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The impact of the natural gas price on industrial performance during a hybrid war

ABSTRACT: In the contemporary world, natural gas is one of the focuses of hybrid wars and is used as a tool of international economic and political pressure to gain appropriate benefits. The long-term pressure of Russia on Ukraine using a combination of military, political, economic, information and energy tools is one of the most striking cases of applying natural gas as a weapon in a hybrid war. Exploring the case of Ukraine, the authors confirmed the hypothesis about the change in the impact of the prices of natural gas on the performance of its industrial consumers during a hybrid war. The study covered three industrial sectors that are major consumers of natural gas – the metallurgy, chemical and pharmaceutical industries. The data of nine key companies of these industries for the period 2006–2019 were analyzed; this period was divided into two parts – before the hybrid war (2006–2013) and during it (2014–2019). The authors identified the heterogeneity of the influence of natural gas prices on the performance of different industrial enterprises. However, since the onset of the hybrid war, all of them have shown a reducing correlation of natural gas prices with

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all the analyzed performance indicators – operating profitability, material-output ratio, and labor productivity. The study managed to build reliable regression models that allow defining the prices of natural gas for the chemical industry and metallurgy, above which these industries in Ukraine become unprofitable. The defined critical levels have a practical implication since they can be tools for regulating natural gas prices for various industrial sectors.

KEYWORDS: natural gas, price change, performance indicators, hybrid war, industries, Ukraine

Introduction

In recent decades, natural gas, like other energy resources, has become a weapon in political conflicts waged by some countries endowed with rich reserves. There is even the term “gas war” that was originally applied in the context of chemical warfare but was later used for international economic and political conflicts. For instance, the cases of Bolivia in 2003 (Perreault 2012) and Russia in 2014 (Pigliucci 2016) are well-known. Successive gas wars since 2006 have been compared and contrasted by Stulberg (2017), who detailed respective dimensions to restraint and costly paralysis experienced by upstream, downstream, and transit states alike. Sometimes, the term “gas war” is even used in an indirect sense for internal pressure by governments on gas consumers (Goncharuk and Cirella 2020). However, in the contemporary world, natural gas has been one of the focuses of hybrid wars and used to apply international pressure for the purposes of securing political and economic benefits.

Nevertheless, in recent years, this term has become firmly attached to the actions of one country – Russia, which is actively using and strengthening its monopoly position in the natural gas market of certain European countries. Although two “aggressors” fighting for the European market in gas supplies were considered a few years ago – the United States and Russia (Tati 2020) – then in the fall of 2021, all of Europe felt the strength of Russia in influencing the supply and price of natural gas on this continent. In October 2021, all the top mass-media (e.g. Ellyatt 2021; Vasilyeva and Huggler 2021) began to write about Russia using energy as a “weapon” in a gas war against its neighbors. Apparently, the most vulnerable of these neighbors is Ukraine, which has already had a long-term hybrid war with Russia (Johannesson and Clowes 2020). To destabilize Ukraine, Russia applied a combination of military, semi-military and strategic communication tools, integrating energy into this strategy via the expropriation of Ukrainian energy assets and applying pressure on gas prices (Rühle and Grubliauskas 2015).

Since the start of the hybrid war with Russia in 2014, the consumption of natural gas in Ukraine has significantly decreased and is in the range of 28–32 billion cubic meters per year (Fig. 1).

This reduction was the result of various factors associated with the annexation of the industrially developed region of Donbass, which consumed a large amount of gas, as well as a partial

