

Piotr KWIATKIEWICZ

Adam Mickiewicz University, Poznań, Poland

ORCID: 0000-0002-3517-9974

Krzysztof MELNAROWICZ

Warsaw School of Economics

ORCID: 0000-0001-6762-1029

Robert SOBKÓW

WSHIU University, Poznań, Poland

ORCID: 0000-0003-4823-778X

Geopolitical Implications of Oil Price Forecasts: An Analysis of the Club of Rome's Report on Global Growth Limits and Market Realities

Abstract: The report by the Club of Rome experts from 1972 indicated the possibility of a relatively short-term global raw material supply deficit, including energy resources. According to the authors of this document, the growing demand for resources coupled with diminishing available reserves was the cause. The anticipated outcome was a dynamic, exponential increase in commodity prices, including crude oil, in the perspective of the coming decades. The purpose of this article is to demonstrate whether the forecasts of the Club of Rome's report from over half a century ago, regarding the rise in oil prices, are reflected in the actual market situation and to attempt to determine the potential direction of changes in the barrel prices of this commodity. The authors of the article adopted the hypothesis that the price of crude oil might not necessarily increase exponentially as global resources are depleted. As a result of the analysis of nominal and real prices of WTI crude oil after the publication of the Club of Rome's report, i.e., from 1973 to the end of 2022 (a period of 50 years), the fundamental conclusions contained in the report have not been confirmed. A significantly different course of changes in crude oil prices in the specified period was indicated, compared to what was predicted in the report.

Key words: Raport of the Club of Rome, oil prices, price trends of the crude oil

Introduction

The verification of the assumptions made in the report of the Club of Rome, "The Limits to Growth" (Meadows et al., 1973), constitutes an extremely significant step in understanding and managing the challenges associated with global development. This report, first published in 1972, shook the world of science and politics by introducing the concept of natural resource limits and the necessity of sustainable development onto the global agenda. In this article, we take a closer look at this report and its impact on our contemporary ecological and economic perspective. We analyze the key findings in the document and present the results of research and verification attempts, especially after 50 years, which allow us to better understand the changes occurring in our natural environment and the challenges posed by the limits to growth. It is also intriguing to consider whether the thesis put forth by the Club of Rome is still relevant or if we need to adjust our perspective in the face of changing realities. In today's world, where eco-

logical challenges, natural resources, and sustainable development issues are becoming increasingly pressing, the Club of Rome's report titled "The Limits to Growth" remains one of the most important documents that have shaped the direction of global discourse.

The aim of the authors' investigations, on one hand, is to determine whether the predictions made by the authors of the report over half a century ago regarding the dynamic rise in oil prices over several decades are reflected in market reality. On the other hand, it is an attempt to forecast the potential direction of changes in the prices of this commodity barrel in the future. The hypothesis adopted is that the assumptions of the titular report, according to which, as global reserves of crude oil are depleted, its price will exponentially increase, are only partially true because they related not so much to global natural reserves but rather to easily exploitable deposits. Verifying this hypothesis will help guide future discussions on trends and further activity in the scope of sustainable development.

Review of the literature on the subject

Since the publication of the "Limits to Growth" report in 1972 (Meadows et al., 1973),¹ numerous scientific publications have emerged, seeking to verify the conclusions contained in the report and understand their relationship with oil prices and other aspects of global development. The Club of Rome's report was an econometric model that analyzed the potential effects of population growth, natural resource utilization, and their impact on the environment. Its results and forecasts sparked much debate and discussion among economists, scientists, and ecologists. After its publication, many studies focused on verifying these predictions. In subsequent years, there were further updates to the report.

In 1992, an update to the original report was released (Meadows et al., 1992), developed similarly to its predecessor by the Club of Rome. Its main task was to update data, examine and discuss global growth trends, natural resource utilization, and the impact of human activity on the environment. The report presented forecasts regarding the possibility of sustaining global economic and population growth in the context of limited natural resources.

In 2004, the report was once again updated by the Club of Rome (Meadows et al., 2004). The authors analyzed which predictions presented in the report had proven true and which had changed over three decades since the initial publication.

On the fortieth anniversary of the Club of Rome's establishment, a report was also released in 2018, translated into Polish by the Institute of Applied Research at the Warsaw University of Technology (Von Weizsäcker, Wijkman, 2018). It serves as a synthesis of alarming irregularities characterizing the contemporary world and serves as a warning about the negative consequences of current phenomena. The authors point out that the messages and warnings contained in the Club of Rome's 1972 report titled "Limits to Growth" remain relevant (Meadows et al., 1973).

One of the recent verifications of the report was conducted in 2021 by Gay Herrington (2021). The researcher prepared various scenarios based on similar assumptions

¹ The Polish translation was published a year later, in 1973.

made in the original 1972 report. She considered 10 key criteria: population, fertility and mortality rates, food production and services, industrial production levels, ecological footprint, non-renewable resource exploitation, human well-being, and levels of persistent pollution. Based on new data, the analyst identified two most probable development scenarios for the coming years: “business as usual” and “technological scenario.” Both scenarios concluded that the current development based on continuous GDP growth is unsustainable. The author summarized that the global economy will first slow down over the next decade, and then, around 2040, macroeconomic indicators will begin to decline. She also emphasized the significance of the social scenario, involving a change in social awareness. Yuval Noah Harari (2018) also wrote about this last scenario, which involves a cultural change or a new narrative of the world.

In addition to the verifications of the original Limits to Growth report, many other works and publications have emerged, either refuting or confirming its theses and forecasts. Among these works is the analysis by G. Turner (2008), who confirmed the theses put forward in the first report. He also analyzed (Turner, 2014) which predictions from the original report were confirmed and which were negated due to erroneous data.

“J. L. Simon’s book (1981) also emerged, criticizing the report of the Club of Rome. The researcher argued that the forecasts included in the report were incorrect. They did not consider the flexibility of the world economies in adapting to changing conditions. In his book, he argued that human innovation and the ability to adapt to ecological problems would allow for survival and development. Simon continued his criticism in another monograph, challenging both the predictions regarding natural resources and the concept of limited growth (Simon, Kahn, 1984).

A noteworthy critique of the Club of Rome report is P. Sabina’s book (2013). The author presented the history of a bet between ecologist Paul Ehrlich and economist Julian Simon concerning the change in the prices of five selected natural resources (copper, chromium, nickel, zinc, and tungsten). Ehrlich predicted that the prices of these resources would rise within a decade due to their limited supply in the face of growing demand resulting from overpopulation. Simon, on the other hand, argued that prices would fall, citing the development of technology and innovation contributing to more efficient use of natural resources. The economist won the bet, which became a point of criticism for Ehrlich’s predictions and the Club of Rome report.

Danish economist B. Lomborg (2001) also raised doubts about some ecological propositions in the core assumptions of the 1972 Club of Rome report in his book. The researcher used statistical data and data analysis to challenge some ecological arguments and presented his own conclusions. His approach was deeply rooted in economics, focusing on the assessment of the costs and benefits of environmental actions and the identification of the most efficient ways to address environmental issues.

In 2014, a publication by the Polish Academy of Sciences resulted from the activities of the Forecast Committee “Poland 2000 Plus” operating under the auspices of the Polish Academy of Sciences (Galwas, Wyżnikiewicz, 2014). Researchers within this Committee carried out a research project titled “Global Threats to Development Barriers,” simultaneously referencing the Club of Rome report. The book selected problems and potential threats that could slow down or even halt development. It addressed issues

such as resource wastage, environmental protection, energy sources, water resources, and sustainable development.

