Chair of Economic- and Business Management

Master's Thesis

Leading indicators in macroeconomics to better understand business cycles and predict commodity trading

Patrick Oberschmidleitner, BSc

August 2023

Scope

Patrick Oberschmidleitner is assigned to research the topic of

Leading indicators in macroeconomics to better understand business cycles and predict commodity trading

and to process this topic in his master's thesis.

The central aim of this master thesis is to develop and implement a forecast model based on macroeconomic indicators, to predict business cycle changes before their occurrence to better understand business cycles and predict commodity trading, with a specific focus on the commodities of oil, copper, and uranium.

In the first part, the master thesis shall cover the theoretical foundation for a better understanding and the boundaries necessary. First, the author shall review the literature and investigate the fundamentals of economic and business cycles. Second, the author should provide an extensive overview of indicator types and commodities. Further, the author should identify and evaluate influencing economic factors of commodities and identify and evaluate the relevant indicators by determining the theoretical implementations for a suitable forecast model. The aim is to identify economical or technical key leading indicators which can provide early signals of business cycle turnaround points in these commodity markets and develop effective forecasting models for commodity price movements.

In the second empirical part, the author shall apply his theoretical findings and his built model to available data from past events and infliction points to gain proof of applicability. Furthermore, the author shall enhance his model by re-evaluating the selected lead indicators for suitability regarding their sensitivities to the selected indicating elements. In addition, cross-dependencies and -influences through the application of an influence matrixe should be evaluated and displayed. Finally, by the example of the three selected commodities, the before-developed forecasting model's findings, benefits and limitations shall be displayed, discussed and concluded.

Leoben, June 2023

Univ.-Prof. Dr. Wolfgang Posch

Lehrstuhl für Wirtschafts- und Betriebswissenschaften

MONTANUNIVERSITÄT LEOBEN
www.unileoben.ac.at

EIDESSTATTLICHE ERKLÄRUNG

Ich erkläre an Eides statt, dass ich diese Arbeit selbständig verfasst, andere als die angegebenen Quellen und Hilfsmittel nicht benutzt, und mich auch sonst keiner unerlaubten Hilfsmittel bedient habe.

Ich erkläre, dass ich die Richtlinien des Senats der Montanuniversität Leoben zu "Gute wissenschaftliche Praxis" gelesen, verstanden und befolgt habe.

Weiters erkläre ich, dass die elektronische und gedruckte Version der eingereichten wissenschaftlichen Abschlussarbeit formal und inhaltlich identisch sind.

Datum 27.08.2023

Unterschrift Verfasser/in
Patrick Oberschmidleitner

Principle of equality

For reasons of readability, gender-specific formulations have not been used in this paper. It is explicitly stated that the masculine forms used for persons are to be understood for both genders.

Acknowledgement

I would like to take this opportunity to thank everyone who supported me through my study and during the process of this thesis.

First of all, I would like to express my gratitude to Univ.-Prof. Dipl.-Ing. Dr.mont. Wolfgang Posch, head of the Chair of Economic- and Business Management at Montanuniversität Leoben, for the opportunity to write this thesis at this Chair.

I would like to express by deepest gratitude to my supervisor Dipl.-Ing. MBA Franz Siegmeth for his ongoing support and help during the process of my work. Without his guidance and persistent help this thesis would not have been possible.

Lastly, I would not want to remiss to mention my family and friends, who supported me during my studies. Special thanks go to my parents, without their support this would not have been possible. Many thanks also go to Veronika, for her continuous support during the time in Leoben.

Kurzfassung

Ziel dieser Arbeit war es, ein auf makroökonomischen und technischen Indikatoren basierendes Prognosemodell zu entwickeln, bewerten und zu implementieren, um Veränderungen im Konjunkturzyklus vor ihrem Auftreten vorhersagen zu können und um Konjunkturzyklen besser zu verstehen. Die Ergebnisse sollen dazu beitragen den Rohstoffhandel zu verbessern, wobei der Schwerpunkt auf den mittelfristigen Zyklen der Rohstoffe Öl, Kupfer und Uran lag.

Zuerst werden die theoretischen Grundlagen der Konjunkturzyklen für ein besseres Verständnis der zyklischen Bewegungen behandelt. Anschließend werden diese analysiert und in lang-, mittel- und kurzfristige Konjunkturzyklen nach Kondratieff, Schumpeter, Juglar, Kuznets und Kitchin unterteilt. Es wird hervorgehoben, wie wichtig es ist, diese Zyklen zu verstehen und vorherzusagen, und es wird erklärt, wie sie sich auf Investoren, politische Entscheidungsträger, Forscher und Unternehmen auswirken. Nach einer Einführung in den Rohstoffmarkt und den Prozess des Rohstoffhandels werden die Wirtschaftszyklen auf den Rohstoffmärkten für Öl, Kupfer und Uran bewertet. Die Arbeit gibt anschließend einen umfassenden Überblick über technische und ökonomische Indikatoren mit einer ersten Bewertung ihrer Vorhersagbarkeit. Darüber hinaus werden die wirtschaftlichen Einflussfaktoren von Rohstoffen identifiziert und bewertet. Die theoretischen Erkenntnisse werden dann in einem erstellten Modell angewendet, das jeden analysierten Indikator nach seiner Vorhersagefähigkeit einstuft und bewertet. Des Weiteren wird bewertet welche Indikatoren in geeigneter Weise miteinander korrelieren, um diese kombinieren und für die Vorhersage von Preisbewegungen verwenden zu können. Dafür werden die Indikatoren auf verfügbare Kurschartdaten von vergangenen Ereignissen und Wendepunkten angewandt, um ihre Anwendbarkeit zu testen. Das vorgeschlagene Modell wertet 18 verschiedene Indikatoren aus, von denen 8 technische und 10 wirtschaftliche Indikatoren sind. Mittels einer Korrelationsmatrix wird die Korrelation zwischen verschiedenen Indikatoren bewertet, um hoch korrelierende Indikatoren mit Vorhersagender Tendenz zu identifizieren. Die Ergebnisse zeigen, dass für Öl, Kupfer und Uran eine Kombination aus ausgewählten technischen Indikatoren die vielversprechendsten Ergebnisse liefert, um mögliche Trendwenden in den kurz- und mittelfristigen Zyklen erkennen zu können. Abschließend wird ein Preisausblick für Öl, Kupfer und Uran gegeben, der zu dem Schluss kommt, dass sich die Energiepreise langfristig in einem Aufwärtstrend befinden.

Abstract

The objective of this thesis was to develop, assess and implement a forecast model based on macroeconomic and technical indicators, to predict business cycle changes before their occurrence to better understand business cycles and predict commodity trading, with a specific focus on the short- and medium-term cycles of the commodities of oil, copper, and uranium.

The theoretical foundation of business cycles for a better understanding of cyclic movements is covered. Business cycles are then analyzed and divided into long-, medium-, and short-term business cycles according to Kondratieff, Schumpeter, Juglar, Kuznets, and Kitchin. It highlights the importance of understanding and predicting these cycles and explains how they affect investors, policymakers, researchers, and corporations. An introductory insight into the commodity market and commodity trading process is provided and afterwards, economic cycles in commodity markets of oil, copper and uranium are evaluated. The thesis then provides an extensive overview of technical and economic indicators with a first evaluation of their leading ability. Additionally, influencing economic factors of commodities are identified and evaluated. The theoretical findings are then applied in a built model, which ranks each analyzed indicator on its predictive ability and evaluates which indicators correlate in a suitable way with each other to combine them and use them for price movement forecasting. Therefore, the indicators are applied to available price chart data from past events and reversal points to gain proof of applicability. The proposed model evaluates 18 different indicators of which 8 are technical and 10 are economic indicators. Via a correlation matrix the correlation between different indicators will be evaluated to identify highly correlating indicators with leading tendency. The outcome shows that for oil, copper, and uranium a combination of selected technical indicators shows the most promising results in detecting possible reversal points in the short- and medium term cycles. At the end, a price outlook for oil, copper, and uranium is conducted which concludes that energy prices are on an upward trend in the long term.

Table of content

List of Figures

List of tables

List of abbreviations

3MYC	3-Month Yield Curve
BB	Bollinger Band
boe	barrel oil equivalent
CAPEX	Capital Expenditures
CCI	Commodity Channel Index
CER	Currency Exchange Rate
CPI	Consumer Price Index
CSI	Consumer Sentiment Index
F&G	Fear & Greed Index
GDP	Gross Domestic Product
IPG	Industrial Production Growth
IR	Interest Rates
MACD	Moving Average Convergence Divergence
OECD	Organization of Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
OPEX	Extended Organization of Petroleum Exporting Countries
PMI	Producing Managers´ Index
PPI	Producer Price Index
R&D	Research and Development
RSI	Relative Strength Index
SMA	Simple Moving Average
SMA48	Simple Moving Average of 48 Months
SO	Stochastic Oscillator
TFP	Total Factor Productivity
UR	Unemployment Rate
USD	United States Dollar
W%R	Williams Percent Range
YCS	Yield Curve Spread of 10-Year Yield Minus 2-Year Yield

1 Introduction

Commodity trading faces difficulties in relation to business cycles, primarily due to the impact of economic fluctuations on supply and demand dynamics. The challenge lies in accurately forecasting these cycles and their duration, as well as adapting trading strategies accordingly. The analyzation and application of macroeconomic indicators might increase the accuracy of forecasting these cycles.

In the theoretical part, the basics of economic and commodity cycles are evaluated by describing past events and decisive turnaround points for these business cycles. Economic and macroeconomic indicators are analyzed and related to the commodity price cycles of oil, copper and uranium. The relevance of these indicators are then evaluated and ranked according to their impact and importance.

In the practical part, the goal is to apply the previously discussed indicators to various events and cycles in the past to see what indicators might give leading advice to forecast commodity inflection points. The findings then can be used to better anticipate commodity trading and cycle movements and to improve inventory level management. The end result will be a forecast based on the current situation for the covered commodities for the near future.

1.1 Initial situation and problem definition

The global economy is characterized by cyclical patterns of expansion and contraction, known as business cycles. These cycles are a natural part of economic activity and involve fluctuations in economic growth, spendings and investments, employment levels, and overall economic output. Business cycles have an impact on various industries like semiconductor, housing, farming, agriculture and food, steel and construction, and sectors, including the commodity trading markets as oil, gas, coal, copper, aluminum, uranium and so on. Commodity trading involves the buying and selling of raw materials such as oil, copper, uranium, and agricultural products.

During an economic expansion, the demand for commodities tends to increase as industries grow and consumer spending rises. This increase in demand can lead to rising commodity prices. Conversely, during an economic contraction or recession, the demand for commodities may decline, causing prices to fall due to reduced consumption and production levels.

Predicting and understanding these business cycles in commodity trading is crucial for traders, investors, policymakers, and businesses. Accurate forecasts of commodity price movements can lead to more informed decision-making and risk management strategies. Additionally, identifying leading indicators that provide early signals of impending changes in commodity prices can offer a competitive advantage and potentially enhance profitability in commodity trading as well as in inventory management.