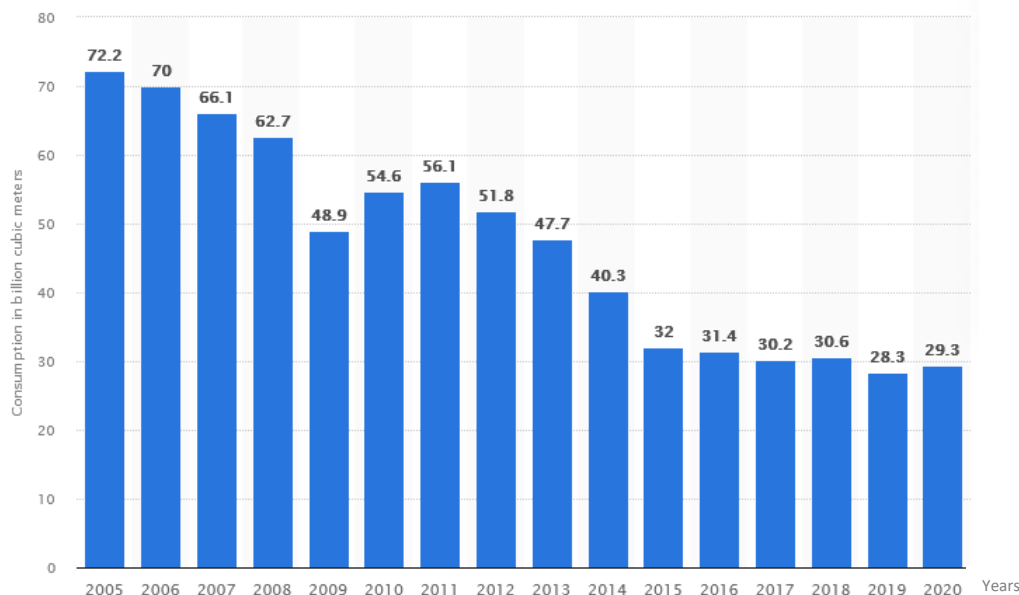


Fig. 1. The total consumption of natural gas in Ukraine 2005–2020

Source: Statista 2021

Rys. 1. Zużycie gazu ziemnego na Ukrainie w latach 2005–2020

reorientation of the economy towards other energy sources, including renewable options. However, natural gas production in Ukraine reached 20.2 billion cubic meters in 2020, down from 20.7 billion cubic meters recorded in 2019 (Elagina 2021) and was relatively stable during the last decade (Fig. 2).

Thus, the deficit of natural gas in 2020 amounted to 9.1 billion cubic meters, which is almost 1/3 of all consumption in Ukraine. This deficit is covered by imports from the countries of Central and Eastern Europe. From the start of the hybrid war, Ukraine refused to buy natural gas from Russia, which removed one of its serious dependencies on the aggressor country. However, this made the natural gas market in Ukraine highly sensitive to changes in natural gas prices in the European market.

The structure of the total consumption of natural gas in Ukraine is shown in Figure 3.

As can be observed, if in 2019, households were the largest natural gas consumer in Ukraine, then in 2020, the electricity generation and industrial production became the dominant consumer of this energy resource in this country. For households, the rise in natural gas prices can be offset by an increase in budget subsidies for housing and communal services, which somewhat reduce the level of energy poverty (Goncharuk et al. 2021). However, industries take the full blow of the gas price growth and experience an increase in production costs, thus incurring losses.

Therefore, we decided to study how painful the increase in natural gas prices is for key industries during a hybrid war, using the case of Ukraine.

