due to the necessity of utilizing alternative, often more expensive, energy sources. Such events underscore the vulnerability of industrial operations to energy reliability, affecting firms' revenues, competitiveness, and reputation, ultimately eroding trust among business partners and consumers (Tang, 2022).

Furthermore, the ramifications of energy supply interruptions extend beyond the industrial domain, posing significant challenges for monetary policy, particularly in managing inflation and ensuring economic stability. The oil price shocks of the 1970s exemplify this, resulting in diminished production and employment levels, coupled with a marked escalation in inflation rates and expectations. This situation highlighted the limitations of monetary policy in securing economic equilibrium (Gavin et al., 2015). Moreover, the way monetary policy reacts to energy price fluctuations can result in additional welfare losses unless monetary policy framework is designed in an optimal way to target core inflation but also accommodate energy price changes (Natal, 2012). Additionally, supply disruptions are likely to complicate the execution of monetary policy by dampening aggregate demand and exerting downward pressure on GDP, deviating from its long-term trajectory (Fornaro and Wolf, 2023). Therefore, for monetary authorities to achieve lasting price stability, it is crucial to precisely evaluate the impact of energy supply disruptions.

Against this backdrop, this paper investigates the implications of unexpected natural gas supply disruptions, with a particular focus on a recent outage in Türkiye in

January 2022, following an unexpected cessation of gas supply from Iran. This incident, characterized by its exogenous nature and broad impact, provides a unique case study for examining the ramifications of energy supply interruptions on industrial metrics. Utilizing a quasi-experimental design, this study presents novel insights into how disruptions in energy supply can act as an impediment to the development of key industrial metrics. Through detailed empirical analysis, we aim to elucidate the connection between energy supply continuity and industrial activity. In doing so, we contribute to a comprehensive understanding of the challenges and opportunities policymakers face in their pursuit of energy resilience and sustainable industrial development.

To investigate the implications of energy supply disruption, we implement a difference-in-differences (DiD) setting comparing 21 industries (classified at 2-digit NACE level) with varying degrees of natural gas reliance for the period January 2021 to December 2022. By way of preview, after the occurrence of widespread natural gas cuts, industries with a higher ex-ante dependence on natural gas as an energy input faced deteriorated ex-post performance in production, revenue streams, job creation, and net importing capabilities relative to industries with a lower degree of natural gas dependence. This decline in economic performance was observed alongside more restrictive financial constraints, as evidenced by the reduced level of change in credit use for the industries most affected. The validity of our DiD design is demonstrated through a series of graphical and placebo analyses. Moreover, our baseline estimations remain consistent across a variety of robustness checks that revised sample coverage, data processing, and the application of industry-level controls.

This paper contributes to several strands of the literature. Firstly, it builds upon existing research on the implications of energy supply security and continuity. Huntington (2018) introduces a novel methodology to measure supply shocks in oil markets with a direct reference to the price multiplier effect of supply cuts concerning OPEC and Persian Gulf production. De Nooji et al. (2007) focus on the electricity market, discussing the value of supply security and estimating the cost of power interruptions (for households, governments, and sectors) in the Netherlands due to lost production and leisure time. Kitamura and Managi (2017) examine the Japanese case and conclude the negative influence of coal supply disruption on the dynamics of the iron and steel industry, while also emphasizing that resuming nuclear power plant operations is vital for preserving a stable electricity supply. Turning attention to the natural gas market, Nick and Thoenes (2014) report the amplifying effect of supply shortfalls on natural gas prices in the short run. Similarly, Wiggins and Etienne (2017) show that the price elasticity of natural gas supply has risen over time. Di Bella et al. (2022) analyze the implications of disruptions in Russian gas for economic output in Europe. A country-level analysis reveals the vulnerability of Central and Eastern European countries, facing almost a 6% shrinkage in GDP. Similar to our paper, Alcaraz and Villalvazo (2017) evaluate the influence of the natural gas shortage on Mexican economic activity when the national state-owned supplier sustained gas restrictions between 2012 and 2013. They highlight the negative impact of gas shortages on regional industrial production, accompanied by a weaker investment outlook due to delays and cancellations of projects. We extend this evidence base by considering a large emerging market (Türkiye) with a prominent energy-importer status to investigate the effect of a sudden gas supply shock on a broader range of economic outcomes. Benefiting from industry-level heterogeneity, we document the effects not only on industrial production but also on a variety of economic outcomes including revenue streams, employment, and net imports.

Secondly, our work contributes to the burgeoning field of research on the impacts of unanticipated shocks—whether natural, socio-political, or financial—on industrial and economic activity. By situating our analysis within the context of an emerging market experiencing an energy-related shock, we do not only fill a significant gap in the literature but also offer insights into the resilience and vulnerability of industrial sectors in the face of such challenges. This aligns with and expands upon previous studies that have investigated the effects of various unanticipated events, including earthquakes (Kajitani and Tatano, 2014; Tokui et al., 2017; Yagi et al., 2020), pandemics (Caggiano et al., 2020; Deb et al., 2022), terrorism (Lenain et al., 2002; Koh, 2007), and political instability (Aisen and Veiga, 2013).

By providing a detailed examination of the immediate and downstream effects of energy supply shocks on Turkish economy, our research not only enriches the academic discourse on energy economics but also offers practical insights for policymakers, industry stakeholders, and researchers. It underscores the importance of developing robust strategies to mitigate the adverse effects of such shocks, particularly in emerging markets with significant energy import dependencies. Through this contribution, we aim to foster a deeper understanding of the complex dynamics at play in global energy markets and the pivotal role that energy security plays in ensuring economic stability and growth.

The remainder of this paper is structured as follows. Section 2 offers an in-depth exploration of the use and importation of natural gas within the Turkish manufacturing industry, along with a detailed account of the specific gas supply outage period utilized to frame our empirical analysis. Section 3 outlines the data sources and methodological framework employed in our study. Section 4 introduces the initial findings. Section 5 is dedicated to presenting a series of robustness checks to validate the internal validity of our results. Finally, Section 6 provides a summary of our conclusions.