Ch. A. S. Hall and J. W. Day, in their research, reviewed the core assumptions of the Club of Rome report and confirmed them. In their article, they wrote: “Many firmly reject what these researchers wrote in the ‘70s, but there is increasing evidence that these Cassandra-like predictions in the core were correct, regarding the dangers of constant growth of the human population and the rise in consumption levels in a world approaching very real material constraints. It is time to reconsider their arguments with the inclusion of new information...” (Charles et al., 2009, p. 234). As a key issue, the authors perceive the matter of peak oil: “...critical to the future is the extent to which fossil fuels and other sources of energy will remain abundant and cheap. Together, oil and gas provide nearly two-thirds of the world’s energy and coal another 20 percent. We do not live in an age of information, a post-industrial age, or (at least not yet) a solar age – but in an age of oil. Unfortunately, it will soon run out: it seems that oil and gas production has reached, or will soon reach, its peak...” (Charles et al., 2009, p. 236).

In addition to reviewing many publications that criticized or confirmed the propositions or predictions in the 1972 Club of Rome report, scientific publications and research on crude oil prices were also reviewed by the authors.

For instance, J. D. Hamilton’s publication (2009) analyzes the causes and consequences of the oil market shock that occurred in 2007–2008. The author examines various factors influencing oil price volatility, such as demand, supply, and geopolitical factors. Similarities and differences between the increase in oil prices during the studied period and earlier price shocks are shown, focusing on the reasons for these price increases and their impact on the economy.

L. Kilian (2009) in his publication examines the differences between supply and demand shocks in the oil market. Through the analysis of these shocks, the author seeks to understand how various factors affect oil prices.

In another publication, L. Kilian, together with B. Hicks (2013), analyzes whether the strong economic growth in the years 2003–2008 was the cause of the oil price shock during that period. They investigate the relationship between economic growth and oil prices to assess the influence of macroeconomic factors on these prices. Similarly, R. Sobków (2017) conducted an analysis of the relationship between oil prices and periods of economic expansion and recession in the USA.

R. Alquist and L. Kilian (2014), on the other hand, analyzed what information can be extracted from future oil contract prices. The authors examined the relationships between current prices and futures contract prices to assess whether the direction of oil price changes can be predicted.

Lastly, R. S. Pindyck (1999) examined the long-term evolution of energy prices, including oil. In this publication, the author analyzes factors influencing energy prices, including crude oil, and examines price trends over time.

Analyzing the literature, research, and analyses related to the 1972 Club of Rome report, researchers have noticed a significant cognitive gap, involving the lack of a long-term trend in crude oil prices based on the WTI index level, which would help verify the assumptions laid out in the “Limits to Growth” report.

Methodological assumptions

In this publication, a study of available literature and research on the Roman report was conducted. Based on the available data, an analysis of long-term trends in crude oil prices was carried out. A hypothesis was also formulated, which was subsequently verified through the conducted research. The research results were compared with the conclusions presented in the 1972 “Limits to Growth” report by the Club of Rome.

The research focuses on the WTI index, which is one of the key indicators of oil prices in global markets. The study covers the period from one year after the publication of the report, namely 1973, until 2022, including the outbreak of the war in Ukraine. This fifty-year research timeframe allows for the consideration of price changes in various economic conditions and geopolitical events that may have influenced the energy commodity market. The analysis of crude oil prices was conducted in two dimensions: nominal and real. The former reflects the value of money in a given period, while the latter takes inflation into account, providing a more accurate understanding of changes in barrel prices in real terms.

The study encompasses various factors affecting changes in crude oil prices, including an analysis of both fundamental factors such as resource availability and demand for the commodity, as well as external variables like geopolitical events, natural disasters, and pandemics. It also considers changes in consumption patterns, the development of new technologies, and the discovery of new reserves.

The research was conducted using the perspective of historical institutionalism, which allowed a focus on the evolution of institutions, social norms, rules, and practices over time and their impact on behavior and social processes. This perspective facilitated a deeper understanding of the phenomena and circumstances that influenced the shaping of crude oil prices over the long term and allowed for a comparison with the conclusions presented in the “Limits to Growth” report.

Summarizing, the historical institutionalism perspective can provide a deeper understanding of the socio-economic and political context that shaped changes in crude oil prices over time. It was used to provide a more comprehensive view of various aspects, including:

- The role of institutions in regulating oil prices, including which institutions regulated the oil market in different historical periods, what mechanisms were used, and what factors influenced the commodity’s price.
- The evolution of regulations and energy policies, tracking changes in extraction, trade, and energy policy in different time periods to determine how they altered the operating framework for the oil market and impacted its prices.
- The impact of geopolitical processes on the market, conducting analytical investigations to determine how changing international relations, trade agreements, or armed conflicts affected the availability and prices of crude oil.
- Technological changes and innovations, conducting scientific inquiries into their impact on the processes of extraction, production, and distribution of crude oil in different chronological periods, providing a fuller picture of potential price changes over a longer time horizon.

During the research procedures, various methodological approaches were employed, including:

- Critical analysis of textual documents, such as newspaper articles, reports, and letters, to identify patterns, trends, and content related to the topic.
- Case study analysis, aimed at identifying details and context related to the studied phenomena.
- Statistical analysis, which helped in making determinations regarding numerical data to identify relationships and patterns in society. This included regression analysis, correlation analysis, variance analysis, and other statistical techniques.
- Systems analysis, which confirmed its utility in establishing relationships between crude oil price increases and the broader global economic system. It helped highlight the impact of changes in crude oil prices on various sectors of the economy, inflation, international trade, and energy policies of states, which were equated with processes specific to the larger economic system.
- Institutional analysis, which allowed for conclusions about the impact of financial institutions, governments, international organizations, or national energy policies on oil price levels. For example, it provided insight into the influence of decisions regarding extraction, trade, taxation, or energy subsidies on the supply and demand for oil, and thus its price.

Throughout the research procedures, comparative methods were used to compare and relate individual cases to one another.

Determinants influencing crude oil price changes in the Last 50 Years. – US Dollar inflation

In the first decade after the publication of the Club of Rome report, two significant events occurred that had a significant impact on oil prices. Both had geopolitical implications with significant economic repercussions. The first of these events was the Middle East crisis associated with the so-called “October War” (also known as the Yom Kippur War) in 1973, which led to a sharp increase in commodity prices, including oil. This conflict provided Arab oil producers with an opportunity to end cooperation on their existing terms, which were yielding diminishing benefits (Примаков, 1983, p. 34). An embargo was used for this purpose. Imposed on Western allies of Israel, who were also oil importers, it proved to be an effective tool of pressure. It allowed OPEC to reshape the prevailing market dynamics and significantly strengthen the position of oil exporters (Kwiatkiewicz, 2011, p. 343). The new status quo seemed particularly unfavorable for the United States, which was the world’s largest consumer and importer of this commodity. Another oil crisis triggered by the Shiite revolution in Iran began in 1979. It was responsible for one of the three highest real oil prices in the last half-century. The resulting serious supply problems confirmed the advantage that interests of oil-producing states had been slowly gaining. Their dominance in the market was beyond doubt, at least temporary. Resource deficits and difficulties in meeting demand put them in a privileged position and allowed them to dictate trade terms, which also influenced price trends.