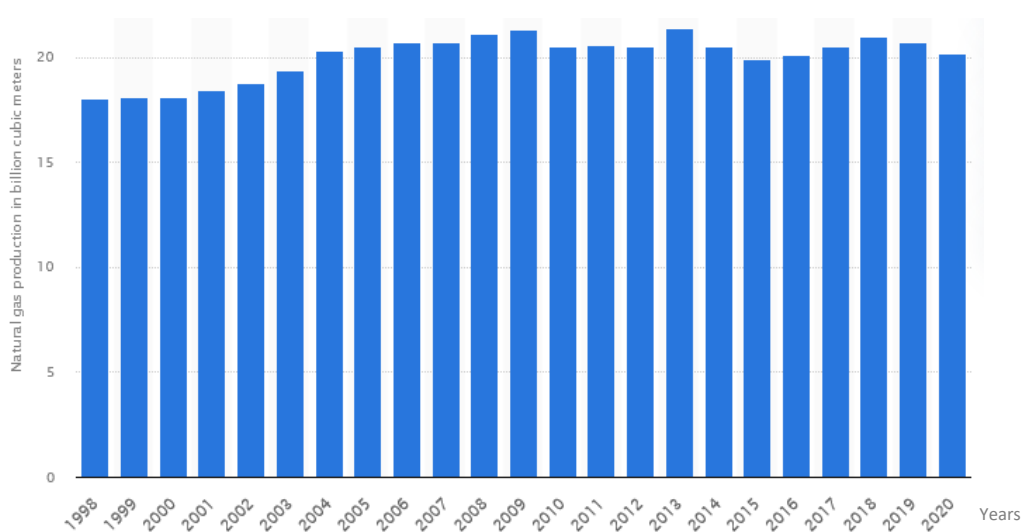


Fig. 2. The total production of natural gas in Ukraine 1998–2020

Source: Elagina 2021

Rys. 2. Wydobywanie gazu ziemnego na Ukrainie 1998–2020

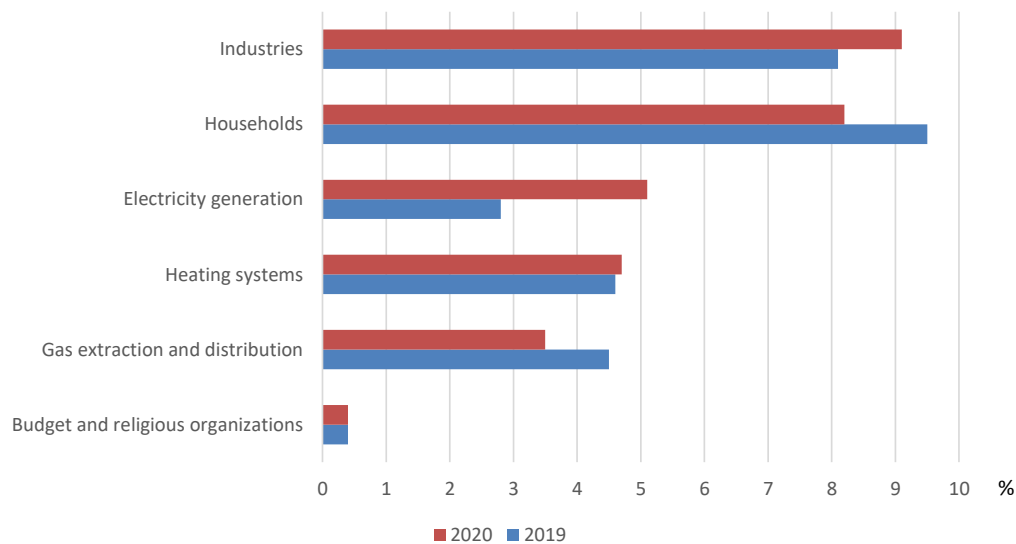


Fig. 3. Structure of the total consumption of natural gas in Ukraine in 2019 and 2020 [billion cubic meters]

Source: Naftogas 2021

Rys. 3. Struktura zużycia gazu ziemnego na Ukrainie w 2019 i 2020 roku [mld m³]

1. The literature review

Exploring the scientific literature, many publications on the natural gas market can be found. Moreover, they relate to both the global market (Bridge and Bradshaw 2017) and the markets of individual continents (Jacobs 2011; Seljom and Rosenberg 2011), regions (Doukas et al. 2013; Khatib 2014) and countries (Erdogdu 2010). Some publications consider the problem of natural gas distribution in European countries (Goncharuk 2008; Goncharuk and Lo Storto 2017; Fiorini and Sileo 2013; Kłaczyński 2018).

Regarding natural gas prices, there are several publications that address the issues of gas pricing factors (Arano and Velikova 2012; Slabá et al. 2013) and the impact of gas price growth on the economy (Goncharuk 2013). So, considering the Russian–Ukrainian gas dispute of January 2009, the Libyan civil war in 2011 and the withheld Russian exports in February 2012, Nick and Thoenes (2014) found that the natural gas price is affected by temperature, storage and supply shortfalls in the short term, while the long-term development is closely tied to both crude oil and coal prices, capturing the economic climate and the substitution relationship between the different energy commodities. It can also be caused by political pressure and gas wars as mentioned above (Tati 2020; Ellyatt 2021), local factors, geopolitics, the development of the gas transport infrastructure, distribution and extraction costs, and even pandemics (Chrulski 2020).

Conversely, an increase in gas prices can significantly affect the economy by applying upward pressure on the CPI and a reduction in actual GDP and residents' welfare (He and Lin 2017) as well as by placing pressure on the profitability of the gas suppliers and distributors (Goncharuk 2013), and a number of industries such as metallurgy and the chemical industry (Goncharuk 2015). Moreover, based on the case of China, He and Lin (2017) established that an increase in gas prices can reduce carbon emissions.

Thus, the literature points to a dependence on many diverse factors and the impact of natural gas and prices on the economies and welfare of different countries. However, until now, no one has figured out how the price of natural gas affects the main consumers during a hybrid war and who suffers from its growth the most. We will try to find this out using the example of three industries in Ukraine – metallurgy and the chemical and pharmaceutical industries.

Thus, the purpose of this study is to figure out how the price of natural gas affects the performance of industrial gas consumers during the hybrid war and who suffers from its growth the most in a case of Ukrainian metallurgy and the chemical and pharmaceutical industries.

2. Methodology

The main *hypothesis* of this study is the changing impact of natural gas prices on the performance of its industrial consumers during a hybrid war.

To identify the impact of natural gas prices on the profitability of the Ukrainian metallurgy, chemical and pharmaceutical industries, in this study the authors used the Pearson correlation coefficient (Obilor and Amadi 2018) and statistical regression analysis including the ordinary least squares (OLS) method (Golden 2014), which are commonly applied in research of energy economics and policy. To identify the impact of the hybrid war on the performance of gas consumers, the entire observation period (2006–2019) was divided into two parts: before the start of the war (2006–2013) and during the war (2014–2019).