2. Background

The use of natural gas as a vital source of energy accelerated in the 1990s and early 2000s in Türkiye, becoming more widespread due to increasing industrial and household demand over time. This historical trajectory led to both the share of natural gas in primary energy and per-capita natural gas consumption in Türkiye remaining above the world and upper-middle-income country group averages (Figures A1 and A2 of the Appendix). Such consumption and demand structures, marked by comparably low local extraction and reserve capacity, render Türkiye highly dependent on imports to procure the required level of natural gas. Despite ongoing efforts to ensure energy security by diversifying sources (including nuclear and renewable sources) and enhancing the capacity of local supply for industrial use, Türkiye's contemporary energy import dependency rate is still sizeable compared to other (European) countries (Figure A3 of the Appendix).

Although recent efforts to diversify natural gas import sources from pipelines to LNG have reduced the concentration of host countries, two major import markets, Russia and Iran, still account for almost 50% of the total imports (Figure A4 of the Appendix) (CBRT, 2023). The current energy input structure also places additional pressure on the current account balance due to the high sensitivity of natural gas imports to global energy prices. For instance, demand and supply imbalances following the pandemic, along with recent geopolitical conflicts in Eastern Europe, have led to significant increases in global energy prices. As a result, given Türkiye's status as an importer, its energy imports have reached historically high levels due to these price increases (Figures A5 and A6 of the Appendix).

Given the significant level of energy dependence, previous studies for Türkiye have aimed to explore the potential impacts on the sustainability of the current account balance and price stability. Erduman et al. (2020) present comprehensive empirical evidence on the import content of production and exports at the sectoral level. Demir et al. (2023) discover that the import dependency of production significantly influences the relationship between real exchange rate fluctuations and the trend in export volume. Yalçın and Yalçın (2021) show that increasing the share of renewable energy and energy efficiency can reduce net imported energy and positively affect the current account balance as anticipated. Regarding the effects on local pricing dynamics, Ertuğ et al. (2020) conduct a sectoral analysis and found that the degree to which import prices are passed through to domestic prices is directly related to the intensity of imported input use, and the impact of exchange rate pass-through intensifies with the level of imported input use. Akçelik and Öğünç (2016) examine the transmission of oil prices to domestic prices.

However, considering the energy dependency on natural gas, none of the previous studies have conducted an empirical investigation into industrial-level economic outcomes such as production, profitability, and employment creation in response to energy supply shocks in the Turkish context. We undertake such an analysis by leveraging a recent incident in 2022 that resulted in an unexpected, widespread, and exogenous variation in the natural gas supply for industrial purposes. On January 20, 2022, BOTAŞ (Petroleum Pipeline Corporation) announced that the natural gas supply from Iran to Türkiye would be cut for 10 days due to a malfunction in the natural gas transmission line. This disruption to the supply-demand balance in the natural gas market, caused by the cessation of the Iranian supply, led to a 40% reduction in daily natural gas consumption by industrial facilities that use natural gas at high levels during the last ten days of January. Furthermore, it was announced that all Organized Industrial Zones (OIZ) in Türkiye would experience a power outage for 3 days starting from January 24. The announced power outage was subsequently extended until January 29.

As the second most important source of electricity generation in Türkiye, the natural gas accounted for approximately 22% of total electricity production in 2022. Therefore, disruptions in the natural gas supply can have both direct and indirect effects on industrial activities due to its significance in electricity production. Consequently, the incident of natural gas outage in January 2022 for Turkish manufacturing firms in the Organized Industrial Zones (OIZs) has the potential to significantly impact real economic outcomes due to its scope and relevance.

3. Data and Empirical Design

Our sample period spans a limited interval around the natural gas outage in January 2022, covering the monthly data from January 2021 to December 2022. Initially, we collect data on the composition of energy inputs from the National Energy

Balance Tables, which are periodically published by the Ministry of Energy and Natural Resources. This annual publication reports the time-varying distribution of comparable industrial energy consumption (at the 2-digit NACE level, in terms of tons of oil equivalent) in Türkiye, ranging from coal to natural gas and from oil to renewables. We gather historical data to calculate the average natural gas dependency ratio across industries (Figure 1).[1] As expected, we observe a considerable degree of heterogeneity across sectors regarding the share of natural gas in the total primary energy supply. Certain industries, such as pharmaceuticals and chemical products, rely heavily on natural gas to sustain production. Conversely, other sectors like basic metals and plastic products have a lower degree of reliance on natural gas as an energy input.

- Insert Figure 1 here -

Next, we gather data on economic output for 21 industries retained in the previous phase, which is subsequently merged with natural gas dependency ratios. We follow production performance by using the disaggregated series of Industrial Production Index via Turkish Statistical Institute (TurkStat). Additionally, we assess sales performance using the detailed series of the Industrial Revenues Index, adjusted for inflation by the relevant sectoral producer price index, which is also disseminated by TurkStat. Labor market outcomes related to industries are gauged using total formal employment figures, which are disaggregated based on industrial activity and sourced from the Social Security Institution. Moreover, we gather information on foreign trade performance through the Import and Export Quantity Indices series published by TurkStat. Lastly, we analyze micro-level commercial credit data, which is accessed through the Credit Registry at the Central Bank of the Republic of Türkiye and aggregated at the 2-digit NACE level accordingly.

Previous literature on energy economics discipline has vastly employed causal inference methods, mainly DiD technique, to evaluate the implications of energy

[1] We retrieve data for 2014-2021 to calculate the long-term average tendency of each industry to use natural gas.

regulations and shocks on household, firm, and environmental outcomes.[2] In our study, we also adopt a DiD model to assess the industrial consequences of a nationwide disruption in the procurement of natural gas supply. The general model of interest is formed as follows:

$$Outcome_{it} = \beta(Post\ Outage_t * High\ Natural\ Gas_i) + \delta_i + \gamma_t + \varepsilon_{it} \quad (1)$$

where $Outcome_{it}$ represents $Production$, $Revenues$, $Employment$ and $Net\ Imports$ behavior of a specific industry i in time t. The unit of observation is classified at 2-digit NACE level due to data constraints at higher frequency. The dichotomous variable $Post\ Outage_t$ switches to the value of one in January 2022 when widespread natural gas cuts took place, while otherwise zero before this designated date. The binary variable $High\ Natural\ Gas_i$ decomposes industries into two groups based on the ex-ante intensity of natural gas use relative to total energy input. It takes the value of one for the specific group of industries with higher than median value (24.6%) of the ratio of natural gas to total energy input (treated group), whereas it takes the value of zero for the remaining industries (control group). Variable definitions and summary statistics are provided in Table A1 of the Appendix.