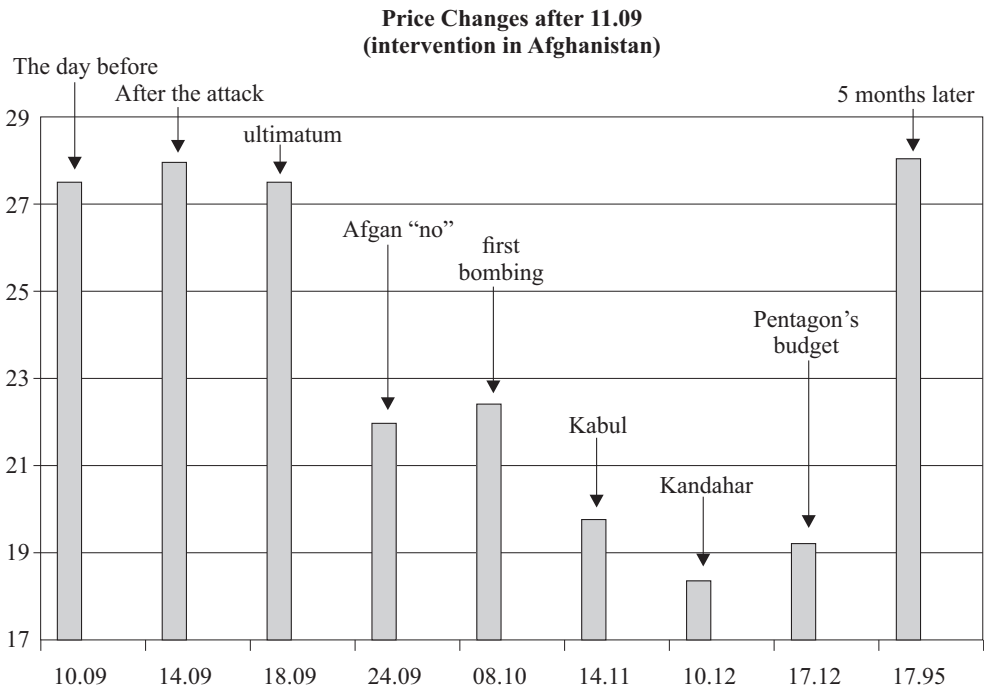
The second series of events related to armed conflicts that had an impact on raising commodity prices in the 1970s was the Islamic revolution in Iran and the Iran-Iraq war, more precisely, the removal of Western oil companies from that country and the state takeover of the extraction sector, in simpler terms – ownership transformations. The price per barrel (average annual price – \$13.6 USD/bbl, average for January 1979 – \$13.08 USD/bbl) skyrocketed to \$30.03 USD/bbl (eia.doe.gov, 2023). The Iran-Iraq war that began in the middle of the following year, after a brief increase in prices when the annual average rose to \$35.69 USD/bbl in 1980, quickly contributed to the systematic decline in oil price quotations.

In the period from 2001 to 2010, two powerful armed conflicts took place in the Middle East, specifically in Afghanistan and Iraq. Afghanistan was among the least significant players on the global oil market. It did not have documented natural resource reserves (eia.doe.gov, 2023), and its internal demand of less than five thousand barrels per day could be considered negligible (eia.doe.gov, 2011). Moreover, it was located off the main transit routes, making it insignificant for the industry from a logistical perspective as well. The impact of the conflict on oil barrel stock market quotations can be linked to concerns about the escalation of hostilities in neighboring countries. To some extent, it can also be associated with potential threats arising from its impact on the moods in Muslim societies. Both elements, in analogy to the situation in the last two decades of the 20th century, met all the conditions to be perceived as factors stimulating increased production and a decrease in the long-term price of oil in the Middle East and Central Asia.

However, the key role in selecting factors affecting oil prices associated with armed conflicts should be attributed to entirely different concerns, namely those related to the financial costs of American military involvement in Afghanistan and the impact of this burden on the state budget and the condition of the United States' economy. While in the short, several-week period, it served as a stimulus for its recovery to a degree that allowed for revenues to neutralize additional expenditures, over time, the steadily increasing burdens from this source exceeded the benefits to the economy. As a result, it gradually became a negative factor affecting the pace of its development. At least this is one way to interpret the changes in the stock market quotations of the price per barrel of oil. The first weeks of the armed intervention by the United States against the Taliban regime led to a noticeable drop in prices. Oil initially dropped by about \$10 USD/bbl from over \$27 USD/bbl at the end of September to just under \$18 USD/bbl in mid-November 2001, and then steadily rose in the following months, returning to price levels seen in the same period a year earlier by May 2002.

The fluctuations in the exchange rate during the summer of 2002 were not significantly different from those seen twelve months prior. In the autumn, there was no price drop of a similar scale. The dynamics of price changes at that time had a purely cyclical and seasonal nature, following the typical trends for that season. The issue of the impact of the military intervention in Iraq on the oil market was significantly more complex. Here, all the elements that influenced barrel prices in the case of U.S. involvement in Afghanistan came into play. However, given the much larger scope of the entire operation, it operated at a significantly higher level for each of these elements. From the beginning, the most important factor in this context was the impact on

Fig. 1. The prices of crude oil before the military intervention in Afghanistan and in its first months

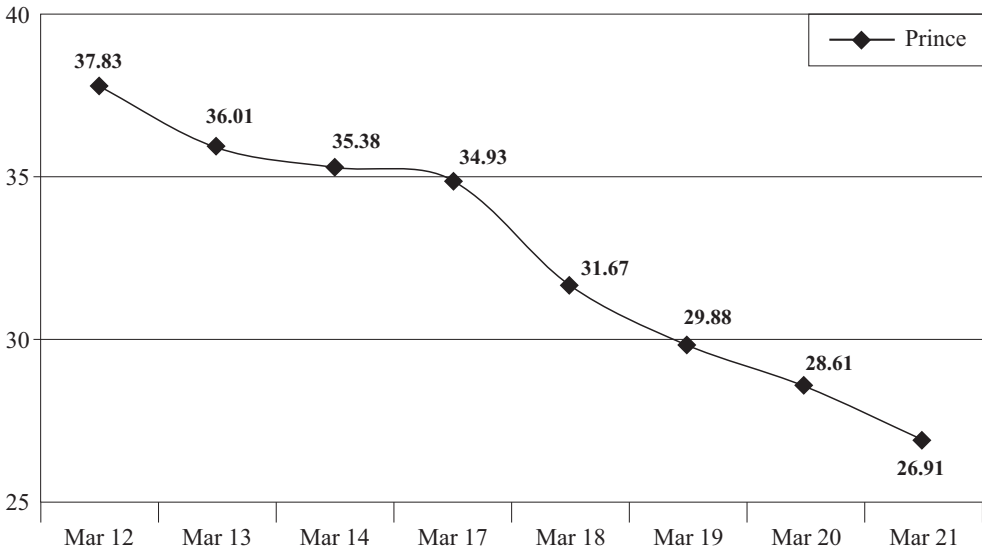


Source: Developed by the authors based on US Energy Information Administration, F.O.B. (Free on Board) Spot Prices of West Texas Intermediate (WTI) Crude Oil, http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm.

the U.S. budget burdens. It was somewhat connected to and implied by the other two factors. These relations were determined by the geopolitical location of the Republic of Iraq, its affiliation with the Arab world, and its strong international position, which fundamentally differed from the isolated Taliban regime in the world. The escalation of the conflict, potentially leading to the transfer of hostilities to the oil-rich areas of the Persian Gulf region, could have had catastrophic consequences for the global economy. The scale of the operation required resources, and not just military ones. The threat to U.S. finances and economic conditions associated with the possibility of a prolonged conflict in Iraq was further burdened by the experience gained from the ongoing war in Afghanistan, which, contrary to initial assumptions, continued. As a result, the costs incurred for actions in Iraq overlapped with the expenses allocated for the war in Afghanistan.