The research methodology for this study was as follows:

1. Identifying the changes in natural gas prices for industrial consumers.
2. Evaluating the performance indicators for three considered industries – metallurgy, chemical and pharmaceutical industries within appropriate companies.
3. Testing possible correlations between the natural gas prices and the performance of observed industrial companies.
4. Applying a regression analysis to identify the quantitative relationships and developing the predictive models.
5. Comparing the models for the hybrid war period and the previous period to find any difference.
6. Developing appropriate recommendations for a national regulator for the setting of natural gas prices.

To evaluate the performance of the industrial companies, the following indicators were applied in this study:

- a) the percentage ratio of operating profit to the cost of operations, named as the *operating profitability indicator*,
- b) the ratio of material costs to the same products net sales, named as the *material-output ratio*,
- c) the ratio of the net sales to the number of employees of the same period, known as the *labor productivity*.

3. Data Collection

The following data sources were used to conduct this study:

1. Monthly average levels of prices of natural gas for Ukrainian industrial consumers during 2005–2020, obtained from official sources.

2. The Ukrainian industrial companies' (metallurgical, chemical and pharmaceutical) annual reports for 2006–2020, confirmed by audit reports.
3. Valid data from the previous studies of the authors.

4. Results

Over the last fifteen years, the natural gas prices for industrial consumers in Ukraine have heterogeneously changed (Fig. 4).

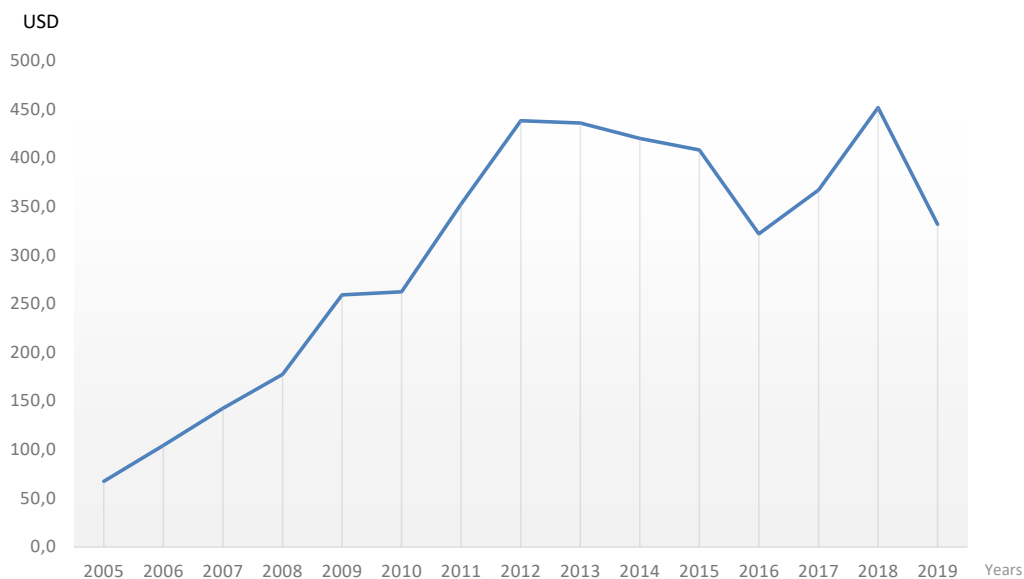


Fig. 4. The change of annual natural gas prices for industrial consumers in Ukraine, in USD per thousand cubic meters
Source: calculated by authors using the data from Naftogas (2021) and NBU (2021)

Rys. 4. Zmiana rocznych cen gazu ziemnego dla odbiorców przemysłowych na Ukrainie w dolarach za tysiąc metrów sześciennych

As can be seen, except for 2013–2016 and 2019, the price of natural gas for industrial companies in Ukraine increased with the highest growth rates in 2009, as well as in 2011–2012 and 2018. On average, the annual growth rate in 2005–2019 was 12.1%. In total, over fifteen years, the natural gas price in USD terms increased by 4.9 times.

Additionally, a group of metallurgical, chemical and pharmaceutical companies were selected for evaluating the influence of natural gas price changes on industrial consumers.

The group of metallurgical companies included the largest metal producers in Ukraine (Azovstal, Zaporizhstal and Arcelor Mittal Kryvyi Rih), which produce more than a quarter of all steel in the country. The group of chemical companies included Azot, Odessa Port Plant, Dneproazot, which produce more than a quarter of all chemical products in the country. The group of pharmaceutical companies included Farmak, Darnitsa and the Red Star plant, which produce a significant share of all pharmaceutical products in Ukraine.

The average annual values of selected performance indicators of these companies in 2006–2019 are shown in Figures 5, 6 and 7.