Equation (1) is saturated with industry and time (year-by-month) fixed effects absorbing the standalone $Post\ Outage_t$ and $High\ Natural\ Gas_i$ terms. The main coefficient of interest is β attached to the interaction term $Post\ Outage_t$ x $High\ Natural\ Gas_i$ gauging the extent to which industrial outcomes had varied after the occurrence of energy outage for specific industries with heavier reliance on natural gas compared to before-shock dynamics, in excess of the similar change in control

[2] To name a few examples regarding regulatory and policywise changes, Adan and Fuerst (2016) examine the success of energy efficiency policies in UK to reduce household energy expenditures, Li et al. (2023) analyze the effect of China's coal-to-gas transition process on natural gas consumption, whilst Clò and Fumagalli (2019) evaluate the role of imbalance price regulations on the energy imbalances by focusing on the case of Italy. Another strand of the literature harness similar approaches to quantify the economic consequences of energy outages. Tsvetanov and Slaria (2021) consider the Colonial Pipeline system breakdown to document upward movement in gasoline prices due to disruption in fuel supply. Partridge et al. (2020) examine the positive energy supply shock thanks to shale oil and gas discoveries in understanding the spatial effect on non-financial firm performance and survival. Casey et al. (2020) review the papers taking an interest in the community-based social and health results of energy outages.

industries. We base our inferences on the heteroscedasticity-consistent standard errors clustered at industry-month level.

4. Results

4.1. Baseline Findings

In this section, we discuss baseline empirical findings about the impact of natural gas cut in line with the model given in Equation (1). Column (1) of Table 1 shows that, after controlling for industry and time fixed effects, $Post\ Outage$ x $High\ Natural\ Gas$ variable assumes a negative and significant (at 1% level) coefficient in predicting $Production$. This implies that industries with stronger reliance on natural gas as a means of industrial activity before the widespread disruption in gas supply sustain 5.6% lower production growth rate after the shock in comparison with the industries with weaker reliance. Moving to column (2), we observe that DiD term also takes a negative and significant coefficient in estimating the impact on $Revenues$. This hints that, on top of weaker production tendencies, industries with higher degree of susceptibility to gas supply also experiences deteriorating sales performance and revenue growth, approximately 5.2% lower (on average) than other industries with lower degree of dependence. Column (3) reports that treated industries also suffer from depressed job creation in a statistically significant manner, which is manifested by 1.6% lower employment growth rate of heavily affected industries relative to control industries. Moreover, in column (4), we detect that DiD term is negative and significant. This can be explained with the view that treated industries facing depressed production, revenue creation and employment outlook are likely to need lower level of imported raw materials and intermediate goods (which are normalized based on the exporting intensity of industries).

- Insert Table 1 here -

As an additional analysis, we aim to see if such primary economic effects surrounding industrial performance and outcomes are transmitted into financial constraints of these industries as secondary effects. It is expected that any shocks causing sudden changes in operational capacity and revenue stream of firms might further damage collateral values, debt repayment ability and credit risk, exacerbating the obstacles against accessing external finance. Given the bank-dependent financial architecture in Türkiye, we utilize commercial credits extended to the examined industries by aggregating the micro-level Credit Registry data. In Table A2 of the Appendix, we document that industries influenced more by the disruption in gas supply also have less access to external finance, which is shown by the negative and significant coefficient assigned to DiD term in predicting $Credits$ variable.

4.2. Parallel Trends Assumption

The validity of baseline empirical results can be threatened with the potential violation of parallel trends assumption (Roberts and Whited, 2013; Roth et al., 2023). This presumption posits that the outcome of interest for treated and control groups should have followed similar trends in the absence of treatment. In our setting, this requirement is translated into the condition that industrial performance measures including production, revenues, employment and net imports must follow alike paths for industries with high and low dependence on natural gas in the case of no disruption of energy supply. However, similar to other empirical studies, we are restricted with the fundamental problem of causal inference due to the fact that we fail to observe the potential outcome a specific industry would have experienced if the chosen status of treatment had been different (Holland, 1986; Titiunik, 2015). Therefore, we aim to provide indirect evidence suggestive of the potency of parallel trends assumption in our design with two different sets of analyses.

First, we undertake a graphical analysis, depicted in Figure 2. In each case, we present time-varying average values of outcome variables (production, revenues, employment, net imports and credits) for treated and control groups separately via solid lines, with pre- and post-shock period averages as dashed lines. Overall, we observe that the industrial outcomes follow roughly indistinguishable trends before the natural gas outage and tend to display divergence after the event of interest in the form of weaker production, revenues, employment and net foreign trade growth of treated industries relative to control industries.

- Insert Figure 2 here -

Second, to complement visual analysis, we perform two different placebo tests. In the first test, we obtain data for the same variables from an irrelevant time period to our actual design. In this context, we form our sample interval as January 2018-December 2019 and assume a pseudo natural gas outage having hypothetically occurred in January 2019. We run the same model specification defined in Equation (1) with this pseudo sample and shock definitions. In Table 2, we observe that interaction term coefficients are insignificant and smaller in magnitude (except for $Net\ Imports$ outcome variable for which we end up with opposite sign that is vastly different than baseline case). In the second test, we return to our original sample period but randomize the assignment of $High\ Natural\ Gas$ variable (describing the pre-shock characteristic related to natural gas dependency) to 2-digit NACE industries. In Table 3, we find that placebo estimates are all insignificant for industrial performance proxies. Collectively, our results render support to the view that parallel trends assumption is likely to hold for our empirical design.

- Insert Tables 2-3 here -

5. Robustness Checks

In this part, we present a set of robustness analyses associated with sample coverage, data handling and additional industry-level control variables to enhance the validity of main findings.

In Table 4, we use a shorter post-shock period by restricting the sample interval to January 2021-June 2022 to cover 6 months following the natural gas cut to avoid confounders that might arise in the subsequent periods. Instead, in Table 5, we increase the length of post-shock period by enlarging the sample phase to January

2021-July 2023. The findings are mostly in line with the finding that drastic and unexpected disturbances in natural gas supply result in loss of momentum for production, revenue generation, employment creation and net importing tendencies of highly natural gas-dependent industries in relation to other industries.