Similarly, in case of Afghanistan, the outbreak of conflict did not lead to an increase in prices. However, they soon began to rise and, after a few weeks, reached the level from before the operation, which certainly did not slow down their further successful growth. The lack of prospects for a quick stabilization of the situation in Iraq, and consequently the chances of a decision to withdraw massive military contingents from that country, did not bode well for the future of American finances. It meant an additional and permanent burden on an indeterminate period.

Fig. 2. The prices of crude oil on the eve of the Iraq Freedom operation and after its commencement



Source: Developed by the authors based on US Energy Information Administration, F.O.B. (Free on Board) Spot Prices of West Texas Intermediate (WTI) Crude Oil, http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm, 8.11.2011.

This factor seemed to have a greater influence on commodity prices than the circumstances of conducting the war in a country whose oil potential is one of the largest in the world. Since 1991, it had largely remained untapped. Despite substantial reserves, estimated at over 115 billion barrels at the most conservative estimates (eia.doe.gov, 2011), and very low extraction costs, Iraq, under international sanctions, officially produced just over 0.5 million bbl/d, which was only a fifth or even a sixth of what it used to produce in earlier years (eia.doe.gov, 2011). By the early 21st century, there was significant progress in this regard. In 2002, Iraq was supplying over 2.5 million bbl/d, and its share in global production exceeded 3%. This was also its significance in the global oil market on the eve of the intervention. The conflict temporarily lowered this level to 1.5% (eia.doe.gov, 2011). As a result of the new concession arrangements and the return of foreign companies to the Tigris and Euphrates regions, conditions were created at the end of the decade that allowed the restoration of production to pre-conflict levels. This also laid the groundwork for forecasting a future increase in Iraq's share in global oil trade commensurate with the actual export capabilities of the country (eia.doe.gov, 2011).

While the connection between armed conflicts in Afghanistan and Iraq and oil prices in the first decade of the 21st century may seem indisputable, the impact of the military operations themselves on the stock market prices of this commodity should be considered relatively minor.

The ongoing process of intensive exploration for alternative fuel sources (primarily shale and renewable energy sources), which are more expensive to extract than tradi-

tional fossil fuels, coupled with a simultaneous steady increase in demand for fuel and energy (eia.gov/international, 2023), should lead to the formation of a long-term upward trend in oil prices.

The rise in oil prices, as well as growing concerns about the stability of its sources of supply, primarily from the Middle East, has initiated three new processes:

- The extraction of resources from already discovered reserves that were previously uneconomical to exploit at lower prices.
- The exploration of new reserves, including in areas that were previously considered uneconomical.
- The improvement of existing extraction technologies and the development of new technologies, including those related to shale fuel production.

This last process ultimately led to two so-called shale revolutions in the current century, reshaping the geography of global oil and natural gas production, and, above all, restoring the United States to its position as the largest oil producer and exerting a direct influence on the pricing of oil after many years (eia.gov/tools, 2023).

US Dollar inflation

The increase in oil barrel prices, closely linked to the evolving political situation in Iran, more precisely, the introduction of new ownership regulations regarding extraction concessions (Keddie, 2007), posed significant problems for the American economy. The change in regime in this country was unfavorable for the United States, not only in the context of their interests in the broader Middle East region (Milani, 2011, p. 91).

The more expensive fuels generated a strong inflationary impulse while also creating an obstacle to maintaining the pace of development.

Table 1

Inflation in the United States in the period of 1978–1980

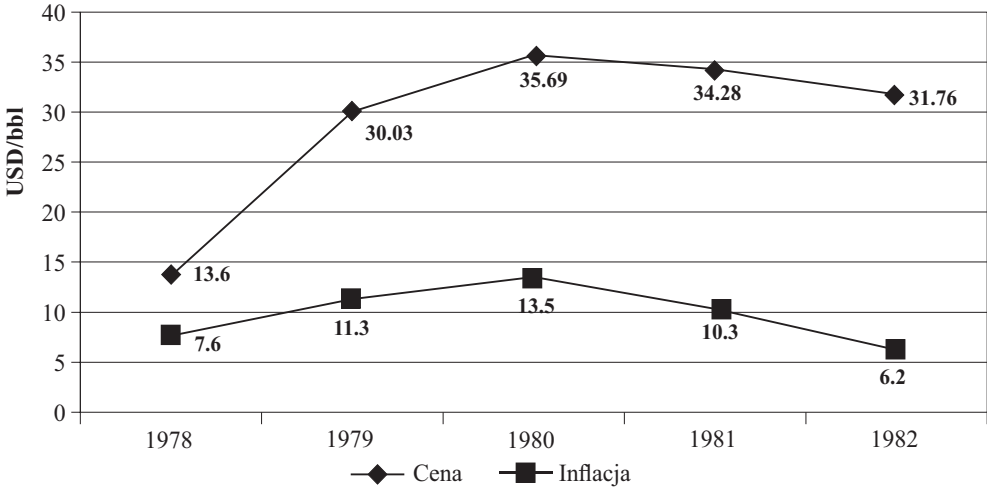
Rok	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1978	6.8	6.4	6.6	6.5	7.0	7.4	7.7	7.8	8.3	8.9	8.9	9.0
1979	9.3	9.9	10.1	10.5	10.9	10.9	11.3	11.8	12.2	12.1	12.6	13.3
1980	13.9	14.2	14.8	14.7	14.4	14.4	13.1	12.9	12.6	12.8	12.6	12.5

Source: Developed by authors based on www.usinflationcalculator.com.

In 1978 the value of the American currency decreased by 7.6%. In 1979, it was already 11.3%, and in 1980, this decline reached 13.5% (Tab. 1). The correlation between the depreciation of the dollar and the rise in oil prices clearly reflected the strength with which both processes were interrelated (Fig. 3).

It is important to note the significance of the growth dynamics, which in this case were more important than the actual oil barrel price values. Over five years, the American currency lost almost half of its purchasing power. Over the decade that has passed since the first crisis, the depreciation of the American currency's value progressed at

Fig. 3. Crude oil prices and USD inflation



Source: Developed by authors based on US Energy Information Administration – International Energy Statistics and <http://www.tradingeconomics.com/united-states/inflation-cpi>, 8.11.2011.

an unprecedented pace. In 1982, the dollar had a real value twice as low compared to the exchange rate in 1973. This implied an expressed price of an oil barrel in dollars (Tab. 2).

Table 2

Depreciation of USD purchasing power in the period of 1973–1982

Rok	1974	1975	1976	1977	1978	1979	1980	1981	1982
1973=1	1.1	1.21	1.28	1.36	1.47	1.64	1.86	2.05	2.17

Source: Developed by authors based on www.usinflationcalculator.com, 8.11.2011.

For the United States, the impact of higher fuel prices did not end with the purely economic influence on the country’s economic condition. The commodity market price, which had never reached such levels, also had political significance. It was reflected on a broad scale that extended beyond the internal situation and was shaped by social repercussions of such prices (Schweizer, 1994, p. 153) and had an influence on subsequent decades.

Analysis of WTI crude oil prices and their long-term trends from 1973 to 2022

The price level of WTI crude oil from 1973 to 2022 is presented in Figure 4.