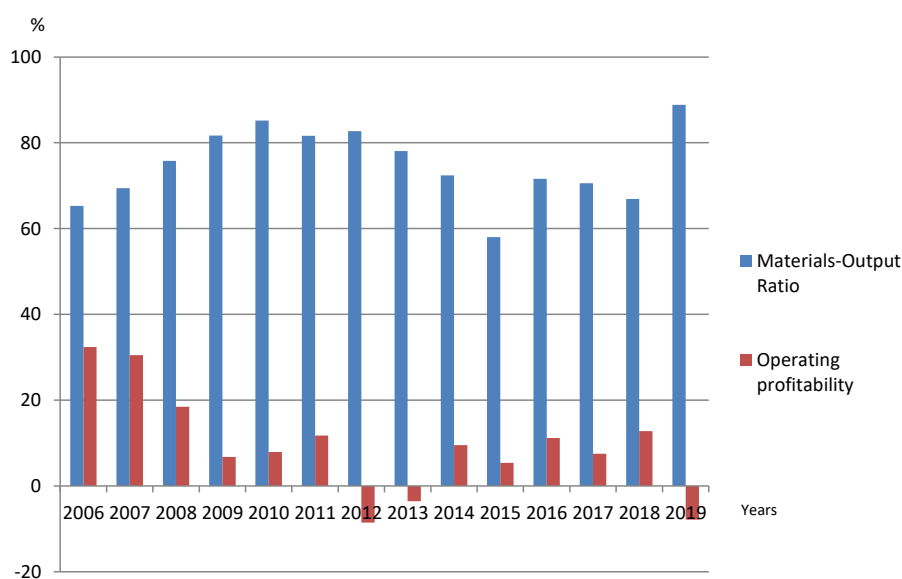


Fig. 5. The average annual values of materials-output ratio and operating profitability for selected metallurgical companies 2006–2019

Source: calculated by the authors using data from the companies' annual reports

Rys. 5. Średnioroczne wartości wskaźnika zużycia materiałów i rentowności operacyjnej dla wybranych przedsiębiorstw hutniczych 2006–2019

It is noticeable that if metallurgical companies were unprofitable only in certain years (2012, 2013 and 2019), then chemical companies began to incur losses in 2009 after the jump in natural gas prices, and from 2012 to 2019 they were consistently unprofitable.

Ukrainian pharmaceutical companies are highly profitable and despite the growth of natural gas prices they achieved and saved a level of profitability of over 40% from 2009.

The results of the correlation analysis between two performance indicators of the observed companies and the prices of natural gas (Tables 1 and 2) enabled the identification of the following relationships and trends.

1. All the observed relationships became weakened after 2014, i.e. from the start of the hybrid war. This means that natural gas has a lower impact on business during a hybrid war.

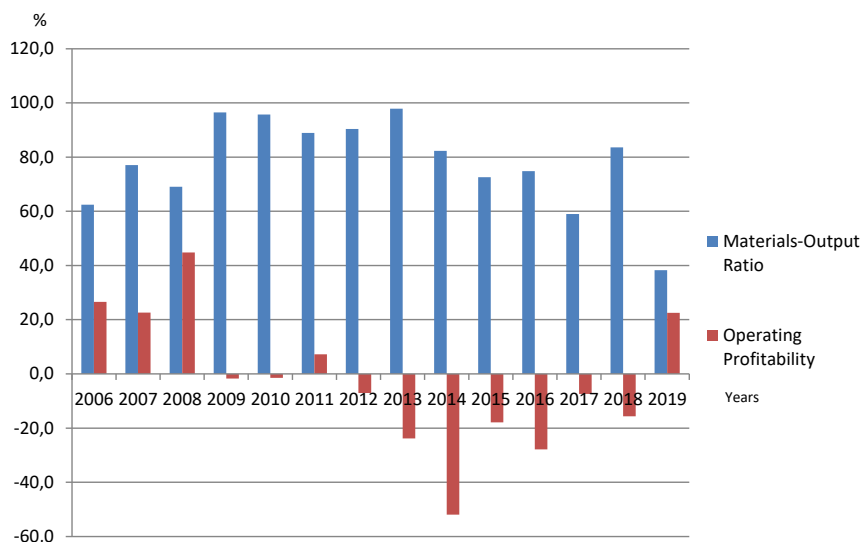


Fig. 6. The average annual values of materials-output ratio and operating profitability for selected chemical companies 2006–2019

Source: calculated by the authors using data from the companies' annual reports

Rys. 6. Średnioroczne wartości wskaźnika zużycia materiałów i rentowności operacyjnej dla wybranych przedsiębiorstw chemicznych 2006–2019