- Insert Tables 4-5 here -

Next, we revise our baseline criteria to define treated and control industries. Considering that the median threshold value of natural gas dependency ratio might still assign industries with quite similar energy input composition to treated and control groups (especially the ones in the close neighborhood of the threshold value), we choose to narrow down the sample by assigning the value of zero to $High\,Natural\,Gas$ dummy variable if the aforementioned ratio stays below 33rd percentile and the value of one if the ratio stays above 66th percentile, whereas we omit the industries for which the ratio is between these two percentile threshold levels. In Table 6, we show that baseline results are invariant to the narrowed industry coverage, potentially alleviating such similarity concerns across treated and control groups. Moreover, instead of using the share of natural gas in total energy input as reference ratio, we prefer the share of natural gas in non-renewable (brown) energy input. In Table 7, we see that baseline results are not contingent on an alternative way to define the natural gas dependence ratio.

- Insert Tables 6-7 here -

Furthermore, we extend the specification in Equation (1) to control for any confounding impact of expectations channel. To this end, we retrieve time-varying data on production, employment and export expectations at the same sectoral level (2-digit NACE level) from Business Tendency Survey implemented by CBRT and construct additional control variables to be added to the model in Equation (1). In Table 8, we still uncover that natural gas cuts have resulted in deteriorating performance on production, sales, employment, and foreign trade fronts.

- Insert Table 8 here -

It might be argued that our sample period (2021-2022) had been an extraordinary episode for global energy commodity markets in terms of supply, pricing and geopolitical uncertainties, which also coincided with the unique shock causing the disruption for the Turkish market. Despite the fact that time fixed effects embedded in our DiD design is capable of controlling for macro-level shocks, in case such price-related disturbances are reflected in individual industries in a varying manner, then the relationship between energy supply and industrial performance can be confounded by such variation in commodity prices. To ensure the validity of our results, we undertake an additional robustness check. We begin our investigation by obtaining (industry-invariant) natural gas import prices covered by the import price index of TurkStat. To end up with an industry-level proxy for price pressures, we later normalize this series with industry PPI figures from TurkStat. Adding the natural logarithm of this series to the set of controls, in Table 9, we find that our main findings remain qualitatively similar.

- Insert Table 9 here -

6. Conclusion

This study examines the profound implications of energy supply disruptions, particularly focusing on the ramifications of a significant natural gas outage in Türkiye. Such disruptions highlight the vulnerabilities inherent in economies lacking a diversified supplier base and sophisticated logistical frameworks for energy procurement. This research conducts an empirical analysis to revisit the relationship between energy supply dynamics and industrial economic outcomes within an emerging market known for its substantial reliance on natural gas.

In terms of strategic implications, our findings underscore the need for comprehensive energy policies that encompass the security, sustainability, and diversification of inputs. A reliance on a more diversified energy mix, to a greater extent including renewable sources, would contribute significantly to achieving a lower carbon footprint globally. Furthermore, the enhanced diversification of energy inputs helps reduce the high level of dependence on specific sources, such as natural gas in our case. Accordingly, the study emphasizes the necessity for policy measures that promote the adoption of innovative technologies and the expansion of energy storage capacities to protect industries against the fluctuations of energy supply. Additionally, policies aimed at alleviating financing constraints for businesses would expedite the adaptation of more energy-efficient production processes in industrial sectors. Given the heightened geopolitical risks globally, special attention should be given to engaging in multinational collaborations to increase energy supply diversity. Such collaborative efforts are crucial for creating a stable and diversified energy supply chain, essential for maintaining industrial productivity and fostering economic growth.

In conclusion, policy measures designed to reduce energy dependency are likely to mitigate the potential secondary economic side-effects of energy supply disruption on local industrial activity in emerging markets, as re-emphasized by this work.

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Table 1: Baseline Results

	(1) **Production**	(2) **Revenues**	(3) **Employment**	(4) **Net Imports**
Post Outage x High Natural Gas	-0.056*** (0.019)	-0.052*** (0.019)	-0.016*** (0.005)	-0.228*** (0.035)
Obs.	504	504	504	456
Industry Fixed Effects	✓	✓	✓	✓
Time Fixed Effects	✓	✓	✓	✓
Adj. R^2	0.72	0.78	0.99	0.88

Notes: This table reports the baseline DiD estimations based on the specification in Equation (1). Main sample covers 21 industries (2-digit NACE level) for the period of January 2021-December 2022. Columns (1), (2), (3) and (4) use the natural logarithm of industrial production index ($Production$), the natural logarithm of industrial revenues index ($Revenues$), the natural logarithm of the number of formally employed people ($Employment$) and the difference between natural logarithms of import and export quantity indices ($Net\ Imports$) as the dependent variables, respectively. The main independent variable of interest is the interaction term between $Post\ Outage$ and $High\ Natural\ Gas$. The model is saturated with industry and time (month-by-year) fixed effects absorbing individual $Post\ Outage$ and $High\ Natural\ Gas$ terms. Variable definitions are provided at Table A1 of the Appendix. Heteroscedasticity-consistent standard errors clustered at industry-month level are given in parantheses. ***, ** and * represent statistical significance at 1%, 5% and 10% levels, respectively.

Table 2: Placebo Test 1

	(1) **Production**	(2) **Revenues**	(3) **Employment**	(4) **Net Imports**
Post Outage x High Natural Gas	0.018 (0.019)	0.008 (0.019)	-0.009 (0.009)	0.132*** (0.041)
Obs.	504	504	504	456
Industry Fixed Effects	✓	✓	✓	✓
Time Fixed Effects	✓	✓	✓	✓
Adj. R^2	0.59	0.59	0.99	0.81

Notes: This table reports the first placebo test conducted to assess the validity of parallel trends assumption. We use a different sample period spanning the interval between January 2018 and December 2019. The pseudo $Post\ Outage$ variable switches to the value of one in January 2019. Columns (1), (2), (3) and (4) use the natural logarithm of industrial production index ($Production$), the natural logarithm of industrial revenues index ($Revenues$), the natural logarithm of the number of formally employed people ($Employment$) and the difference between natural logarithms of import and export quantity indices ($Net\ Imports$) as the dependent variables, respectively. The main independent variable of interest is the interaction term between $Post\ Outage$ and $High\ Natural\ Gas$. The model is saturated with industry and time (month-by-year) fixed effects absorbing individual $Post\ Outage$ and $High\ Natural\ Gas$ terms. Variable definitions are provided at Table A1 of the Appendix. Heteroscedasticity-consistent standard errors clustered at industry-month level are given in parantheses. ***, ** and * represent statistical significance at 1%, 5% and 10% levels, respectively.