In the chart, a significant increase in crude oil prices over the long-term horizon can be observed. Prices rose from an initial level of approximately \$3.5 per barrel to over \$80 per barrel by the end of the presentation period, which is nearly 23-fold. According to the forecast of the Club of Rome report, crude oil prices are expected to increase exponentially. However, the exponential trend of crude oil prices over the specified 50-year

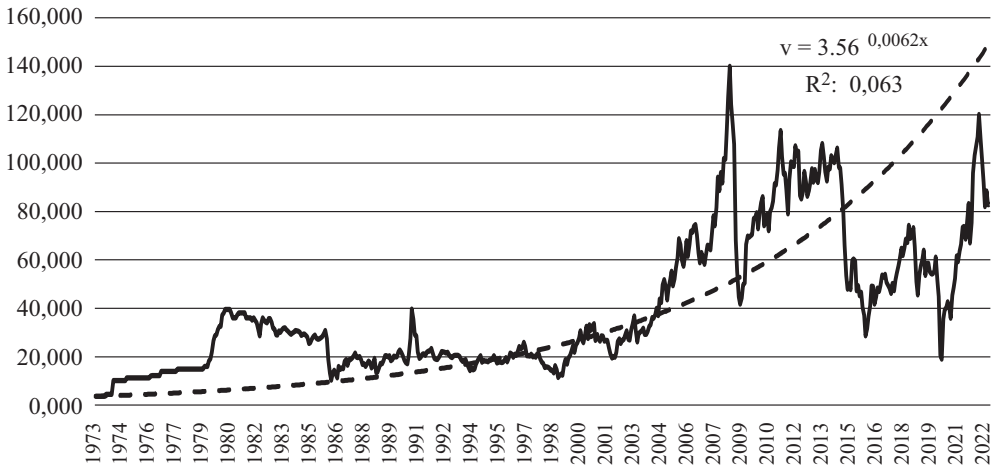
Fig. 4. The nominal prices of WTI crude oil from 1973–2022 (in USD)



Source: Developed by authors based on www.macrotrends.net/1369/crude-oil-price-history-chart, 09.08.2023.

period, as shown in Figure 5 below, indicates only a moderate correlation with actual changes in oil prices during this time ($R^2 = 0.47$).

Fig. 5. Analysis of the trend in real WTI crude oil prices from 1973 to 2022 based on an exponential function (in USD)



Source: Developed by authors based on www.macrotrends.net/1369/crude-oil-price-history-chart, 09.08.2023.

However, it should be noted that the increase in nominal oil prices over the past 50 years has been influenced not only by market factors related to the demand and supply of this commodity but also by a significant monetary factor – inflation. From 1973 to 2022, the overall price level in the US economy increased nearly sevenfold (<https://www.rateinflation.com>, 2023). The observed increase in the nominal price of crude oil between the be-

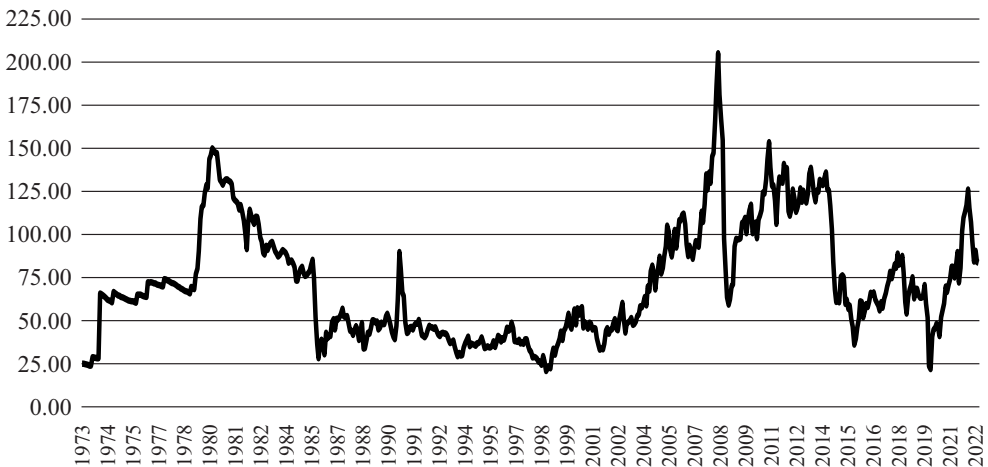
ginning and the end of the analyzed period, from approximately \$3.5 per barrel to over \$80 per barrel in real terms, still represented a price increase, but not by a factor of several tens, but rather by a factor of approximately three. The increase is still significant but not as large as it would appear from the nominal price increase. When adjusting the prices of crude oil from earlier years to the price level in the US economy at the end of 2022, the real price level of this commodity over the past 50 years is presented in Figure 6.

The analysis of the above chart indicates significant differences in the trajectory of the WTI crude oil price index changes based on nominal and real values. These differences point to discrepancies between the claims of inevitable continuous oil price growth made in the 1972 report by the Club of Rome and the actual course of these changes over the last 50 years. Apart from a unique and brief peak in oil prices during the mid-2008 crisis and its echo in 2011, it did not exceed the levels seen at the beginning of 1980. Furthermore, several times during this period, in 1986, at the turn of 1998/1999, and in 2020, WTI crude oil tested price levels that existed even before the Yom Kippur War.

Further analysis of Figure 6 indicates that within 50-year time frame, several periods can be identified where the real price of WTI crude oil exhibited similar levels and trends of change:

- The first period, in 1973, was characterized by a low and stable oil price (nominal 3.5–4.3 USD/bbl, and real 23.5–28.5 USD/bbl). This period marked several years of stable or even decreasing real oil prices, which began in the late 1950s.

Fig. 6. The real prices of WTI crude oil from 1973 to 2022 (in USD, adjusted for purchasing power as of December 31, 2022)



Source: Developed by authors based on www.macrotrends.net/1369/crude-oil-price-history-chart, 09.08.2023.

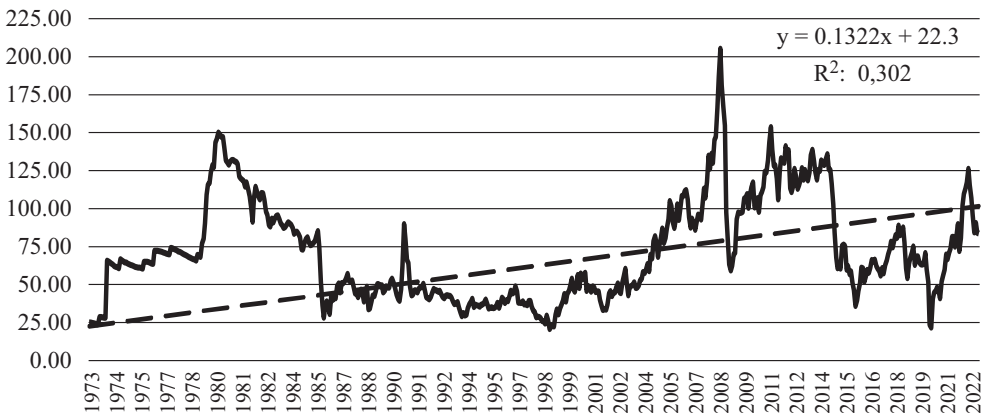
- The second period, from 1974 to 1985 (a total of 12 years), featured dynamic price fluctuations. At the start of this period, prices sharply rose from a real level of 28.5 USD/bbl to 65 USD/bbl, largely due to the Yom Kippur War in the Middle East. Another significant increase occurred in the late 1979 during the Iranian crisis, reaching a peak in the first half of 1980 at 150 USD/bbl. Afterward, oil prices steadily de-