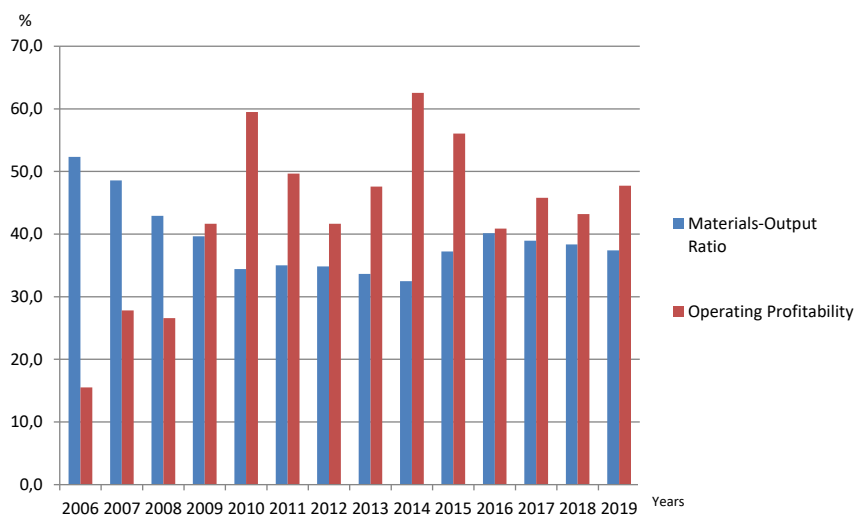


Fig. 7. The average annual values of materials-output ratio and operating profitability for selected pharmaceutical companies 2006–2019

Source: calculated by the authors using data from the companies' annual reports

Rys. 7. Średnioroczne wartości wskaźnika materiałowo-produkcyjnego i rentowności operacyjnej dla wybranych firm farmaceutycznych 2006–2019

TABLE 1. Pearson correlation coefficient for natural gas price and materials-output ratio

TABELA 1. Współczynnik korelacji Pearsona dla ceny gazu ziemnego i wskaźnika zużycia materiałów na jednostkę produkcji

Industry	Pearson correlation coefficient		
	2006–2019	2006–2013	2014–2019
Metallurgy	0.045	0.707	–0.579
Chemical Industry	0.243	0.772	0.667
Pharmaceutical Industry	–0.834	–0.889	–0.457

TABLE 2. Pearson correlation coefficient for natural gas price and operating profitability

TABELA 2. Współczynnik korelacji Pearsona dla ceny gazu ziemnego i rentowności operacyjnej

Industry	Pearson correlation coefficient		
	2006–2019	2006–2013	2014–2019
Metallurgy	–0.748	–0.934	0.492
Chemical Industry	–0.744	–0.819	–0.434
Pharmaceutical Industry	0.724	0.699	0.416

- The closest negative relationship (–0.934) was identified between the operating profitability in metallurgy and natural gas prices in 2006–2013, which was before the hybrid war started. However, during the hybrid war (2014–2019) this relationship became positive (0.492). This means that the hybrid war had an influence upon companies of this industry and made them less dependent upon natural gas and its prices.
- The relatively stable negative influence of natural gas price growth has been identified for chemical companies where natural gas is the main raw material for production. This dependence during the hybrid war became lower but it is still negative (–0.434).
- It can also be seen that the nature of the investigated relationships in pharmaceutical enterprises is opposite to the relationships in chemical industry – they are negative for material-output ratio and positive for operating profitability relationships with a natural price. This means that natural gas price growth has a positive influence upon the profitability of pharmaceutical companies, making them less costly and more successful.

Furthermore, using regression analysis, the following reliable linear models were obtained:

$$P_m = 34.70 - 0.079 g \quad (1)$$

$$P_{ch} = 50.54 - 0.165 g \quad (2)$$

$$P_{ph} = 17.18 + 0.082 g \quad (3)$$

where:

- P_m – the average operating profitability of Ukrainian metallurgical companies [%],
- P_{ch} – the average operating profitability of Ukrainian chemical companies [%],
- P_{ph} – the average operating profitability of Ukrainian pharmaceutical companies [%],
- g – the natural gas price for Ukrainian industrial companies [USD/thousand m³].

Models (1), (2) and (3) are significant (over 0.95 level) and adequate (determination coefficient is higher than 0.55, the Fischer ratio is above 13, p-values are below 0.05). This gives us the right to use developed models to predict the average level of the profitability of the major industrial consumers of natural gas in Ukraine.

As can be seen, the profitability of chemical companies is more sensitive to changes in natural gas prices: at zero price for natural gas, the average profitability of chemical companies will be above 50%; if natural gas price grows on \$100, the average profitability of chemical companies will reduce by 16.5%.