1.2 Objective and research question

The central aim of this master thesis is to develop and implement a forecast model based on macroeconomic indicators, to predict business cycle changes before their occurrence to better understand business cycles and predict commodity trading, with a specific focus on the commodities of oil, copper, and uranium.

In the first part, the master thesis covers the theoretical foundation for a better understanding and the boundaries necessary. First, the author shall review the literature and investigate the fundamentals of economic and business cycles. Second, the author should provide an extensive overview of indicator types and commodities. Further, the author should identify and evaluate influencing economic factors of commodities and identify and evaluate the relevant indicators by determining the theoretical implementations for a suitable forecast model. The aim is to identify economical or technical key leading indicators which can provide early signals of business cycle turnaround points in these commodity markets and develop effective forecasting models for commodity price movements.

In the second part the author applies his theoretical findings and his built model to available data from past events and infliction points to gain proof of applicability. Furthermore, the author shall enhance his model by re-evaluating the selected lead indicators for suitability regarding their sensitivities to the selected indicating elements. In addition, cross-dependencies and -influences through the application of an influence matrix should be evaluated and displayed. Finally, by the example of the three selected commodities, the before-developed forecasting model's findings, benefits and limitations shall be displayed, discussed and concluded.

1.3 Research methodology

The research for this thesis is carried out by using a quantitative approach based on (Saunders, Lewis and Thornhill, 2019, 12 ff.). Starting with an extensive literature review to gain comprehensive knowledge and understanding of the business cycle theory and behavior and analyze the principle behind the business cycles of the commodities oil, copper and uranium. Therefore, relevant data on commodity prices, cycles and fluctuations, as well as data on influencing factors is gathered and analyzed. For the literature review of the mentioned commodities the analyzation is divided into long-, medium- and short-term cycles. Commodity price influencing economic factors are analyzed and evaluated for further development and selection of leading indicators for each commodity. For the evaluation, an extensive overview of various economic and technical indicators is conducted and commodity price influencing factors are evaluated. The theoretical findings are then applied in a built model, which ranks each analyzed indicator on its predictive ability. Therefore, the indicators are applied to available price chart data from past events and infliction points to gain proof of applicability. The proposed model enables to evaluate 18 different indicators of which 8 are technical and 10 are economic indicators. Via a correlation matrix the correlation between different indicators will be evaluated to identify highly correlating indicators with leading tendency.

1.4 Structure of the thesis

The thesis starts with the basic concepts and definition of business cycles and the investigation into the patterns and drivers of business cycles. The importance of understanding and predicting business cycles is outlined and refers in this thesis to the commodities of oil, copper, and uranium. It then continues with presenting an overview of business cycles in general, tracing their historical evolution and underlining their crucial role in shaping economic dynamics. The theoretical part and literature research includes the analyzation of business cycles which are divided into long-, medium-, and short-term business cycles. It highlights the importance of understanding and predicting these cycles and explains how they affect investors, policymakers, researchers, and corporations. An introductory insight into the commodity market and commodity trading process is provided. Afterwards, economic cycles in commodity markets of oil, copper and uranium are then evaluated.

The thesis continues with literature and historical events of business cycles in the oil market, to illustrate key insights and findings. The analysis begins with long-term cycles and then moves on to the nuances of medium-term patterns, analyzing the drivers driving oil prices. It then assesses the shorter-term cycles to uncover the immediate forces driving oil price swings. Up next follows the literature and historical analyzation of events which lead to business cycles in the copper market, to illustrate key insights and findings. The thesis continues with long-term cycles and then moves on to the nuances of medium-term patterns, dissecting the influencing factors that steer copper and uranium prices. Subsequently, the shorter-term cycles are evaluated, unraveling the immediate forces that drive copper and uranium price fluctuations.

The author then analyzes macroeconomic indicators, particularly the lagging and leading indicators, which provide invaluable insight into the health and development of economies. Their usage, focusing on their significance in predicting economic trends, is defined and discussed. Diving deeper, the author elaborates on the indicators' applications in commodity trading, providing a context-specific understanding of their utility.

In the second part the author applies his theoretical findings and his built model to available data from past events and reversal points to gain proof of applicability. Furthermore, the author enhances his model by re-evaluating the selected lead indicators for suitability regarding their sensitivities to the selected indicating elements. In addition, cross-dependencies and -influences through the application of an influence matrix should be evaluated and displayed. Finally, by the example of the three selected commodities, the before-developed forecasting model's findings, benefits and limitations shall be displayed, discussed and concluded.

2 Literature review of the business cycle theory and analysis of various indicators

This chapter deals with the basic principles of business cycles in general as well as in commodity trading. It underlines the importance of the understanding and prediction of business cycles and gives an overview of the main commodities, such as oil, copper, and uranium and their business cycles which will be assessed in this thesis. To better anticipate business cycles leading indicators are to be evaluated for each commodity by defining the importance of various indicators and their leading impact. Commonly used leading indicators in macroeconomic analysis, and especially for macroeconomic analysis with relevance for commodities are also evaluated to gain further insights.

2.1 Overview of business cycles

This section gives an overview of business cycles in general, outlines the definition of business cycles in commodities and underlines the importance of understanding and predicting business cycles. At the end, this section gives an overview of the commodity markets of oil, copper, and uranium.

2.1.1 Definition and history of business cycles

Business cycles are recurring patterns of economic expansion, defined by an increase in consumer spending and inflationary behavior, followed by a contraction, defined by a decline in consumer spending and deflationary behavior. The cycles consist of four phases as shown in Figure 1 where the y-axis is measuring the Gross Domestic Product (GDP) or output over time. The GDP measures the value of all finished and produced goods and services within the borders of a nation. This thesis refers to the GDP instead of the Gross National Product (GNP) since it is the most common measure for a country's productivity. The GNP measures the value of all finished and produced goods and services produced by its country's citizens abroad and domestically. The cycle starts with an expansion, followed by a peak, after the peak contraction or recession occurs which is followed by a trough. Since it is a cycle, the trough is again followed by an expansion. This illustration shows a rising trend.

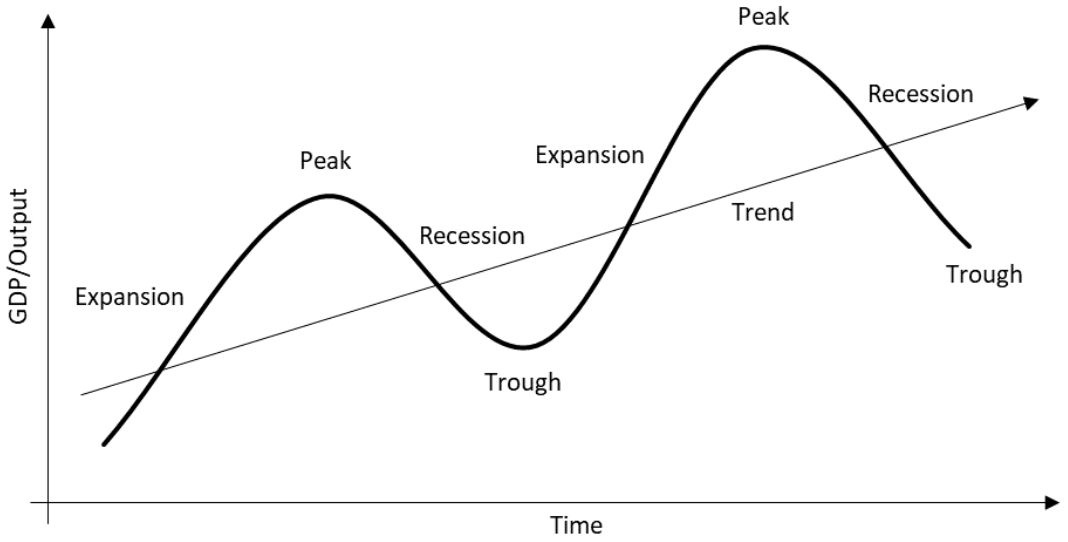

Figure 1: Basic illustration of the four business cycle stages including expansion, peak, recession, and trough, authors creation

The Cycles can be divided into long, medium and short term business cycles. The long term business cycles proposed by (Kondratieff, 1925), refer to long term trends from 40 up to 60 years and are based on technology inventions like the development of the steam engine or the automobile which leads to an economic upswing and expansion of several decades. The medium business cycle, proposed by Simon Kuznets and Clement Juglar refer to cycles with the duration of 15-25, and 7-11 years, respectively. The Kuznets swings are based on construction intensity and infrastructural investments which are relevant for a counties ability to produce, transport and export goods and services and thus shape the economy for a longer period. The Juglar cycle is based on fixed investments such as capital expenditures of companies in fixed capital and assets. An analysis from (Korotayev and Tsirel, 2010, 11 ff.) confirms the presence of Juglar cycles in world GDP dynamics. The short term business cycle was proposed by Joseph Kitchin in 1923 typically occurs within a period of less than two years or 8 quarters and is defined by inventory and employment management. It results from the time lag arising from the requirement to adjust production, inventory- and employment level to the market´s demand (Korotayev and Tsirel, 2010, 12 ff.).

Long term business cycles

Long-term business cycles, also known as Kondratieff waves or super-cycles, refer to extended and cyclical patterns of economic growth and decline that can last for several years or even decades. These cycles include periods of economic growth with rising output, employment, and investment, followed by periods of economic downturn with declining economic activity and investment. Long-term business cycles are influenced by a combination of factors including technological advances, global economic conditions, demographic shifts, and major policy changes (Korotayev and Tsirel, 2010, 4 ff).

The Soviet economist Nikolai Dmitrievich Kondratieff (Kondratieff, 1925) was one of the first to observe and link the economy to its cycles. In his paper “Long waves in economic life,” which was released in 1926, Kondratieff examined and confirmed the existence of business cycles and argued that modern economies fluctuate in cycles of 40 to 60 years. In his paper, he also concluded that capitalist economies are constantly shaped by cycles of expansion and recession. Nikolai Kondratieff believed that is was possible to forecast the tendency of development and future economic growth based on economic, social, and cultural factors which reflect the social wellbeing and output of a country. Kondratieff therefore studied the price level statistics of different economies, such as of the British, US, German and French (Narkus, 2012, pp. 4–5). His used data included prices of output products and raw materials, foreign trade, bank deposits, wages and interest rates as well as other data reflecting changes in supply and demand. In his published article in 1925 he had identified three long term waves, wave number four was then identified by the Austrian economist Joseph A. Schumpeter and the fifth wave was identified by other researches (Wilenius and Casti, 2015, pp. 335–349) Narkus, 2012, pp. 4–5.