- clined, reaching 75 USD/bbl by the end of 1985, and then sharply plummeting at the beginning of 1986 to nearly the same level as the start of the period in January 1974.
- The third period, from 1986 to 2001 (a total of 16 years), was characterized by relatively stable and low prices, except for a brief episode during the Gulf War.
 - The fourth period, from 2002 to the end of 2014 (a total of 13 years), once again featured dynamic price changes. Initially, there was a sharp increase in oil prices from around 30 USD/bbl, occasionally exceeding 170 USD/bbl, only to drop to around 60 USD/bbl at the turn of 2014 and 2015. During this period, the oil market experienced two significant events: the global financial crisis of 2008–2009 and the so-called shale revolution. Both events had a significant impact on both the level and dynamics of oil price changes.
 - The fifth and final period, from the beginning of 2015 to the end of 2022 (a total of 8 years), coincided with the start of the so-called second shale revolution. During this time, oil prices fluctuated widely, ranging from 40 to 80 USD/bbl. The dynamic oil price changes in this period align with the expectations of experts at the beginning of the second shale revolution, suggesting that oil prices entered a “long period of instability”. In the current period, within the range of 40–80 USD/bbl, there were only three exceptions to the price fluctuations – first during the “Second Iranian Crisis” at the end of 2018, a short-term drop at the onset of the COVID pandemic, and disturbances at the beginning of the Ukraine conflict. These cases should be considered as incidental.

The discrepancies in the formation of crude oil prices, as highlighted in the report by the Club of Rome, can also be observed in the realm of upward trends. Due to the significant impact of inflation on the nominal prices of WTI crude oil (cumulative inflation rate approximately 600% between 1973 and 2022), the analysis of crude oil price trends should be conducted exclusively based on real prices, adjusted for the influence of inflationary factors in the economy.

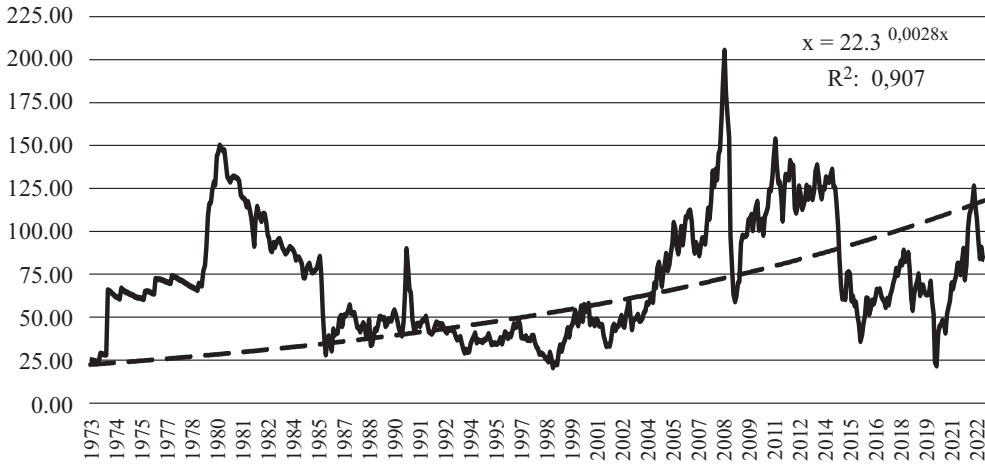
The analysis of the trend in real crude oil price changes was carried out by fitting them to various functions: linear, exponential, power, logarithmic, and polynomial, as presented in Figures 7–11.

Fig. 7. The analysis of the trend of real WTI crude oil prices from 1973 to 2022 based on a linear function (in USD)



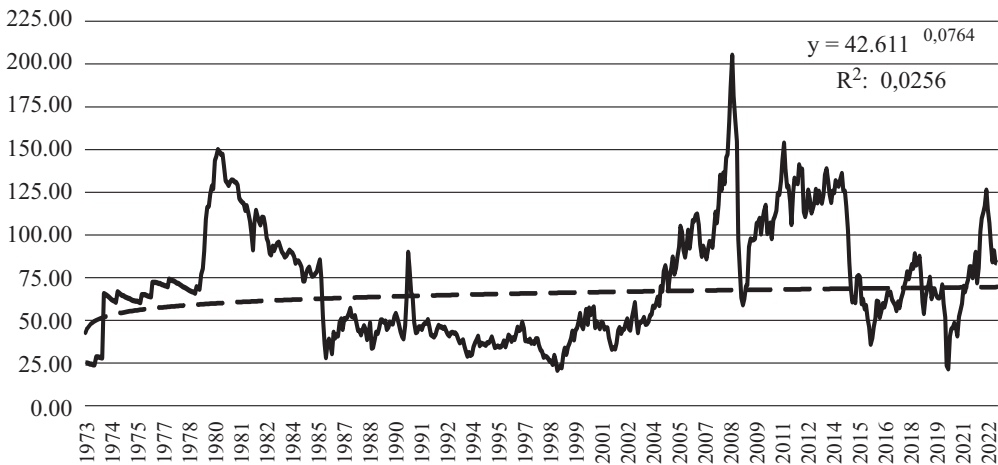
Source: Developed by authors based on www.macrotrends.net/1369/crude-oil-price-history-chart, 09.08.2023.

Fig. 8. Analysis of the trend of real WTI crude oil prices from 1972–2021 based on an exponential function (in USD)



Source: Developed by authors based on www.macrotrends.net/1369/crude-oil-price-history-chart, 09.08.2023.

Fig. 9. The analysis of the trend of real WTI crude oil prices from 1973 to 2022 based on a power function (in USD)

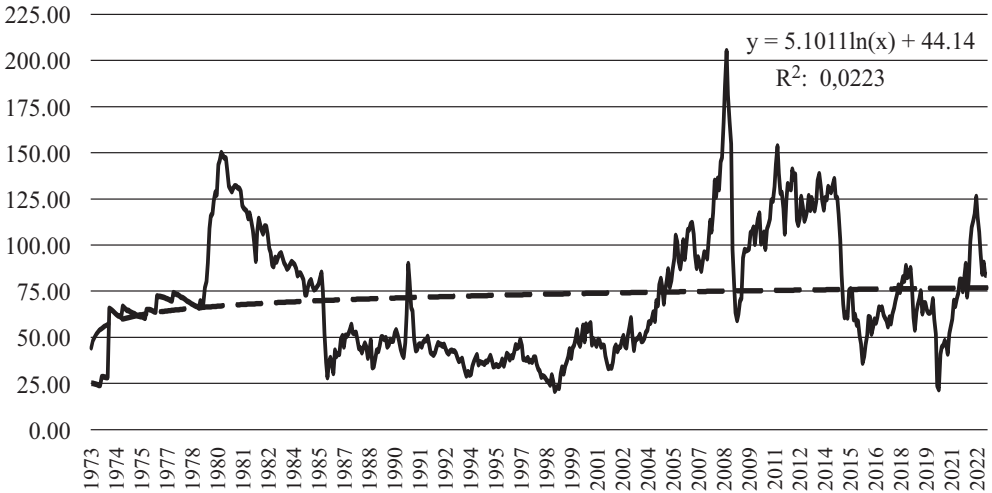


Source: Developed by authors based on www.macrotrends.net/1369/crude-oil-price-history-chart, 09.08.2023.