Table 3: Placebo Test 2

	(1) Production	(2) Revenues	(3) Employment	(4) Net Imports
Post Outage x High Natural Gas	-0.002	0.003	0.007	-0.022
	(0.018)	(0.018)	(0.005)	(0.038)
Obs.	504	504	504	456
Industry Fixed Effects	✓	✓	✓	✓
Time Fixed Effects	✓	✓	✓	✓
Adj. R^2	0.72	0.77	0.99	0.86

Notes: This table reports the second second placebo test conducted to assess the validity of parallel trends assumption. We keep the main sample period same (spanning the interval between January 2021 and December 2022, but we randomize the treatment assignment by using a pseudo $High\ Natural\ Gas$ variable reshuffling the the status of ex-ante high natural gas dependency. Columns (1), (2), (3) and (4) use the natural logarithm of industrial production index ($Production$), the natural logarithm of industrial revenues index ($Revenues$), the natural logarithm of the number of formally employed people ($Employment$) and the difference between natural logarithms of import and export quantity indices ($Net\ Imports$) as the dependent variables, respectively. The main independent variable of interest is the interaction term between $Post\ Outage$ and $High\ Natural\ Gas$. The model is saturated with industry and time (month-by-year) fixed effects absorbing individual $Post\ Outage$ and $High\ Natural\ Gas$ terms. Variable definitions are provided at Table A1 of the Appendix. Heteroscedasticity-consistent standard errors clustered at industry-month level are given in parantheses. ***, ** and * represent statistical significance at 1%, 5% and 10% levels, respectively.

Table 4: Robustness Checks-Shorter Post Outage Period

	(1) Production	(2) Revenues	(3) Employment	(4) Net Imports
Post Outage x High Natural Gas	-0.063***	-0.049**	-0.009**	-0.087**
	(0.022)	(0.022)	(0.004)	(0.035)
Obs.	378	378	378	342
Industry Fixed Effects	✓	✓	✓	✓
Time Fixed Effects	✓	✓	✓	✓
Adj. R^2	0.74	0.80	0.99	0.91

Notes: This table reports the robustness analysis shortening the post gas outage period to 6 months following the supply disruption. Main sample covers 21 industries (2-digit NACE level) for the period of January 2021-June 2022. Columns (1), (2), (3) and (4) use the natural logarithm of industrial production index ($Production$), the natural logarithm of industrial revenues index ($Revenues$), the natural logarithm of the number of formally employed people ($Employment$) and the difference between natural logarithms of import and export quantity indices ($Net\ Imports$) as the dependent variables, respectively. The main independent variable of interest is the interaction term between $Post\ Outage$ and $High\ Natural\ Gas$. The model is saturated with industry and time (month-by-year) fixed effects absorbing individual $Post\ Outage$ and $High\ Natural\ Gas$ terms. Variable definitions are provided at Table A1 of the Appendix. Heteroscedasticity-consistent standard errors clustered at industry-month level are given in parantheses. ***, ** and * represent statistical significance at 1%, 5% and 10% levels, respectively.

Table 5: Robustness Checks-Longer Post Outage Period

	(1) **Production**	(2) **Revenues**	(3) **Employment**	(4) **Net Imports**
Post Outage x High Natural Gas	-0.063*** (0.020)	-0.056*** (0.021)	-0.018*** (0.006)	-0.284*** (0.035)
Obs.	651	651	651	589
Industry Fixed Effects	✓	✓	✓	✓
Time Fixed Effects	✓	✓	✓	✓
Adj. R^2	0.74	0.77	0.99	0.87

Notes: This table reports the robustness analysis extending the post gas outage period following the supply disruption. Main sample covers 21 industries (2-digit NACE level) for the period of January 2021-July 2023. Columns (1), (2), (3) and (4) use the natural logarithm of industrial production index ($Production$), the natural logarithm of industrial revenues index ($Revenues$), the natural logarithm of the number of formally employed people ($Employment$) and the difference between natural logarithms of import and export quantity indices ($Net\ Imports$) as the dependent variables, respectively. The main independent variable of interest is the interaction term between $Post\ Outage$ and $High\ Natural\ Gas$. The model is saturated with industry and time (month-by-year) fixed effects absorbing individual $Post\ Outage$ and $High\ Natural\ Gas$ terms. Variable definitions are provided at Table A1 of the Appendix. Heteroscedasticity-consistent standard errors clustered at industry-month level are given in parantheses. ***, ** and * represent statistical significance at 1%, 5% and 10% levels, respectively.

Table 6: Robustness Checks-Alternative Treatment and Control Group Classification

	(1) **Production**	(2) **Revenues**	(3) **Employment**	(4) **Net Imports**
Post Outage x High Natural Gas	-0.050** (0.019)	-0.044** (0.020)	-0.012** (0.005)	-0.263*** (0.041)
Obs.	360	360	360	336
Industry Fixed Effects	✓	✓	✓	✓
Time Fixed Effects	✓	✓	✓	✓
Adj. R^2	0.76	0.81	0.99	0.88

Notes: This table reports robustness analysis revising the treatment variable definition. $High\ Natural\ Gas$ binary variable takes the value of one for the industries with higher than 66th percentile of the distribution of the natural gas energy input dependency ratio, while assuming the value of zero for the industries with lower than 33rd percentile of the distribution by discarding the industries in between. Columns (1), (2), (3) and (4) use the natural logarithm of industrial production index ($Production$), the natural logarithm of industrial revenues index ($Revenues$), the natural logarithm of the number of formally employed people ($Employment$) and the difference between natural logarithms of import and export quantity indices ($Net\ Imports$) as the dependent variables, respectively. The main independent variable of interest is the interaction term between $Post\ Outage$ and $High\ Natural\ Gas$. The model is saturated with industry and time (month-by-year) fixed effects absorbing individual $Post\ Outage$ and $High\ Natural\ Gas$ terms. Variable definitions are provided at Table A1 of the Appendix. Heteroscedasticity-consistent standard errors clustered at industry-month level are given in parantheses. ***, ** and * represent statistical significance at 1%, 5% and 10% levels, respectively.