The first cycle lasted 50 years from around 1780 to 1830 and is built on the invention of the steam engine and the resulting economic upwind, the second cycle lasted around 50 years from 1830 to 1880 and is based on the progress in the railway and steel industry (Wilenius and Casti, 2015, p. 336). Joseph A. Schumpeter investigated the Kondratieff cycles further and identified the end of the third wave. The third cycle started in the 1880s, reached its peak in the 1920s and ended with the great depression in 1930. This cycle was determined by the electrification of processes and the breakthroughs in the chemical industry. The fourth Kondratieff cycle lasted from 1930 until 1970 and was shaped by the automotive sector as well as the petrochemical sector. The fifth cycle started in the year 1970 and ended in 2010 with the great financial crisis and was dominated by information and communications. (Wilenius and Casti, 2015, p. 340) The fifth wave peaked with the oil embargo of several OPEC members in the 1980s, which caused the oil prices to rise worldwide and resulted in a significant increase in inflation in developed and developing countries. The sixth Kondratieff cycle is currently ongoing, started in 2010 and could last until 2050 to 2060 when considering the average cycle duration of 40 to 50 years, which means, that the peak of this cycle could happen around the year 2030. The listed cycles can be seen in Figure 2 (Wilenius and Casti, 2015, pp. 335–349) (Narkus, 2012, pp. 4–23).

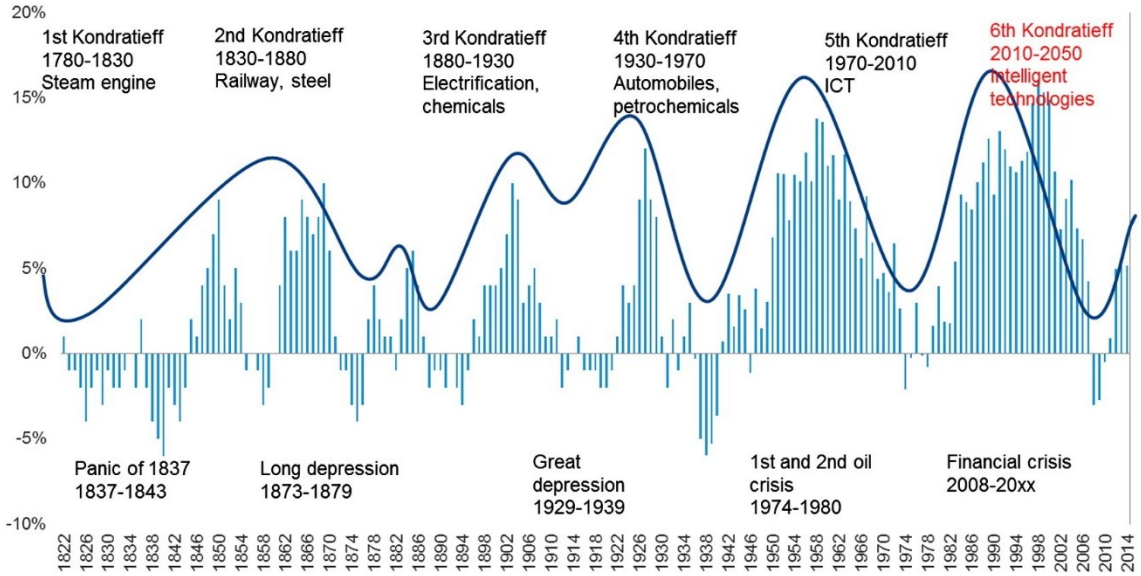

Figure 2: Projected population growth in different regions of the world with comparison to the super-cycles proposed by Kondratieff (Wilenius and Casti, 2015, p. 339)

Speaking of historic long term business cycles, Samuel Benner was a 19th century farmer who published a book in 1875 on how business cycles work and predicting business commodity prices. In his book he identified years of panic, good times, and hard times. In panic years the market panicked and irrationally either bought or sold a stock until its price skyrocketed or strongly crashed. In good times prices were high and it was the best time to sell stocks, shares and assets of all kinds. In hard times Benner recommends buying assets such as stocks, or commodities and holding them until the "boom" years of the good times. The cycles can be seen in Figure 3. Comparing the Kondratieff cycles and the cycles of Samuel Benner, similarities in cyclic behavior can be found (von Thienen, 2023, pp. 3–4) (McMinn, 2018).

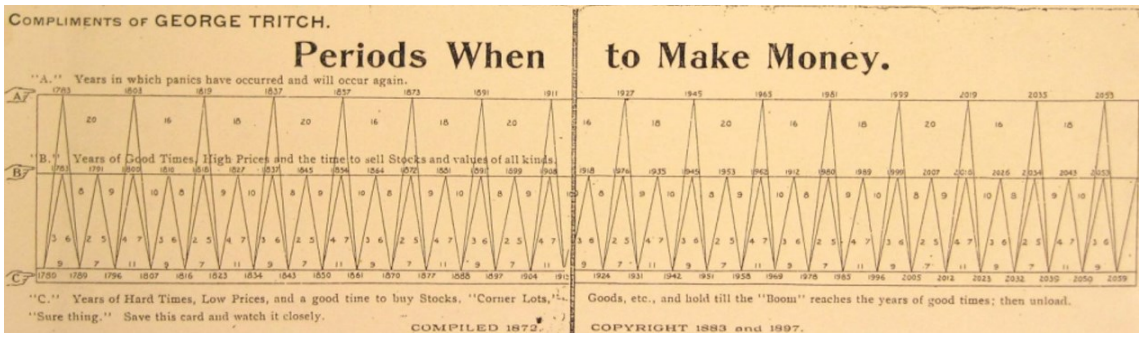

Figure 3: The Benner Cycle from 1780 to 2059, on periods when to make money from 1875 (von Thienen, 2023)

Medium term business cycles

Medium-term business cycles are recurring patterns of economic expansion and contraction with a typical duration of several quarters to a few years. These cycles consist of phases of economic growth, followed by periods of economic slowdown or recession, and are influenced by factors such as monetary policy, consumer behavior, and investment dynamics.

Clement Juglar was one of the first to discover and describe business cycles. According to Juglar, the business cycle, which has a period of between 7 and 11 years, includes investment in fixed capital, and not just employment level changes (Korotayev and Tsirel, 2010, 12). The Kitchin cycles are generated primarily by market information asymmetries, while the Juglar cycle is driven by investment and innovation aspects. In the beginning of Juglar cycles, demand exceeds supply by far and cannot be met by the full employment of fixed capital. As a result new capital assets are created through increasing investments. The declining demand is not noticed immediately and affects output with some time delay. If the growth was achieved through the increase in the employment of fixed capital assets the impact and delay is not so significant. But if the output was achieved through investment in fixed capital, the time delay will be significantly greater. The period of Juglar cycles is significantly longer than that of Kitchin cycles (Korotayev and Tsirel, 2010, 11 ff).

Kuznets swings, also known as demographic or building cycles/swings, were first connected by Kuznets himself with demographic processes, particularly with immigrant inflows/outflows and the resulting changes in construction intensity. The Kuznets swings are cycles with a duration of 15-25 years and refer to investments in construction and infrastructure. However, there are other more general models of Kuznets swings. For example, as (Korotayev and Tsirel, 2010, p. 13) wrote, Forrester proposed linking Kuznets fluctuations to large investments in fixed capital while accounting for Kondratieff waves through the physical and economic links between the capital-consuming and capital-producing sectors. These models provide alternative explanations for the occurrence of Kuznets swings, beyond the original demographic and building factors identified by Kuznets (Korotayev and Tsirel, 2010, p. 12).

Figure 4 shows medium-term cycles for US GDP per capita, unemployment rate and Research and Development (R&D) investment. The dashed line indicates the percentage deviations from the base trend with periodicity from 6 to 200 quarters, or 1,5 to 50 years. The solid line shows the medium-frequency component with periodicity from 32 to 200 quarters, or 8 to 50 years. The difference between the two lines represents the high frequency content of 6 to 32 quarters, or 1,5 to 8 years. The medium-frequency component influences fluctuations between 6 and 200 quarters. Unemployment shows medium-term fluctuations and negatively correlates with the GDP per capita. GDP per capita results by dividing the nation’s GDP by the nation’s total population. On the contrary, medium-term fluctuations in R&D investment correlate procyclical. This shows that traditional business cycle analysis which is limited to 32 quarters, may only capture a fraction of the relationship between GDP and the labor market and may not fully relate these fluctuations to R&D dynamics (Ševčík and Tsasa, 2021, p. 7)

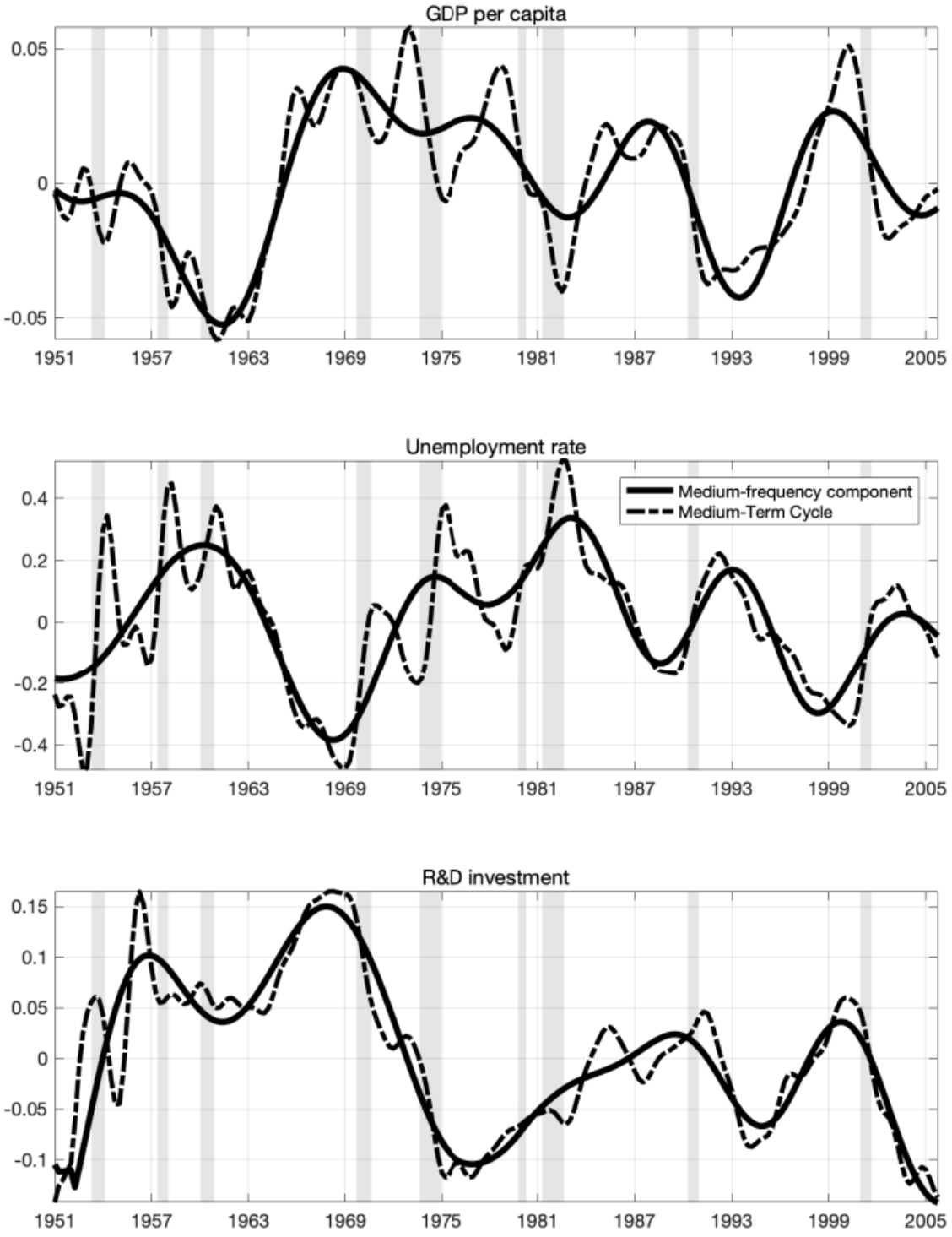

Figure 4: The medium-term cycle. U.S. quarterly data of GDP per capita, unemployment rate, and R&D investments 1951–2006 (Ševčík and Tsasa, 2021, p. 8)