While for pharmaceutical companies the rise in natural gas prices increases profitability, for metallurgical and chemical companies, it lowers operating profitability. Models (1) and (2) enable us to establish the critical gas price for appropriate industries, i.e. the price at which an industry has zero margin and above which the industry becomes unprofitable. So, according to them, the critical price of natural gas for metallurgy is 439 USD, and for the chemical industry, it is 306 USD. Comparing these levels with the existing dynamics of gas prices for industrial consumers (Fig. 8), we can see why the majority of companies in the metallurgical and chemical industries suffer losses.

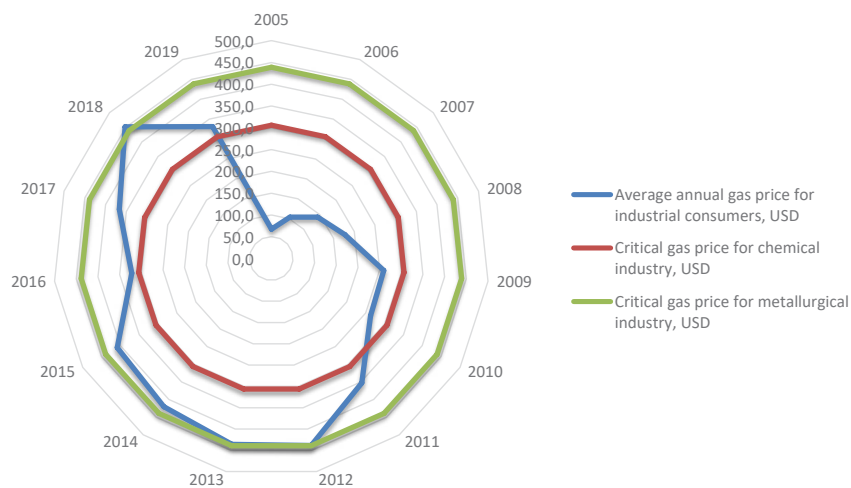


Fig. 8. The average actual annual gas prices and critical levels for natural gas prices for Ukrainian industrial consumers (chemical and metallurgical) [USD per thousand m³]

Source: calculated by the authors using data from the companies' annual reports, Naftogas 2021 and NBU 2021

Rys. 8. Średnioroczne ceny gazu oraz progi krytyczne dla cen gazu ziemnego dla ukraińskich odbiorców przemysłowych (chemicznych i hutniczych) [USD/tys. m³]

To ensure break-even operations of enterprises in these industries, the state regulator should keep natural gas prices below these limits. Otherwise, the production of these industries will lose economic sense, which will cause serious losses for the economy.

Analyzing the impact of natural gas prices on labor productivity, we found a very high positive relationship between these indicators for the pharmaceutical industry in the period up to 2013 – the Pearson's correlation coefficient was 0.91. However, since the beginning of the hybrid war in the period 2014–2019 this correlation has eased considerably and became moderately positive (0.315). For steel and chemical companies, this weakening of the correlation was even stronger (down to 0.301 and 0.117, respectively). These facts also support our hypothesis that during the hybrid war, the impact of natural gas prices on the efficiency of industrial gas consumers decreases.

5. Discussion

According to the trends and relationships identified above, the differentiation of natural gas prices for different industrial consumers is appropriate. However, if for metallurgy the established critical level of gas prices is not disastrous and was not exceeded in most of the analyzed years, then chemical enterprises are very sensitive to any increase in natural gas prices. Thus, for the regulator of the gas market in Ukraine, it can be recommended to set lower prices for manufacturers of chemical products for which natural gas is a raw material.

Comparing the obtained critical levels with similar indicators obtained earlier (Goncharuk 2016), it can be seen that for the chemical industry, they increased significantly, and that for metallurgy, they also increased. Since in an earlier paper (Goncharuk 2016) the 2005–2013 period was considered, i.e. period before the hybrid war, our results for the 2005–2019 period already include the impact of this war on the relationships between natural gas prices and operational profitability.

Considering regression results in combination with the results of estimates of the correlation in periods before and during the hybrid war (Tables 1 and 2), we can see that an increase in the critical level for metallurgy (from 406 to 439 USD) occurred after 2014 and is associated with a hybrid war, which apparently forced steel companies to abandon gas technologies in favor of other sources of energy, e.g. electricity. As a result, the correlation between the gas prices and profitability of these companies changed from negative in 2006–2013 to positive after 2013, i.e. during the hybrid war. In the case of the chemical industry, such a technological escape from gas is not possible since natural gas is a raw material for production. Nevertheless, even in such conditions, after 2013, under the influence of the factor of hybrid war, chemical enterprises were able to reduce their dependence on natural gas somewhat and their sensitivity to its price. As a result, the level of correlation between the price of natural gas and the profitability of chemical companies decreased from -0.819 to -0.434 .