Table 7: Robustness Checks-Alternative Natural Gas Dependency Ratio

	(1) Production	(2) Revenues	(3) Employment	(4) Net Imports
Post Outage x High Natural Gas	-0.084***	-0.093***	-0.016***	-0.129***
	(0.017)	(0.017)	(0.005)	(0.037)
Obs.	504	504	504	456
Industry Fixed Effects	✓	✓	✓	✓
Time Fixed Effects	✓	✓	✓	✓
Adj. R^2	0.73	0.78	0.99	0.86

Notes: This table reports robustness analysis revising the treatment variable definition. $High\ Natural\ Gas$ binary variable is defined based on the natural gas energy input dependency ratio calculated as the share of natural gas in total "brown" sources of energy (instead of total sources of energy in the baseline case including renewables etc.). Main sample covers 21 industries (2-digit NACE level) for the period of January 2021-December 2022. Columns (1), (2), (3) and (4) use the natural logarithm of industrial production index ($Production$), the natural logarithm of industrial revenues index ($Revenues$), the natural logarithm of the number of formally employed people ($Employment$) and the difference between natural logarithms of import and export quantity indices ($Net\ Imports$) as the dependent variables, respectively. The main independent variable of interest is the interaction term between $Post\ Outage$ and $High\ Natural\ Gas$. The model is saturated with industry and time (month-by-year) fixed effects absorbing individual $Post\ Outage$ and $High\ Natural\ Gas$ terms. Variable definitions are provided at Table A1 of the Appendix. Heteroscedasticity-consistent standard errors clustered at industry-month level are given in parantheses. ***, ** and * represent statistical significance at 1%, 5% and 10% levels, respectively.

Table 8: Robustness Checks-Controlling for Expectations

	(1) Production	(2) Revenues	(3) Employment	(4) Net Imports
Post Outage x High Natural Gas	-0.049***	-0.047**	-0.015***	-0.229***
	(0.017)	(0.018)	(0.005)	(0.036)
Obs.	504	504	504	456
Industry Fixed Effects	✓	✓	✓	✓
Time Fixed Effects	✓	✓	✓	✓
Adj. R^2	0.75	0.79	0.99	0.87

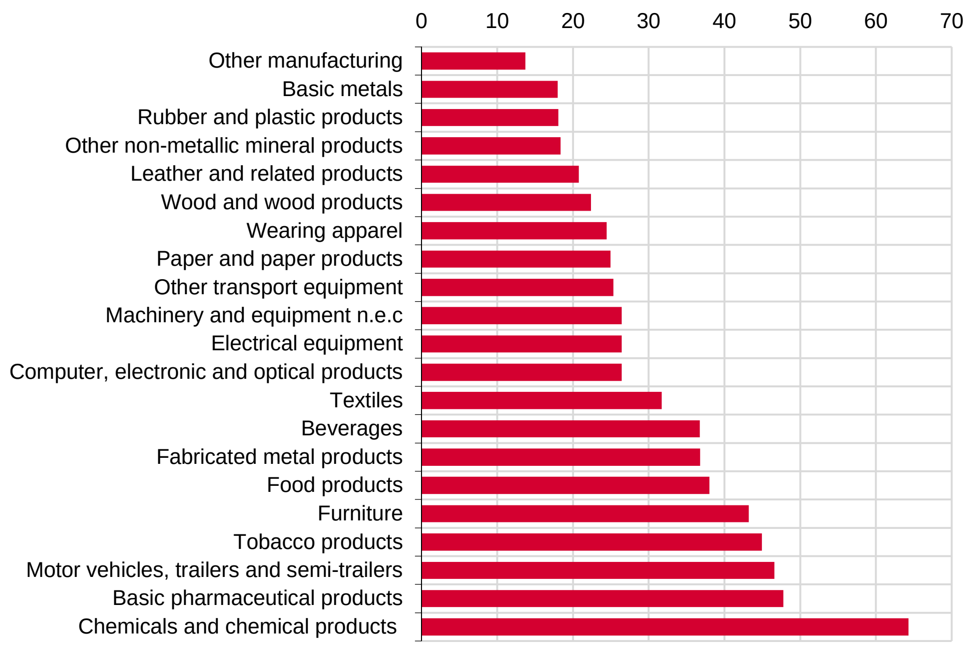
Notes: This table reports the robustness analysis controlling for time-varying industry-level controls about production, employment and export expectations derived from Business Tendency Survey. Main sample covers 21 industries (2-digit NACE level) for the period of January 2021-December 2022. Columns (1), (2), (3) and (4) use the natural logarithm of industrial production index ($Production$), the natural logarithm of industrial revenues index ($Revenues$), the natural logarithm of the number of formally employed people ($Employment$) and the difference between natural logarithms of import and export quantity indices ($Net\ Imports$) as the dependent variables, respectively. The main independent variable of interest is the interaction term between $Post\ Outage$ and $High\ Natural\ Gas$. The model is saturated with industry and time (month-by-year) fixed effects absorbing individual $Post\ Outage$ and $High\ Natural\ Gas$ terms. Variable definitions are provided at Table A1 of the Appendix. Heteroscedasticity-consistent standard errors clustered at industry-month level are given in parantheses. ***, ** and * represent statistical significance at 1%, 5% and 10% levels, respectively.