Figure 5 highlights the importance of the medium-frequency component in labor market variables such as labor market tightness, labor productivity, total factor productivity (TFP) vacancies, and wages. (Ševčík and Tsasa, 2021, p. 7). Statistical measures are now being utilized to formally characterize medium-term business cycles for key macro variables. This analysis provides valuable insights into the dynamics of medium-term

business cycles in the U.S. economy. It also demonstrates their importance to understand economic trends

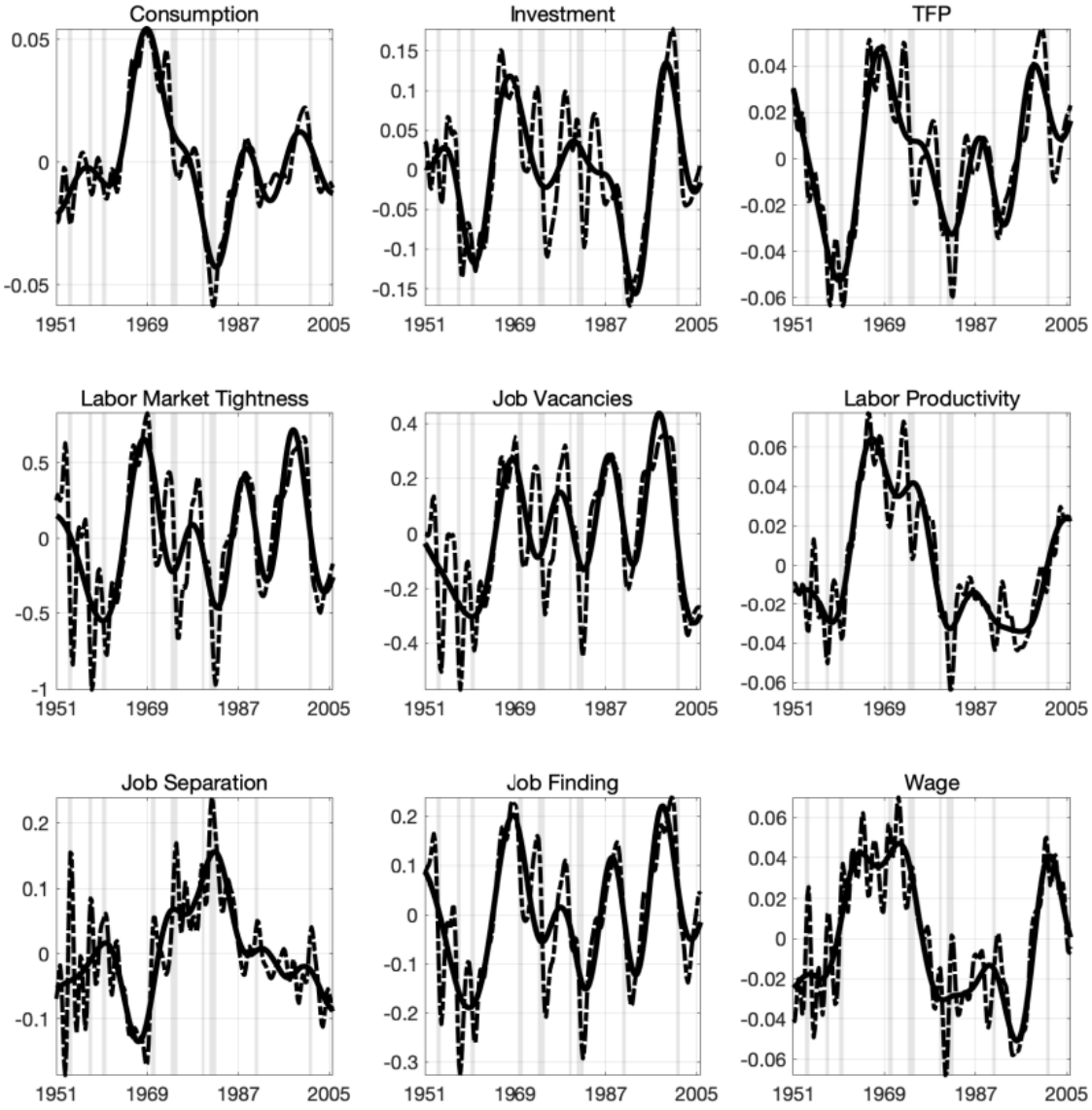

Figure 5: Medium-term variations for key macro variables as consumption, investment, TFP, labor market tightness, job vacancies, labor productivity, job separation, job finding, and wage. U.S. quarterly data: 1951-2006 (Ševčík and Tsasa, 2021, p. 9)

The analysis of medium-term business cycles is a valuable tool for corporations, organizations, policymakers and researchers to gain insights into the underlying dynamics of the economy and to understand business cycle movements. These cycles capture fluctuations over a medium-term timeframe, which often leads to delayed supply and demand shifts which are too late noticed. Understanding these cycles can improve interactions and planning of goods, labor markets, and innovation activities, which can in return result in sustainable growth and stability of businesses and organizations.

Short term business cycles

Short-term business cycles are short fluctuations in economic activity and typically occur within a period of up to two years or 8 quarters and are believed to result from the fluctuations of enterprises' inventories. These cycles follow an increase in consumption and thus also production, which is called economic expansion. The contraction phase is then characterized by decreasing demand and delayed decrease in production. Short-term business cycles are influenced by various factors, including changes in inventory levels, interest rates, and consumer sentiment (Korotayev and Tsirel, 2010, 11 ff). The short term business cycle, proposed by Joseph Kitchin in 1923, was deduced from bank clearing interest rates and commodity prices in US and UK during the period 1890-1922 (David White, 2006). Companies respond to economic upswings and demand increases by increasing output through full capacity use. As a result, the supply increases and the market is flooded with commodities, leading to an imbalance in supply and demand. This excess supply causes demand to decline and prices to drop. The unsold goods then accumulate, and the inventory stocks rise. A perfect example occurred in 2022 as the inventory stock of the semiconductor industry was so full, that the inventory stock had to be sold at a discount. The time required to realize that the supply exceeds demand, and to make the decision to reduce production, is often too long which leads to cycle decrease. These delays in time generate the Kitchin cycles. If the trough is reached and the inventories are sold for discount or otherwise, the cycle begins to increase again (Haltom *et al.*, 2019).

2.1.2 Business cycles in commodities

Commodity markets have experienced seismic changes over the past centuries. Extremely high increases in productivity resulted in a decreasing trend in prices relative to manufactured goods and services.

Industrial commodity prices experienced two large medium-term cycles in the 1970s and 2000s and energy prices are on an upward trend in the long term. The importance of global shocks for commodity prices has increased over time, at the same time the importance of commodity-specific shocks has decreased. Figure 6 A and B show medium-term cycles of 8-10 years and the permanent component, or long-term cycle, which is above 20 years. C and D on the x-axis show the time in months, t=0 refers to the peak of global industrial production before the economy declined. The y-axis shows the change in commodity price relative to the prior year. The grey area represents the range of previous cycles from 1970 to 2021, the red line represents the median cycle and the blue line represents the cycle during the COVID-19 downturn (Baffes and Nagle, 2022, pp. 18–19).

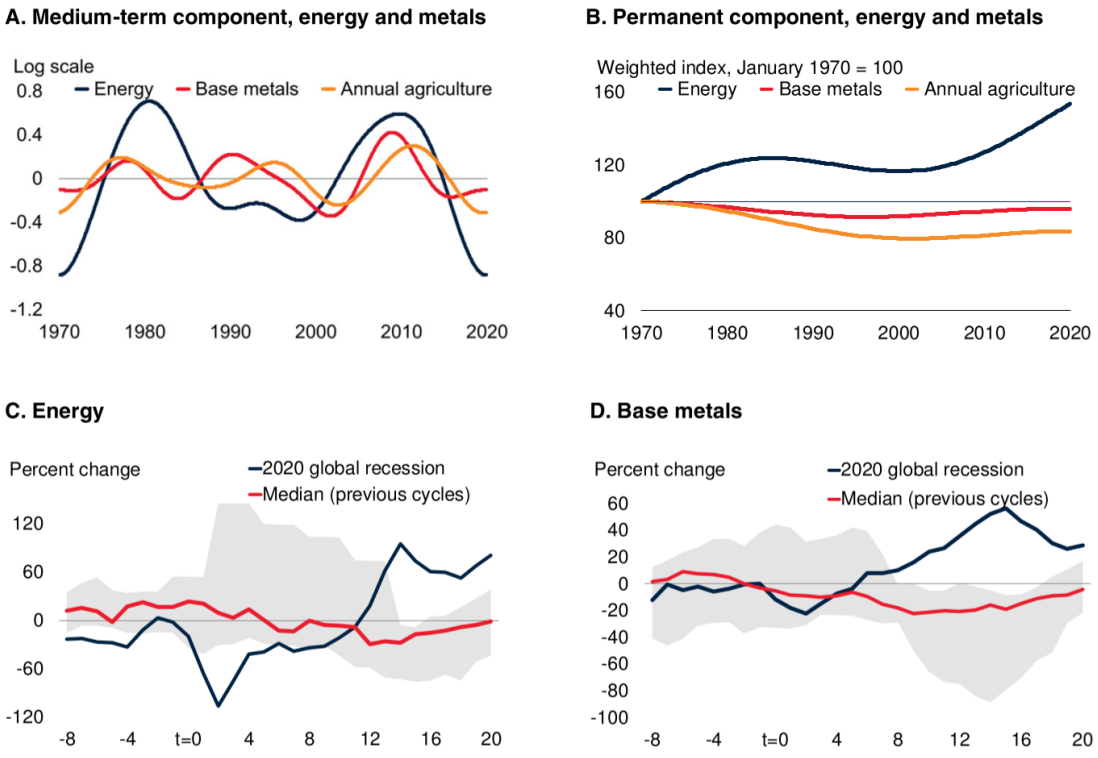

Figure 6: Energy and base metals cycle of medium-term component and permanent component (Baffes and Nagle, 2022, p. 19).