While all computed trend lines (linear, power, logarithmic, exponential, and polynomial) show an upward trend, which could suggest a relative worsening of the ratio of consumption to available resources in the longer term, for real oil prices, all computed trend lines exhibited a correlation level of only 0.01–0.05. This excludes the possibility of indicating a statistically significant relationship. It is worth noting only, as an interesting observation, that the analysis of the oil price trend based on polynomial functions indicated that with a 4th-degree polynomial function, the calculated correlation coefficient

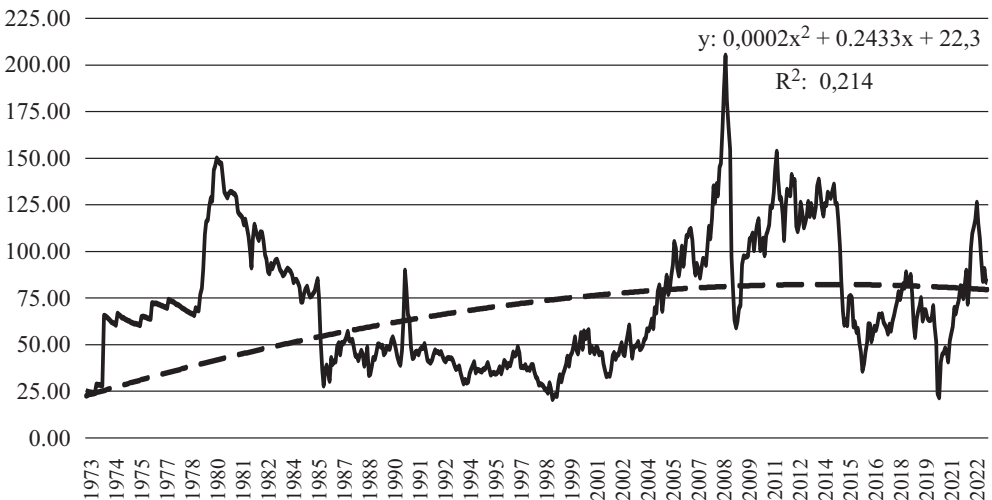
reached a level of 0.42 (Figure 8), and for a 6th-degree polynomial, it even reached 0.67 (Figure 12), suggesting a strong correlation of oil prices during the analyzed period with such a specified trend function. However, this was not the kind of relationship and trend that the experts of the Club of Rome had in mind.

Fig. 10. Analysis of the trend of real WTI crude oil prices from 1972 to 2021 based on a logarithmic function in USD



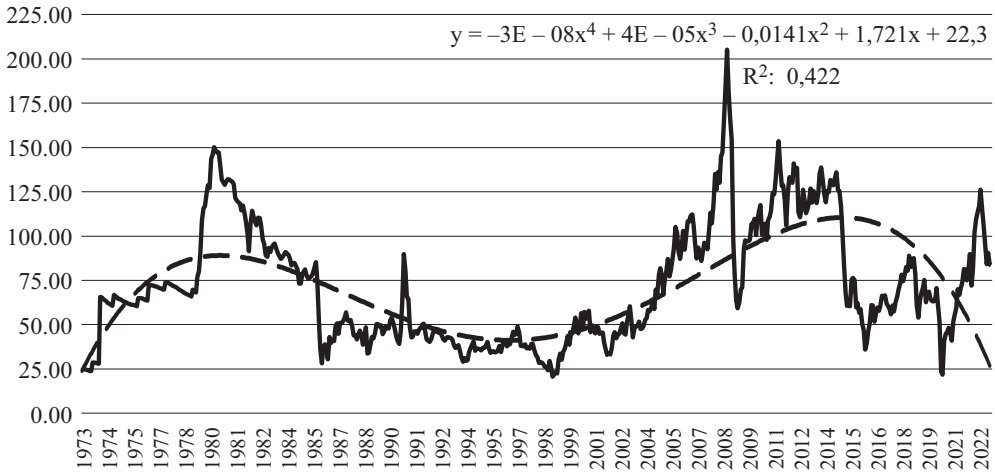
Source: Developed by authors based on www.macrotrends.net/1369/crude-oil-price-history-chart, 09.08.2023.

Fig. 11. The analysis of the trend of real WTI crude oil prices from 1973 to 2022 based on a second-degree polynomial function (in USD)



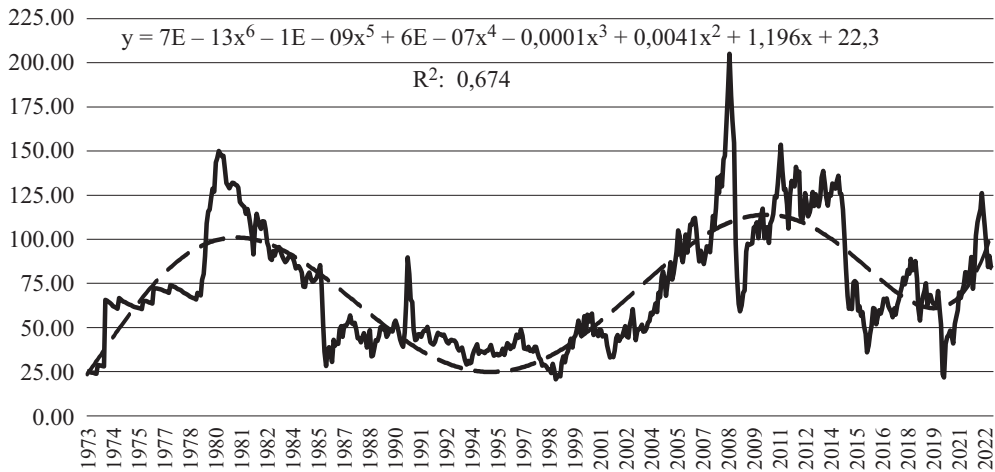
Source: Developed by authors based on www.macrotrends.net/1369/crude-oil-price-history-chart, 09.08.2023.

Fig. 12. Analysis of the trend of real WTI crude oil prices from 1972 to 2021 based on a fourth-degree polynomial function (in USD)



Source: Developed by authors based on www.macrotrends.net/1369/crude-oil-price-history-chart, 09.08.2023.

Fig. 13. Analysis of the trend of real WTI crude oil prices from 1972–2021 using a 6th-degree polynomial function (in USD)



Source: Developed by authors based on www.macrotrends.net/1369/crude-oil-price-history-chart, 11.08.2023.

Conclusions

Crude oil is considered one of the key commodities in the development of the global economy. The 1972 report by the Club of Rome, “The Limits to Growth,” pointed to the possibility of a relatively short-term supply shortage of resources worldwide, including energy resources, resulting in exponential price growth. Verifying the conclusions out-

lined in the Club of Rome report is an essential step in understanding and managing the challenges related to global development. As a result of a review of the literature and an analysis of previous research related to the Club of Rome report, a significant cognitive gap was identified, characterized by the lack of a long-term trend in oil prices based on the WTI index, which could help verify the assumptions made in the “Limits to Growth” report. The authors of the article hypothesized that the price of WTI crude oil would not necessarily increase exponentially as global resources were depleted.

As a result of the analysis of nominal and real WTI crude oil prices over a 50-year period following the publication of the Club of Rome report, from 1972 to the end of 2022, the fundamental conclusions in this report were not confirmed. There were significantly different price trends during this period than what was predicted. The data analysis presented in the article, particularly in figures 9 and 11, did show a long-term increase in the price of WTI crude oil during the research period, both in nominal and real terms. In nominal terms, prices increased more than twentyfold, from approximately \$3.5 to around \$85 per barrel. Even in real terms (at the end of 2022 prices), there was more than a threefold increase (from approximately \$25 to \$85). While the direction of these changes, based on the presented data, cannot be disputed – the price of WTI oil did increase in the long term in both nominal and real terms – a deeper statistical analysis of these changes reveals the interpretative complexity of the results.