Table 9: Robustness Checks-Controlling for Price Shocks

	(1) Production	(2) Revenues	(3) Employment	(4) Net Imports
Post Outage x High Natural Gas	-0.053***	-0.048***	-0.015***	-0.225***
	(0.017)	(0.016)	(0.004)	(0.036)
Obs.	504	504	504	456
Industry Fixed Effects	✓	✓	✓	✓
Time Fixed Effects	✓	✓	✓	✓
Adj. R^2	0.75	0.81	0.99	0.88

Notes: This table reports the robustness analysis controlling for time-varying industry-level price index that is defined as the ratio of natural gas import price index to industry PPI indices. Main sample covers 21 industries (2-digit NACE level) for the period of January 2021-December 2022. Columns (1), (2), (3) and (4) use the natural logarithm of industrial production index ($Production$), the natural logarithm of industrial revenues index ($Revenues$), the natural logarithm of the number of formally employed people ($Employment$) and the difference between natural logarithms of import and export quantity indices ($Net\ Imports$) as the dependent variables, respectively. The main independent variable of interest is the interaction term between $Post\ Outage$ and $High\ Natural\ Gas$. The model is saturated with industry and time (month-by-year) fixed effects absorbing individual $Post\ Outage$ and $High\ Natural\ Gas$ terms. Variable definitions are provided at Table A1 of the Appendix. Heteroscedasticity-consistent standard errors clustered at industry-month level are given in parantheses. ***, ** and * represent statistical significance at 1%, 5% and 10% levels, respectively.

Figure 1: Natural Gas Dependency Ratios Across Industries (%)



Source: Ministry of Energy and Natural Resources

Figure 2: Parallel Trends

Notes: This figure demonstrates the average values of *Production, Revenues, Employment* and *Net Imports* for treatment and control industries over time as solid lines. Pre- and post-outage averages for both treatment and control groups are demonstrated as dashed lines. The vertical solid line marks the date of occurrence for natural gas outage.

Appendix – Supplementary Tables and Figures

Table A1: Variable Definitions and Summary Statistics

Panel A: Variable Definitions and Data Sources		
Series	**Definition**	**Source**
Production	Logarithm of industrial production index at 2-digit NACE level	TurkStat
Revenues	Logarithm of industrial revenues index at 2-digit NACE level	TurkStat
Employment	Logarithm of number of formally employed people at 2-digit NACE level	Social Security Institution
Net Imports	The difference between logarithm of import quantity index and logarithm of export quantity index at 2-digit NACE level	TurkStat
Credits	Logarithm of commercial loans at 2-digit NACE level	CBRT
Post Outage	A binary variable taking the value of one from January 2022 onwards, otherwise zero	Authors' Calculations
High Natural Gas	A binary variable taking the value of one for 2-digit NACE industries with higher than median threshold value of (averaged) natural gas energy input dependency ratio, otherwise zero	Ministry of Energy and Natural Resources

Panel B: Summary Statistics						
	(1) Obs.	**(2) Mean**	**(3) Std. Dev.**	**(4) Median**	**(5) P5**	**(6) P95**
Production	504	4.961	0.245	4.951	4.603	5.344
Revenues	504	4.942	0.270	4.930	4.558	5.425
Employment	504	11.721	1.121	12.119	9.709	13.181
Net Imports	456	-0.418	-0.532	-0.349	-1.147	0.357
Credits	504	16.645	1.116	16.774	14.721	18.263

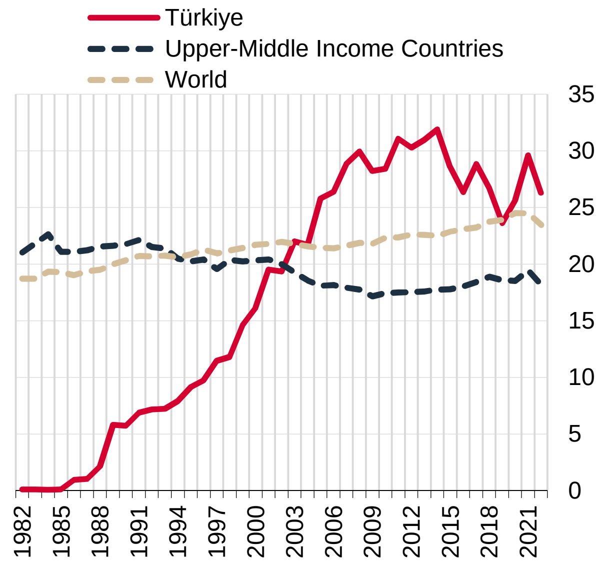
Notes: This table reports data definitions and summary statistics of the variables used in the empirical analysis. Panel A provides abbreviations, definitions and sources of the variables, whereas Panel B provides descriptive statistics including mean, standard deviation, median, 5th percentile and 95th percentile.

Table A2: Credit Financing

	(1) Credits
Post Outage x High Natural Gas	-0.067* (0.036)
Obs.	504
Industry Fixed Effects	✓
Time Fixed Effects	✓
Adj. R^2	0.97

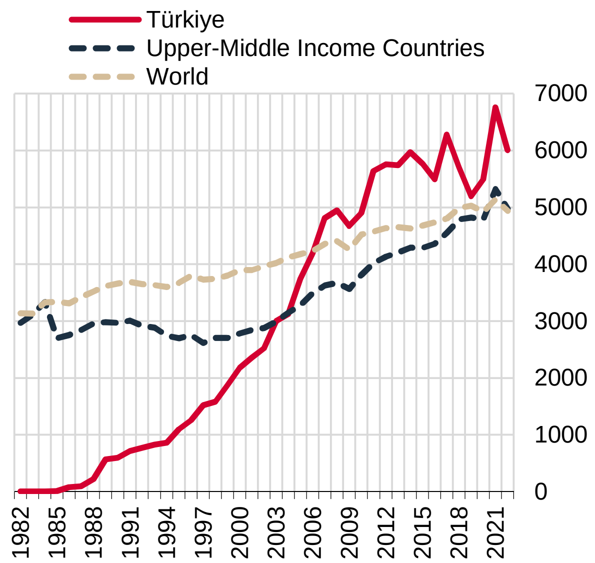
Notes: This table reports DiD estimations for the evolution of financial constraints via the level of credit use for treated and control industries following the natural gas outage. Main sample covers 21 industries (2-digit NACE level) for the period of January 2021-December 2022. Column (1) uses the natural logarithm of commercial credits extended to the industries (Credits) as the dependent variable. The main independent variable of interest is the interaction term between $Post\ Outage$ and $High\ Natural\ Gas$. The model is saturated with industry and time (month-by-year) fixed effects absorbing individual $Post\ Outage$ and $High\ Natural\ Gas$ terms. Variable definitions are provided at Table A1 of the Appendix. Heteroscedasticity-consistent standard errors clustered at industry-month level are given in parantheses. ***, ** and * represent statistical significance at 1%, 5% and 10% levels, respectively.