In the short run, commodity prices often behave similarly, considering real terms, or inflation-adjusted terms, energy prices are trending upward in the long run. Main drivers for fluctuations in metal prices have been global demand shocks resulting from wars or e.g. the Great Depression in 1929. High commodity prices in return were often the reason for innovations in other technologies to substitute the current technology. Business cycles are influenced by changes in demand, changes in technology, new innovations, or policies, and all of them contribute to the business cycle movement of commodities. A change in demand influences the price, where a decrease in demand leads to lower prices and an increase in demand leads to higher prices and decreasing affordability of the energy source. An increase in fossil fuel prices also results in the increase of e.g. prices in the agricultural sector since the machinery is powered by fossil fuel. High prices for fossil fuels force the innovation in alternative technology to find new and cheaper ways to generate power or power machinery with alternative feedstock (Baffes and Nagle, 2022, 27 ff).

2.1.3 Importance of understanding and predicting business cycles

Business cycles have a significant impact on organizations and business decisions. Understanding and predicting business cycles is crucial for several reasons. By forecasting economic downturns, organizations, corporations, and businesses can adjust their capital accordingly. By monitoring the cyclicity of the economy and creating projections, businesses can make strategic decisions to prepare for phases of contraction and expansion. These decisions can include adjusting production levels,

managing inventory, or optimizing resource allocation. During expansion businesses can adjust their production and inventory to increasing demand to meet customer needs. Also investments in new projects are often increased, and more employees are hired. During a recession, organizations may lay off workers, cut back on investment, lay off employees, and reduce production. Understanding business cycles allows for more accurate economic forecasting. Tracking leading indicators and analyzing historical patterns supports proper decision making. As a result companies can improve their competitiveness, and chances of success (Milašauskaitė, 2023)(Eriksen, 2015).

2.1.4 Overview of oil, copper, and uranium commodity markets

This thesis deals with the commodities of oil, copper, and uranium which play a critical role in supporting industrial, energy, and technological sectors. Understanding the dynamics of these commodity markets is essential for companies, researchers, investors, and policymakers. This subchapter provides a short overview of commodities and an analysis of the following chapters on oil, copper, and uranium.

Commodities are raw materials used for further processing or use and are traded on spot or futures markets. In spot or physical markets, buyers and sellers exchange physical goods which are then immediately transferred after the transaction is finished. On the futures markets, the raw material is traded in advance with so-called futures, forwards or options. With futures contracts the buyer and seller agree on a predetermined price for a defined quantity on a particular date in the future for delivery. This type of trading is the most common because the buyer can secure the required quantity of goods that he needs for his business in the future at a current price and is not exposed to short-term price fluctuations. Forward contracts are similar to futures but are not standardized and typically negotiated directly between two parties. They offer more flexibility, but risks come with the lack of standardization. Option contracts give the buyer the right but not the obligation to buy or sell a commodity at a specific price. Options are used to profit from price fluctuations and can be used in trading strategies. Commodities are a common way for investors to diversify their portfolios, as the price of commodities tends to correlate negatively to the stock market. Physical gold, for example, is considered a good hedge (investing in an asset with a low price correlation to usual investing) because it is physical and tends to appreciate in times of high inflation.

Oil is one of the most important, well-known and traded commodities in the world. It serves as a primary energy source for various sectors. The oil market follows both short-term and long-term cyclical patterns. Short-term price fluctuations are influenced by geopolitical events, supply disruptions, changes in demand and financial speculation. In addition, the Organization of the Petroleum Exporting Countries (OPEC) plays a crucial role in influencing oil prices through production decisions. Long-term cycles in the oil market are driven by global economic growth, technological advances and changes in energy policies. The price of oil has gone through several significant cycles, with significant price spikes at times of supply shortages or geopolitical tensions. World oil demand is highly dependent on economic expansion and industrial activity.

Copper is an essential metal for use in various industries such as electrical wiring, mechanical engineering, construction and many other fields. The copper market exhibits

cyclical price trends, dynamic interactions between supply and demand, and sensitivity to economic and industrial developments. Copper prices follow cyclical trends and follow both short-term and long-term fluctuations. Economic expansion is shifting industrial activity and global developments are affecting short-term cycles. Investment cycles in construction and infrastructure projects determine the medium-term cycles in the copper market. Demand from growing economies, especially China, has a significant impact on copper prices. In addition, the emergence of new sources of supply and technological innovations can influence medium-term price developments. The main drivers of the copper market are economic growth, industrial expansion and construction activities. The transition to low-carbon technologies and increasing demand for copper in power infrastructure and electric vehicles could lead to further shifts in the copper market in the future.

Uranium is a critical raw material for nuclear power generation, medical and military uses, and is therefore critical to meeting global energy needs as we transition to more sustainable sources. Uranium prices show cyclical behavior with significant price spikes and long-term volatility. Long-term cycles in the uranium market are shaped by factors such as nuclear power capacity expansion, global production and competitive energy commodity prices. The sustainability of uranium as a fuel source and the availability of secondary sources are also affecting market dynamics. Expectations of future uranium prices and time lags in investment and production decisions contribute to price volatility in the uranium market.

2.2 Literature review, analyzation and evaluation of business cycles in oil

The oil industry plays an important role in the global economy, and understanding the dynamics of business cycles in oil is essential for investors, policymakers, researchers, and companies. This chapter aims to explore the long-term, as well as medium-term cycles of oil prices, followed by an examination of the short-term cycles. By analyzing these cycles, insights into the patterns, drivers, and macroeconomic implications of oil price fluctuations are gained.

The global oil market has experienced numerous price booms and busts, as well as supply management and price fixing. Standard Oil, the Interstate Oil Compact Commission (IOCC), and Seven Sisters were the most prominent companies involved in price fixing between 1879 and the 1970s. The organization of petroleum exporting countries (OPEC), which was founded by Iran, Iraq, Saudi Arabia, Kuwait and Venezuela in Iraq in 1960, and OPEC+, which refers to all additional members of Qatar, Indonesia, the United Arab Emirates, Libya, Nigeria, Algeria, Gabon, Angola, Ecuador, Congo and Equatorial Guinea, has been involved in supply management since then (OPEC, 2023). These events had significant macroeconomic implications for both commodity exporters and commodity importers. World crude oil production increased from 1 million barrels per day (mb/d) in 1920 to about 100 mb/d in 2023. Between the 1930s and 1970s, crude oil prices were low and stable, due to the influence of the Seven Sisters international Cartel and the federally administered IOCC in the United States. However, since the rise of OPEC, prices have undergone sharp cycles, as Figure 7 shows, where periods of high

prices have led to the emergence of new producers, for example in the Middle East after World War II and in Alaska, Mexico and the North Sea in the 1970s. After several price increases by OPEC in the early 1970s, there was a global oil price shock in 1973/74. A second price shock occurred in 1979 and 1980 as a result of the Iranian Revolution and the war between Iraq and the Islamic Republic of Iran. The result was a significant drop in global oil production and a sharp rise in prices (Baffes and Nagle, 2022, 31 ff).

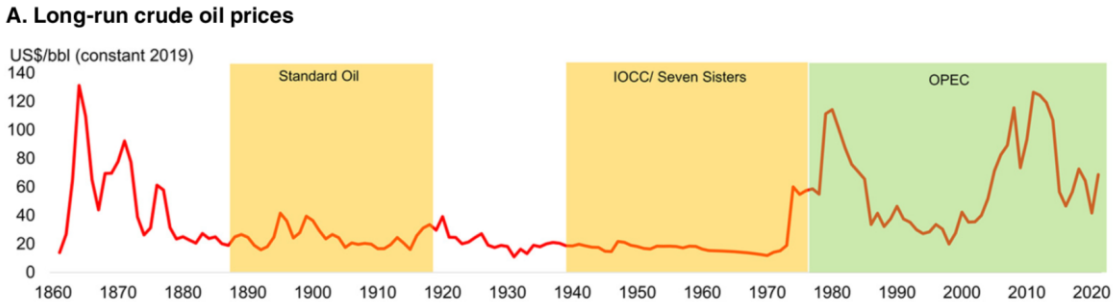

Figure 7: Long-run crude oil prices in USD/bbl and constant 2019 USD per barrel from 1860 to 2021 (Baffes and Nagle, 2022, p. 32)

2.2.1 From long-term cycles to medium-term cycles and influencing factors of oil

Since the beginning of the 20th century five crude oil super cycles can be identified with the underlying trend, shown in Figure 8, reaching its peak in the 1920s, followed by a decline until the 1950s and from then on showing an upward trend till today (Posch, 2017, p. 175).

Figure 8: Trend line of real oil price from 1863 to 2023, in 2021 USD per barrel, authors creation, based on (Nasdaq Data Link 2021)

As the literature states, Kondratieff (Kondratieff, 1925) defines long term business cycles as cyclic swings of over 40 to 60 years (Wilenius and Casti, 2015, pp. 335–349). As shown in Figure 9, five crude oil super cycles can be identified since the start of the recording of crude oil data from (Nasdaq Data Link, 2021). Starting at the beginning of the data recordings, five so called long-term, or super cycles of 40 to 60 years can be identified, with the fifth currently ongoing. The first cycle peaks in the 1870s and reaches its trough around 1890, from where the second cycle starts to expand until it peaks around 1910. The contraction continues and the second cycle reaches its low around 1930 where the cycle started again to expand until the 1950s and again reaching its low

in the 1970s. The fourth super-cycle continued reaching its peak around 1985 followed by the trough in 2000. The fifth and current super-cycle started back in 2000 and continues until today. These fife super-cycles show an average cycle duration of 40 years and thus fulfil the criteria of a super-cycle as defined by (Kondratieff, 1925).

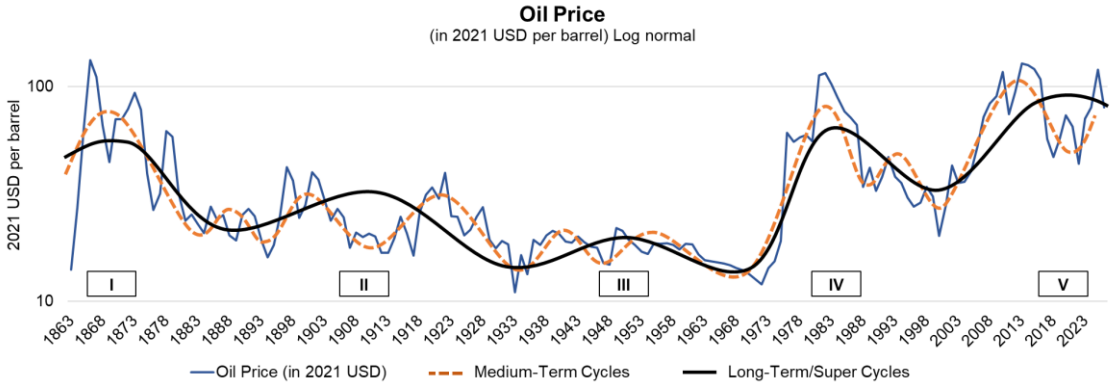

Figure 9: Real oil price in 2021 USD per barrel from 1863 to 2023, authors creation, based on (Nasdaq Data Link, 2021)

The medium term business cycle was proposed by Simon Kuznets and Clement Juglar. The Kuznets cycle with a duration of 15-25 years refer to investments in construction and infrastructure. The Juglar swings with a duration of 7-11 years are based on fixed investments such as capital expenditures of companies in fixed capital and assets (Korotayev and Tsirel, 2010, 11 ff). Figure 9, starting again in the 1870s with the first peak in 1870 and the following trough around 1880. From there on, the expansion begins with the second cycle until the peak is reached around 1888 followed by the decrease until the turning point in 1895 is reached. The third cycle begins in 1895 and ends around 1910 after 15 years and the fourth cycle starts with the year 1910 and lasts until 1935. In the 35 years between the year 1935 and 1970 two more cycles can be detected before the seventh cycle starts to expand around 1970 reaching its peak in 1983 and decreasing to its turning point around 1988. The eighth cycle lasted from 1988 to 2000. Around 2000 the ninth cycle starts, reaching its peak around 2013 and again followed by the decrease and the turning point around 2020. From 2020 on the tenth and current cycle is ongoing. These 10 medium-term cycles show an average cycle duration of 16 years and thus fulfil the criteria of a medium-term-cycle as defined by Kuznets (Korotayev and Tsirel, 2010).