The article pointed out the occurrence of high fluctuations in oil prices in the short and medium term. Moreover, over the analyzed 50 years, there were long periods during which oil prices remained stable at a low level, even testing the level from the beginning of the analysis period. The calculations presented in the article also indicate that attempts to establish a single, clear trend in oil prices covering the entire research period, only for nominal prices, resulted in a result that could only be partly related to the Club of Rome experts’ “Limits to Growth” report. During the research period, the price of WTI oil did indeed rise, and quite dynamically, but this increase was largely due to the decline in the real value of the U.S. dollar (inflation) rather than due to real growth in oil prices – the real price of oil increased about threefold, while the real value of the dollar depreciated sevenfold. Furthermore, even the calculated trend lines for nominal prices did not indicate statistically significant correlations. For real prices, the correlation coefficients were close to zero. Changes in fluctuations indeed occurred with varying intensity and in different directions over long time periods, not as the Club of Rome experts envisioned them. Therefore, the conclusions of the report must be considered unconfirmed, and thus, they provided investors with misleading information about the actual conditions in which they were expected to operate in the following decades. Consequently, it is necessary to agree with Zyblikiewicz that “haste and far-reaching simplifications, the adoption of the assumption of geometric growth, and the lack of efforts to mitigate the effects of extrapolation significantly diminished the substantive value and impact of this report” (Zyblikiewicz, 2013, p. 468).

Research on the alignment of the Club of Rome report’s economic projections with reality should continue. Above all, longer periods covered by data analysis in the future may lead to an increase in the correlation between real oil prices and the exponential trend suggested in the report. They may also lead to the identification of additional factors influencing short and long-term energy commodity prices, beyond those

identified in this article. Above all, they will lead to better commodity price forecasts in the future.

Author Contributions

Conceptualization (Konceptualizacja): Piotr Kwiatkiewicz, Krzysztof Melnarowicz, Robert Sobków

Data curation (Zestawienie danych): Piotr Kwiatkiewicz, Krzysztof Melnarowicz, Robert Sobków

Formal analysis (Analiza formalna): Piotr Kwiatkiewicz, Krzysztof Melnarowicz, Robert Sobków

Writing – original draft (Piśmiennictwo – oryginalny projekt): Piotr Kwiatkiewicz, Krzysztof Melnarowicz, Robert Sobków

Writing – review & editing (Piśmiennictwo – sprawdzenie i edytowanie): Piotr Kwiatkiewicz, Krzysztof Melnarowicz, Robert Sobków

Competing interests: The author have declared that no competing interests exist
(**Sprzeczne interesy:** Autor oświadczył, że nie istnieją żadne sprzeczne interesy)

Bibliography

- Alquist R., Kilian L. (2014), *What do we learn from the price of crude oil futures?*, *Journal of Applied Econometrics*, 29(3), pp. 454–478.
- Belasco A., *The Cost of Iraq, Afghanistan, and Other Global War on Terror Operations Since 9/11*, Congressional Research Service, The Federation of American Scientists, <http://www.fas.org/sgp/crs/natsec/RL33110.pdf>, 29.11.2011.
- Charles A., Hall S., Day J. W. (2009), *Revisiting the Limits to Growth After Peak Oil*, *American Scientist*, “Sigma Xi”, 97/3, May–June.
- Galwas B., Wyżnikiewicz B. (2014), *Czy kryzys światowych zasobów?*, Komitet Prognoz “Polska 2000 Plus” przy Prezydium PAN, Dom Wydawniczy ELIPSA, Warszawa.
- Herrington G. (2021), *Update to limits to growth: Comparing the world3 model with empirical data*, “*Journal of Industrial Ecology*”, 25, pp. 614–626, <https://doi.org/10.1111/jiec.13084>.
- Harari Y. N. (2018), *Homo deus. Krótka historia jutra*, Wydawnictwo Literackie, wydanie pierwsze, Kraków, pp. 52–68.
- Hamilton J. D. (2009), *Causes and consequences of the oil shock of 2007–08*, “*Brookings Papers on Economic Activity*”, University of California, San Diego, 40(1), pp. 215–261.
- Independent Statistics and Analysis U. S. Energy Information Administration (2011), eia.doe.gov.
- Independent Statistics and Analysis U. S. Energy Information Administration (2023), eia.doe.gov.
- Keddie N. R. (2007), *Współczesny Iran*, Wydawnictwo Uniwersytetu Jagiellońskiego, Kraków.
- Kilian L. (2009), *Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market*, “*American Economic Review*”, 99(3), pp. 1053–1069.
- Kilian L., Hicks B. (2013), *Did unexpectedly strong economic growth cause the oil price shock of 2003–2008?*, “*Journal of Forecasting*”, 32(5), pp. 385–394.
- Kwiatkiewicz P. (2011), *Mocarstwa wobec Iraku*, Wydawnictwo Adam Marszałek, Toruń, p. 343.

- <https://www.rateinflation.com/inflation-rate/usa-historical-inflation-rate>, 09.07.2023.
- International Energy Agency, http://www.iea.org/index_info.asp?ID=2335, 25.07.2023.
- US Energy Information Administration, [eia.doe.gov, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=57&aid=6](http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=57&aid=6), 11.11.2022.
- US Energy Information Administration, <http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0504>, 10.08.2023.
- US Energy Information Administration, F.O.B. (Free on Board) Spot Prices of West Texas Intermediate (WTI) Crude Oil, http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm.
- US Energy Information Administration, <http://www.eia.doe.gov/emeu/aer/txt/ptb1107.html>, 15.08.2023.
- US Energy Information Administration, <http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=5&aid=2&cid=regions,r7,&syid=2001&eyid=2010&unit=TBPD>, 11.11.2019.
- World Crude Oil Prices, http://tonto.eia.doe.gov/dnav/pet/pet_pri_wco_k_w.htm.
- www.macrotrends.net/1369/crude-oil-price-history-chart, 07.09.2023.

Geopolityczne skutki prognoz cen ropy naftowej: Analiza raportu Klubu Rzymskiego dotyczącego globalnych ograniczeń wzrostu gospodarczego i rzeczywistości rynkowej

Streszczenie

Raport ekspertów Klubu Rzymskiego z 1972 r. wskazywał na możliwość stosunkowo krótkotrwałego globalnego deficytu podaży surowców, w tym zasobów energetycznych. Według autorów tego dokumentu przyczyną był rosnący popyt na zasoby w połączeniu ze zmniejszającymi się dostępnymi rezerwami. Przewidywanym rezultatem był dynamiczny, wykładniczy wzrost cen surowców, w tym ropy naftowej, w perspektywie nadchodzących dekad. Celem tego artykułu jest wykazanie, czy prognozy raportu Klubu Rzymskiego sprzed ponad pół wieku dotyczące wzrostu cen ropy naftowej znajdują odzwierciedlenie w rzeczywistej sytuacji rynkowej oraz próba określenia potencjalnego kierunku zmian cen baryłek tego surowca. Autorzy artykułu przyjęli hipotezę, że cena ropy naftowej niekoniecznie musi wzrosnąć wykładniczo w miarę wyczerpywania się światowych zasobów. W wyniku analizy cen nominalnych i realnych ropy naftowej WTI po opublikowaniu raportu Klubu Rzymskiego, tj. od 1973 r. do końca 2022 r. (okres 50 lat), nie potwierdziły się podstawowe wnioski zawarte w raporcie. Wskazano na istotnie odmienny przebieg zmian cen ropy naftowej w podanym okresie, w porównaniu z przewidywaniami w raporcie.

Słowa kluczowe: Raport Klubu Rzymskiego, ceny ropy naftowej, trendy cenowe ropy naftowej