Figure A1: Share of Natural Gas in Primary Energy (%)



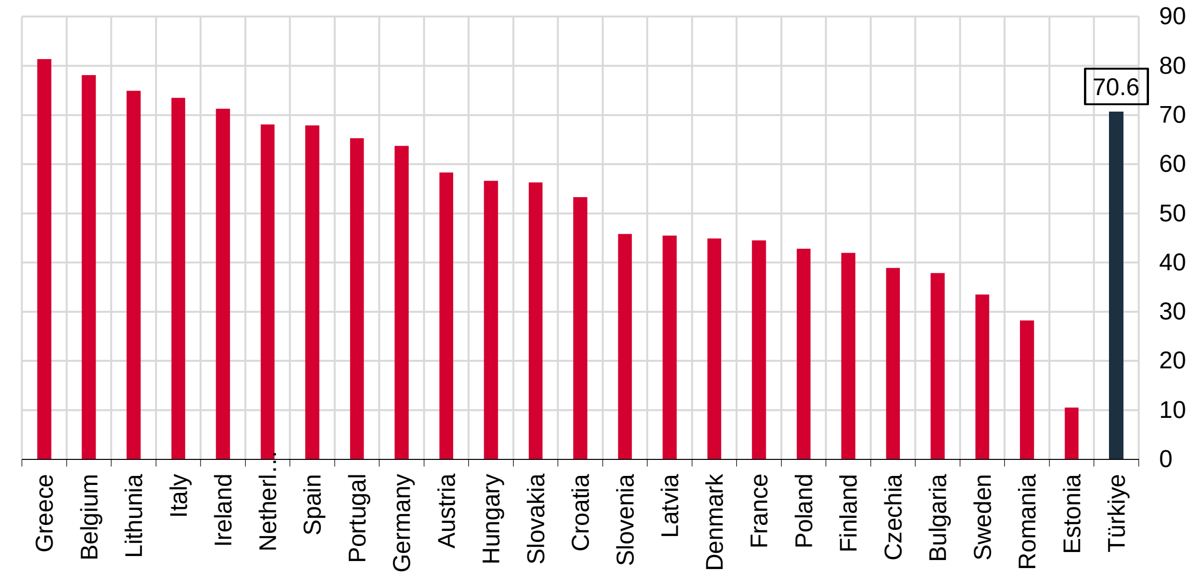
Source: Our World in Data

Figure A2: Per capita Gas Consumption (kWh)



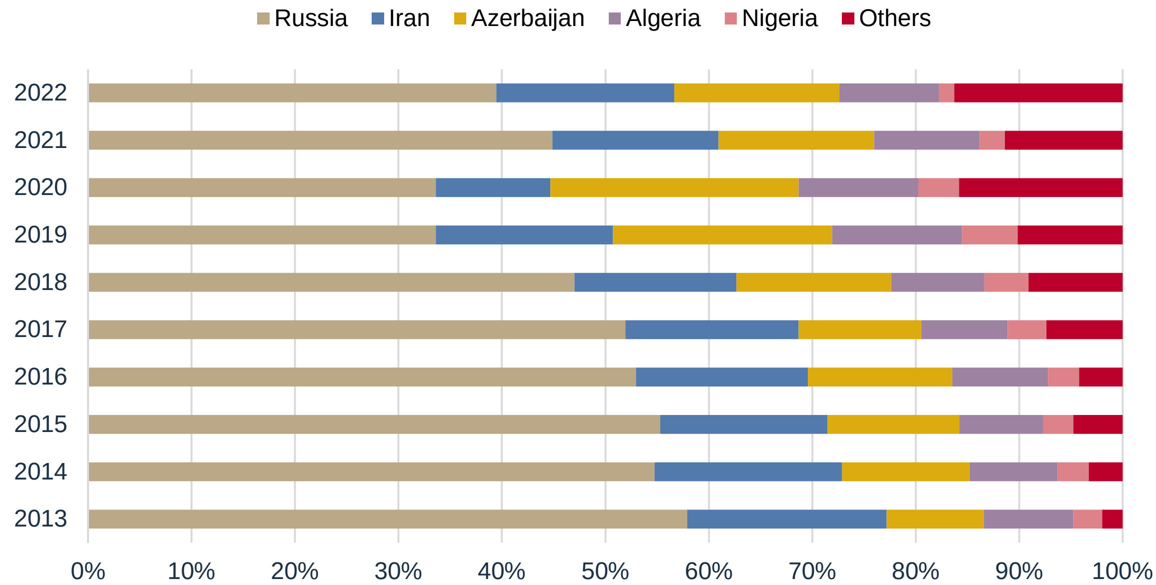
Source: Our World in Data

Figure A3: Energy Imports Dependency Ratio (%, As of 2020)



Source: EuroStat

Figure A4: Natural Gas Import Shares by Source Country (%)

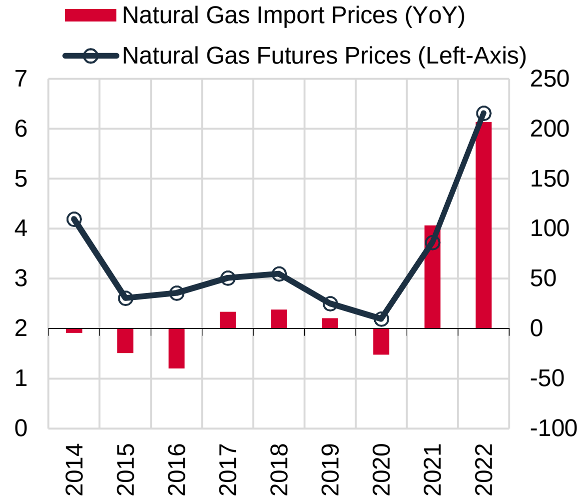


Source: Energy Market Regulatory Authority

Figure A5: Total Energy Imports (Annualized, Billion USD)

Source: TurkStat

Figure A6: Türkiye Natural Gas Import Prices and Global Prices (Year-on-Year % Change)



Source: TurkStat, Bloomberg

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