According to the Worldbank report (Kabundi, Vasishtha and Zahid, 2022, p. 188) oil prices have experienced 11 troughs since the 1970, which are primarily associated with global recessions, production agreements and decisions made by the OPEC.

Fluctuations and cycles in investments and capital expenditures

As Kuznets and Juglar propose, the cyclic behavior results in changes in investments in infrastructure and capital expenditures of companies. Figure 10 describes the investments in oil and gas as a share of world GDP (International Monetary Fund, 2022). Additionally, Figure 10 shows the fourth and fifth long-term cycle of the oil price, which was evaluated in Figure 9. While low oil prices lead to fewer investments in exploration and production, higher oil prices lead to more investments. Figure 10 shows that in the year 1978 the price increased sharply. With a time delay of two to five years, one can

see the rise in investments and the peak in 1982, two years after oil hit its highest price. A similar pattern can be seen from 2002 on as the oil price started to increase gradually until 2008. The investments in the oil and gas industry increased, again with a time delay. During the shale revolution, which started around 2012 in the USA, capital expenditures in exploration and development peaked at 0,9 % of global GDP in 2014. Since then, the share of investments in oil and gas upstream declined to 0,5 % of global GDP in 2021 (International Monetary Fund, 2022).

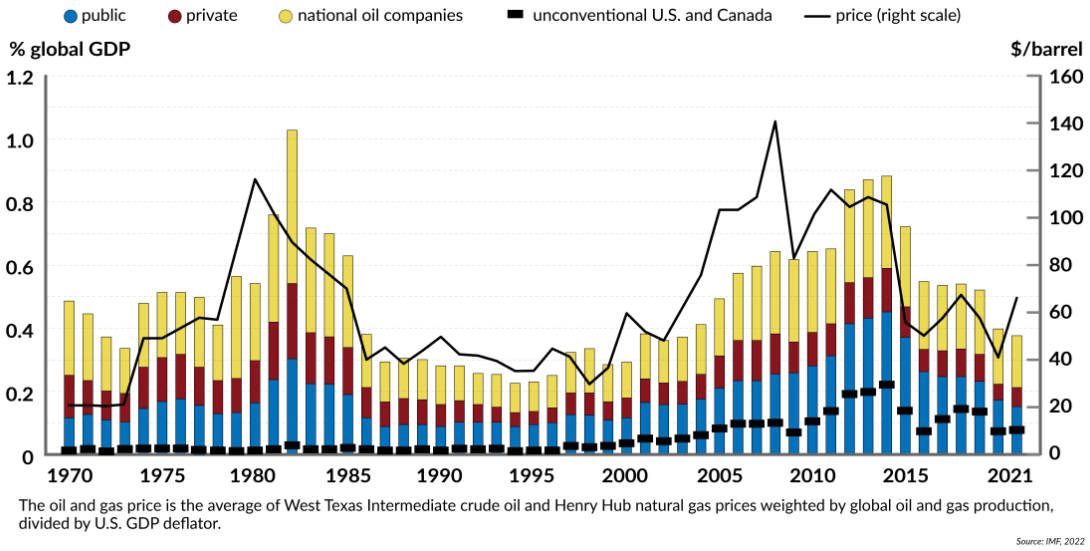

Figure 10: Oil and gas investment as a share of world GDP and USD per barrel, from 1970 to 2021 (Nakhle, 2022)

The oil and gas industry has experienced a cyclical reversal that has disproportionately affected publicly traded companies, leading to a decline in oil and gas investment, especially in Africa and America as opposed to Russia and the Middle East. In the oil and gas industry swings in investments and capital expenditures (CAPEX) are not unusual and the analysis from 1970 to 2021 shows that the main driver for capital expenditures is the oil price. When oil and gas prices increase by 10 percent, global investments in the sector also rises by 3 % in the same year and by 5 % cumulatively after two years. Due to a broader range of factors influencing their investment decisions, national oil companies tend to exhibit less reactivity. Over the past decade, fossil fuel investments have shown a typical boom-bust cycle. Nonetheless, the 40 percent decline in oil and gas prices between 2014 and 2016 from USD 120 per parrel to USD 70 per barrel, followed by a partial recovery, led to a deeper than expected 40 percent decrease in capital expenditure between 2014 and 2019 (International Monetary Fund, 2022).

A peer group analyzation from (Thunder Said Energy, 2022) consisting of ExxonMobil, Chevron, BP, Shell, and TOTAL, represents about 10% of the world's oil production. They increased their exploration spending fourfold, from USD 5 bn annually in 1995-2005 to an average of USD 20 bn annually during the peak of the 30-year oil and gas cycle in 2010-2015. The exploration spend per barrel of oil equivalent (boe) rose from USD 1 to USD 4 over this period but has since declined back to USD 1/boe, or roughly USD 1 billion per company per year in 2022, Figure 11. Historically, the industry needed to spend an average of USD 2.5/boe on exploration from 2005-2019 to maintain organic

production at a steady level. Under-investment could lead to a prolonged energy shortage, especially if lower-carbon gas should substitute coal as part of the energy transition towards net zero emissions. The pressing issue of sustained gas shortages in Europe raises questions about whether exploration spending in the 2020s and 2030s will resemble that of the 2000s and 2010s (Thunder Said Energy, 2022).

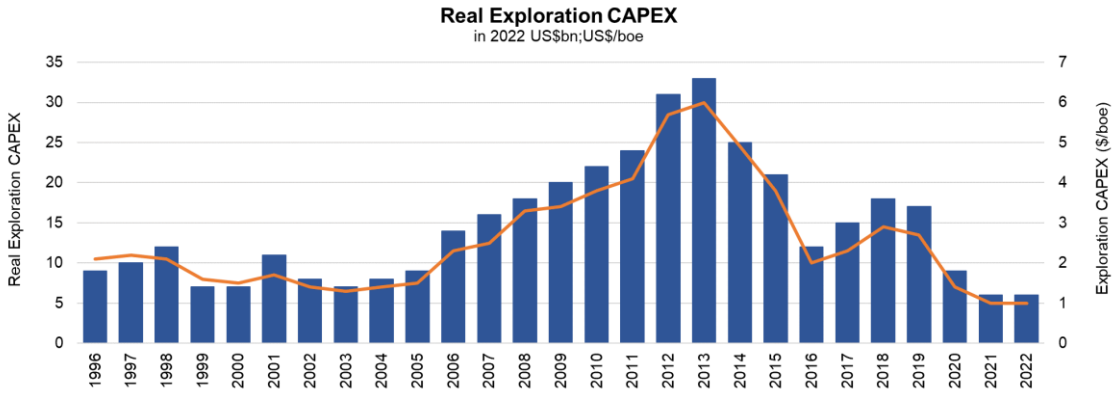

Figure 11: Real Exploration CAPEX from 1996 to 2022 in billion USD and USD/boe, authors creation, based on (Thunder Said Energy, 2022).

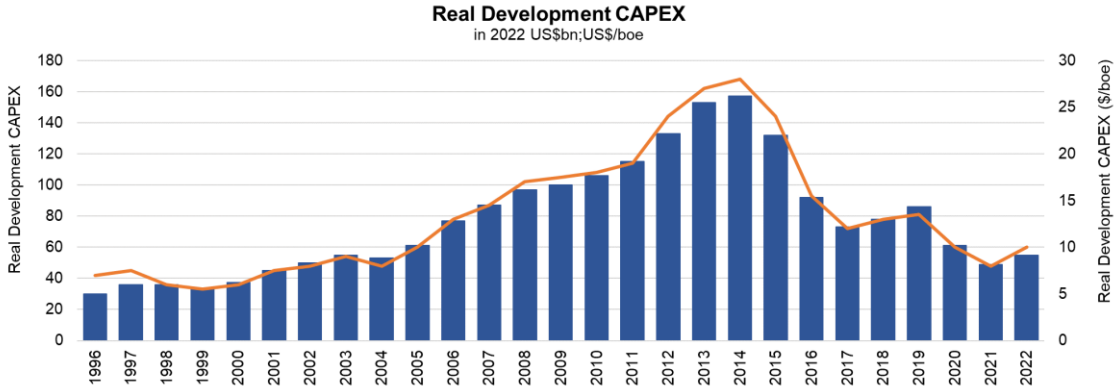

Figure 12: Real Development CAPEX from 1996 to 2022 in billion USD and USD/boe, authors creation, based on (Thunder Said Energy, 2022).

The data provided by (Ahmadi, Manera and Sadeghzadeh, 2019b) are presented in the form of an unbalanced panel of US oil and gas companies for the period 1974 to 2018. The following annual variables are included and data: short-term assets, total assets, long-term debt, short-term liabilities, depreciation and amortization, market value of equity, capital expenditure and income before extraordinary items. Capital expenditure on property, plant, and equipment serves as a proxy for firm investment (Ahmadi, Manera and Sadeghzadeh, 2019b, p. 4). Figure 13 displays the annual mean of the investment capital ratio for all firms in relation to the volatilities of demand and supply shocks. The observed patterns indicate a stronger negative correlation between the investment measure and the volatility of the demand shock, particularly after the year 2000. The correlation coefficient between the mean investment capital ratio and demand shock volatility is -0.46, while the correlation coefficient with supply shock volatility is 0.27 (Ahmadi, Manera and Sadeghzadeh, 2019b, p. 4). This suggests that demand shocks have a more significant impact on the investment capital ratio of firms than supply shocks. When the volatility of demand shocks rises, the investment capital ratio tends to

decline, indicating a more cautious stance towards investment and vice versa when the volatility of supply shocks increases, the investment capital ratio tends to rise, reflecting a more optimistic investment approach.