Given the relatively low share of natural gas in the cost of pharmaceutical products, their consistently high profitability and low material consumption, pharmaceutical companies perceive positively the rise in prices for natural gas. This can explain the positive correlation and the increasing regression model (3) for the pharmaceutical industry in Ukraine. However, even for successful pharmaceutical companies, the positive impact (correlation) of natural gas prices on labor productivity has dropped from 0.910 to 0.315 since the beginning of the hybrid war. The same trend was seen for the metallurgy and chemical industry that supports our hypothesis on the significant impact of the hybrid war on the relationship between natural gas prices and the performance of its industrial consumers.

Conclusions

The study made it possible to confirm the hypothesis about the change in the influence of natural gas prices on the productivity of its industrial consumers during the hybrid war. However, this impact is not constant across all the industrial consumers of natural gas.

Having the highest negative relationship (-0.934) before the war, Ukrainian steel companies abandoned gas technologies in favor of other sources of energy and made the correlation between gas prices and profitability positive (0.492) during the hybrid war. In the case of the chemical industry, such a technological escape from gas is not possible because natural gas is a raw material for production. However, under the influence of hybrid war, chemical enterprises are able to somewhat reduce their dependence on natural gas and their sensitivity to its price (from -0.819 to -0.434). This applies even to relatively successful pharmaceutical companies in a similar manner to the metallurgy and chemical industry because the onset of hybrid war has shown a reducing correlation of natural gas prices with all the analyzed performance indicators, i.e. operating profitability, material-output ratio, and labor productivity. This supported the hypothesis on the significant impact of the hybrid war on the relationship between natural gas prices and the performance of its industrial consumers.

In addition to confirming the main hypothesis, the study managed to build reliable regression models that allow establishing critical levels for natural gas prices for metallurgy and chemical industry, above which these, industries in Ukraine become unprofitable. Since the beginning of the hybrid war, these levels have changed: to a greater extent for metallurgy (up to 439 USD per thousand cubic meters), and to a lesser extent for the chemical industry (down to 306 USD per thousand cubic meters). This also confirms the hypothesis about the influence of the hybrid war on the relationship between the price of natural gas and the efficiency of its industrial consumers.

The defined critical levels have a practical implication since they can be a tool for regulating natural gas prices for various industrial sectors. Such a tool will allow the state regulator to effectively differentiate the prices set, especially for the chemical industry, which from 2012 to 2018 was an unprofitable sector of the Ukrainian economy due to the inadequately high price of natural gas.

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Wpływ ceny gazu ziemnego na wyniki przemysłu w czasie wojny hybrydowej

Streszczenie

We współczesnym świecie gaz ziemny jest jednym z narzędzi używanych w wojach hybrydowych i jest wykorzystywany do wywierania międzynarodowej presji gospodarczej i politycznej w celu uzyskania odpowiednich korzyści. Długotrwała presja Rosji na Ukrainę za pomocą kombinacji narzędzi militarnych, politycznych, ekonomicznych, informacyjnych i energetycznych jest jednym z najbardziej uderzających przypadków zastosowania gazu ziemnego jako broni w wojnie hybrydowej. Badając przypadek Ukrainy, autorzy potwierdzili hipotezę o wpływie zmian cen gazu ziemnego na wyniki jego odbiorców przemysłowych podczas wojny hybrydowej. Badanie objęło trzy sektory przemysłu, które są głównymi konsumentami gazu ziemnego – przemysł metalurgiczny, chemiczny i farmaceutyczny. Przeanalizowano dane dziewięciu kluczowych firm z tych branż za lata 2006–2019; okres ten został podzielony na dwie części – przed wojną hybrydową (2006–2013) i w jej trakcie (2014–2019). Autorzy zidentyfikowali niejednorodność wpływu cen gazu ziemnego na funkcjonowanie różnych przedsiębiorstw przemysłowych. Jednak od początku wojny hybrydowej wszystkie one wykazywały zmniejszającą się korelację cen gazu ziemnego ze wszystkimi analizowanymi wskaźnikami efektywności – rentownością operacyjną, relacją materiałów do produkcji oraz wydajnością pracy. W badaniu udało się zbudować wiarygodne modele regresji, które pozwalają określić ceny gazu ziemnego dla przemysłu chemicznego i hutniczego, powyżej których te branże na Ukrainie stają się nierentowne. Zdefiniowane progi mają praktyczne znaczenie, ponieważ mogą być narzędziami regulacji cen gazu ziemnego dla różnych sektorów przemysłu.

SŁOWA KLUCZOWE: gaz ziemny, zmiana cen, wskaźniki efektywności, wojna hybrydowa, przemysł, Ukraina