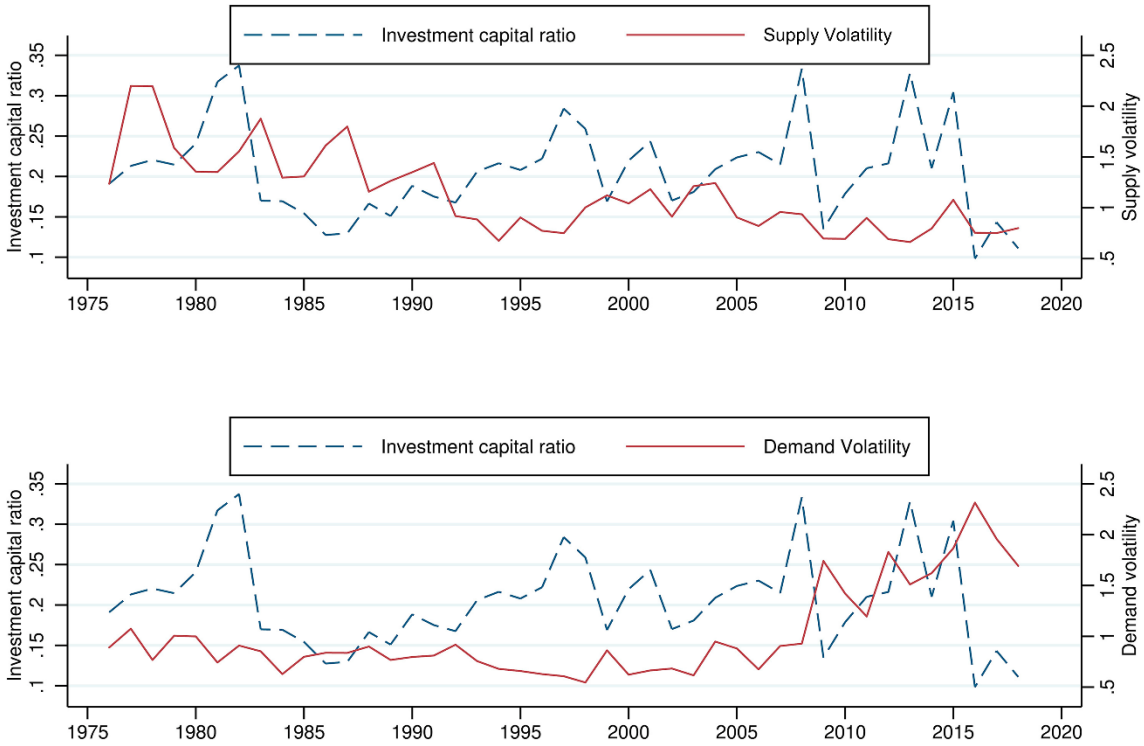

Figure 13: Firm investment capital ratio versus annualized supply shock and demand shock volatilities (Ahmadi, Manera and Sadeghzadeh, 2019b).

2.2.2 Short-term cycles and influencing factors of oil

The short term business cycle, proposed by Joseph Kitchin in 1923 (Korotayev and Tsirel, 2010, 11 ff). typically occurs within a period of less than two years or 8 quarters and is believed to result from the fluctuations of enterprises' inventories. The short-term movement of oil prices is influenced by a combination of factors. Supply and demand imbalances, driven by changes in global oil supply and demand, can lead to direct price fluctuations. Decisions made by major oil-producing nations to adjust production levels, such as OPEC and non-OPEC members, can quickly impact the market, causing shifts in prices. Geopolitical events and conflicts in oil-producing regions create uncertainty and can disrupt supply, resulting in short-term price volatility. Additionally, changes in crude oil inventories serve as indicators of supply and demand dynamics, influencing price movements. Currency fluctuations, economic data and indicators, market speculation, market sentiment, and energy policies also play valuable roles in shaping short-term oil prices. These factors make short-term oil price movement prediction challenging. Figure 14 shows the short-term cycles of the monthly oil price from 1995 to today with an average cycle duration of around 1,8 years.

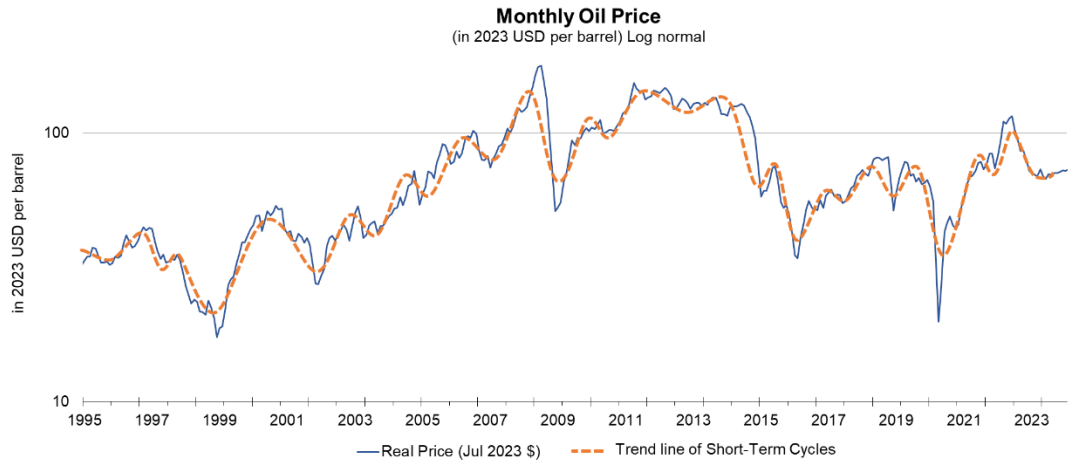

Figure 14: Short-term cycles of monthly oil price in 2023 USD per barrel, from 1995 to 2023, authors creation, based on (World Bank, 2023)

As it is believed, the cyclic behavior results from the change in inventory. Figure 15 shows the change in US crude oil inventories and its 3 month moving average since 2008. Crude oil inventory changes are influenced by many different factors, including production levels, global demand, production decisions by OPEC and non-OPEC members, refining activity, geopolitical events and supply disruptions, imports and exports, market speculation and sentiment, and seasonal factors, as well as government policies and regulations. Inventory levels are directly affected by fluctuations in production, demand and supply disruptions, while decisions by major oil-producing nations can affect global supply dynamics. In addition, processing activities and trade patterns can lead to changes in stock levels. Seasonal fluctuations in demand and changing market sentiment also play a role. In addition, government actions and regulations may further affect the balance between supply and demand in oil markets (Energy Information Administration, 2022). As

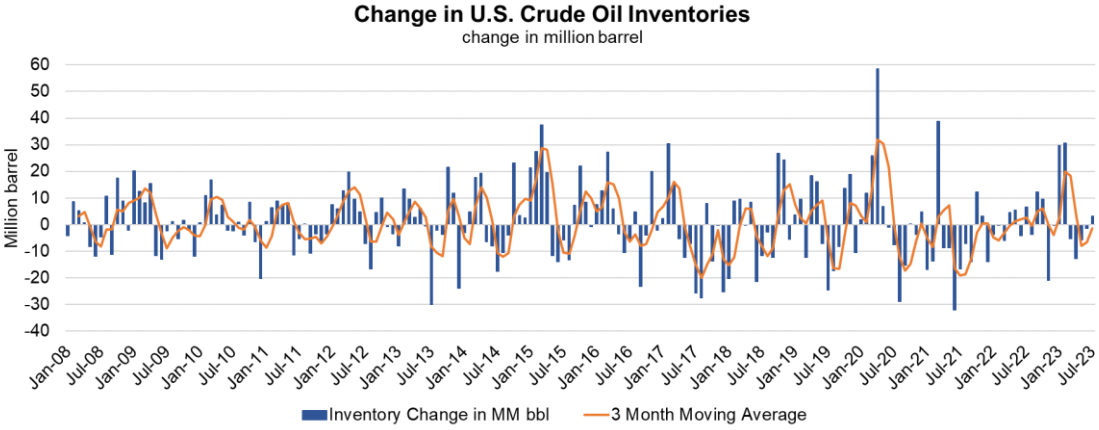

Figure 15: Change in U.S. crude oil inventories in million barrel, from 2008 to 2023, authors creation, based on (Investing.com, 2023)

The change in US crude oil inventories has a substantial impact on global oil prices and serves as a key indicator of market dynamics. When inventories rise, it indicates an oversupply of oil relative to demand, potentially leading to lower prices due to oversupply in the market. On the contrary, decreasing inventories indicate higher demand than

supply, leading to increasing prices. Fluctuations in crude oil inventories influence market sentiment and trigger price volatility. Moreover, the decisions made by major oil-producing nations, particularly OPEC and non-OPEC members, often rely on inventory levels. When inventories are high and prices are falling, organizations may reduce the production to support prices and vice versa (Obstfeld, Milesi-Ferretti and Arezki, 2016).

(Ahmadi, Manera and Sadeghzadeh, 2019a, p. 2) conclude, as Figure 16 displays the historical breakdown of real oil price changes influenced by significant structural shocks. Over time, oil price dynamics have been primarily shaped by a combination of aggregate demand and speculative shocks, which have had a more substantial impact compared to oil supply shocks. Consequently, investors tend to respond more significantly to shocks originating from the demand side of the oil market when making decisions regarding irreversible investments (Ahmadi, Manera and Sadeghzadeh, 2019a, p. 2).

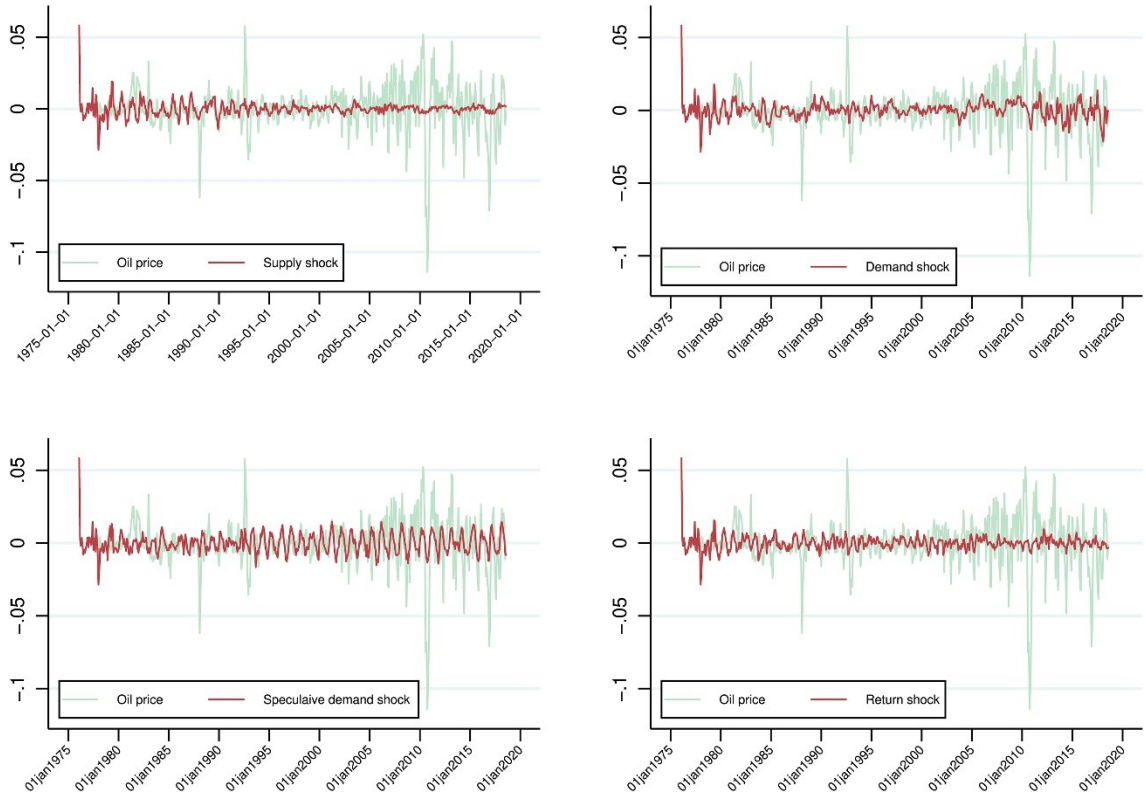

Figure 16: Historical decomposition of real oil price change from 1975 to 2020 (Ahmadi, Manera and Sadeghzadeh, 2019b)

This chapter explored the long, super, and medium-term cycles of oil prices and their macroeconomic implications. The oil industry's significant role in the global economy makes understanding these business cycles crucial for policymakers, investors, companies, and researchers. Historical data shows that oil price dynamics are influenced by aggregate demand and speculative shocks, which have a more significant impact than oil supply shocks. Notable entities like OPEC and non-OPEC members have played roles in supply management and price-fixing. The long-term cycles of oil prices have seen booms and busts, while medium-term cycles have been driven by investments and capital expenditures in response to price fluctuations. Understanding these cycles and their influencing factors is essential for better decision-making in the volatile oil market.

2.3 Literature review, analyzation and evaluation of business cycles in copper

The copper industry plays an important role in the global economy, and understanding the dynamics of business cycles in copper is essential for investors, policymakers, researchers, and companies. This chapter aims to explore the long-term, as well as medium-term cycles of copper prices, followed by an examination of the short-term cycles. By analyzing these cycles, we gain insights into the patterns, drivers, and macroeconomic implications of copper price fluctuations.

Since the 1970 the copper price has experienced eight troughs which have been associated with technical innovations, global recessions or slowdowns, shifts in demand and the emergence of new substitute products. The costs of copper production were reduced significantly in the 1980s and 1990s due to technical innovations. The responsible breakthrough was the development of a new extraction method, where copper could be extracted using a solvent instead of mining. The global recession around 2000, as well as the global recessions of 1982, 1992, and 2020 led to sinking copper prices as a result of shrinking demand. From 2011 to 2015, copper prices witnessed a significant decrease, breaking a decade of relatively stagnant mine production. This decline was largely influenced by the discovery of new supply sources and the implementation of innovative technologies that lowered processing costs. Notably, mine supply experienced robust growth during this period, particularly in key countries like the Democratic Republic of Congo, Kazakhstan, Peru, and Zambia (Baffes and Nagle, 2022, p. 193). The emergence of these new sources played a pivotal role in driving the surge in copper production, subsequently contributing to the overall reduction in copper prices during the mentioned timeframe.

Since the beginning of the 1800s four major periods of industrialization have driven the copper demand. In the late 1700s, as the industrial revolution began in the United Kingdom, the copper demand strongly increased Figure 17. The United States´ industrial revolution started after the Civil War in late 1800s followed by the expansion of western Europe and Japan after World War II in the mid-1900s. Since the 1990s the industrial expansion of China began increasing the demand in Copper further (Baffes and Nagle, 2022, p. 70)

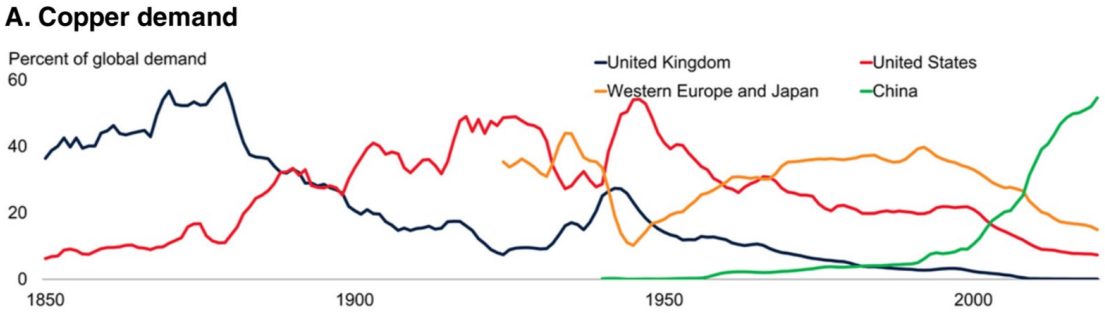

Figure 17: Copper demand in percent of global demand, from 1850 to 2020, for United Kingdom, United Stated, Western Europe and Japan, and China (Baffes and Nagle, 2022, p. 70)

Copper prices show a cyclical pattern over time, characterized by significant fluctuations. Studies have claimed that copper prices show long-term cyclic behavior, although this is questionable. Even though events in mineral commodity markets may repeat in the same order, regularity is far away, and it is not very likely that these cycles reoccur at same intensity or intervals. Copper is one of the most widely used metals, playing a critical role in many industries, including electrical wiring, machinery manufacturing, and building construction (Tapia, Coulton and Saydam, 2020, p. 1). In the past decades, global copper prices have experienced strong fluctuations with general characteristics of extreme upward and downward movements. As (Tapia, Coulton and Saydam, 2020) concludes, copper price does not follow a long-term cyclical behavior, rather exhibiting patterns of chaotic time-related systems. The supply and demand situation ultimately results in price fluctuation, influencing the fundamental values of nonferrous metals. The cyclic behavior of copper prices has implications for industries reliant on copper, such as construction and manufacturing, as well as for investors and policymakers monitoring commodity markets. The transition away from fossil fuels to low-carbon technologies will cause shifts in the demand and supply for commodities. The main uses of copper today are for construction, electric power infrastructure, industrial machinery, transportation, and various consumer goods. The result could lead to major macroeconomic consequences.

2.3.1 From long-term cycles to medium-term cycles and influencing factors of copper

Since the 1900s the underlying trend for copper, shown in Figure 18, reached its first peak at the beginning of the 1900s, followed by the trough in the 1930s. The next peak appeared around 1965, experienced another trough around 1990 before starting to expand again in an upward trend which lasts till today. The figure also shows the long term cyclic trend, proposed by (Kondratieff, 1925). From 1900 through 1935 a half cycle can be determined, between 1935 and 1995 a full cycle of 60 years can be seen and from 1995 until now, a second half cycles with a duration of almost 30 years is ongoing.

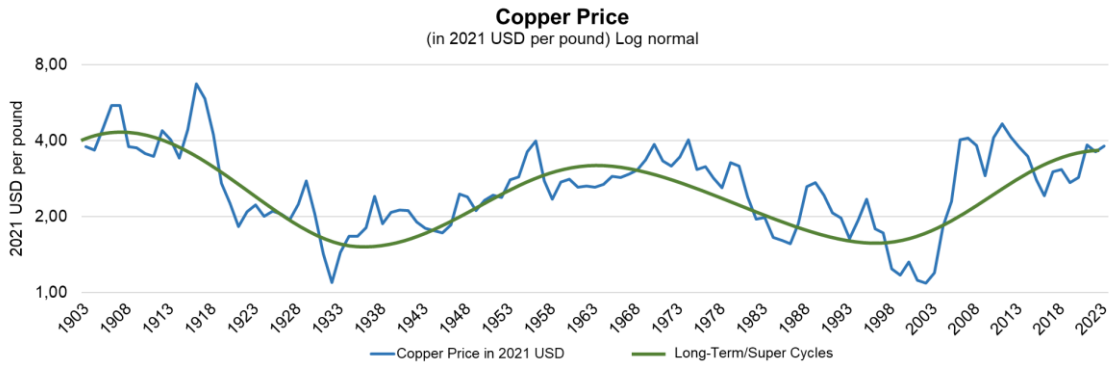

Figure 18: Copper price in 2021 USD per pound, from 1903 to 2023, authors creation, based on (USGS, 2018)

The medium business cycle by Kuznets and Juglar with a duration of 15-25 and 7-11 years refer to investments in construction, and infrastructure and are based on fixed investments such as capital expenditures, respectively (Korotayev and Tsirel, 2010, 12 ff). Supply and demand also plays a critical role in the price fluctuations of copper, and

considering the low price elasticity, which means that the demand is not very responsive to changes in its price, even minor shocks in the supply and demand balance can lead to high volatility and extreme price spikes. The demand side can be influenced by strong growing economies like China and other emerging countries, which boosts the price of copper due to its usage as pivotal input in manufacturing (Su *et al.*, 2020, p. 2). Figure 19 plots monthly realized copper volatility computed as the sum of squared daily returns on copper futures. High peaks of volatility can be seen in 1996, 2006, and during the great financial crisis in the year 2008. Gray areas mark contracting periods of the Chinese economy in its business cycle (Díaz, Hansen and Cabrera, 2021, p. 2). (Díaz, Hansen and Cabrera, 2021, p. 1) concluded variables which can be used to forecast copper volatility. These variables are related to economic fundamentals such as excess demand of copper, or oil, gold, and commodity currencies and the returns on the S&P500 index and could be considered as drivers for cyclic behavior.

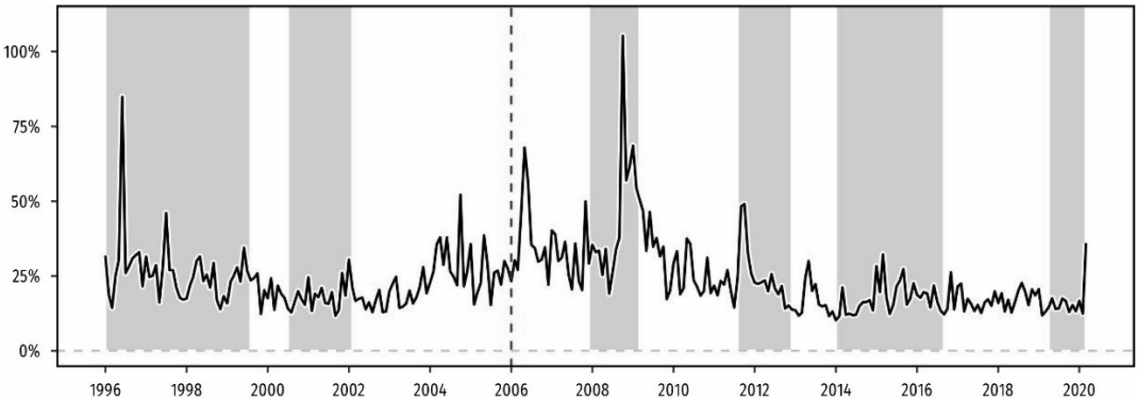

Figure 19: Realized copper volatility, from 1996 to 2020, grey areas mark economic recessions (Díaz, Hansen and Cabrera, 2021)

The supply perspective associates copper supply shocks, which lead to an increase in price, with the primary drivers of low inventory, labor disputes, and political rumors. Additionally, the US-dollar has played a contributing role regarding volatility since the international copper price is usually denominated in it (Su *et al.*, 2020, p. 6). Figure 20 shows 8 medium-term cycles starting from the 1900s with an average duration of 13 years, which follow the proposed duration of Kuznets and Juglar (Korotayev and Tsirel, 2010, 11 ff).

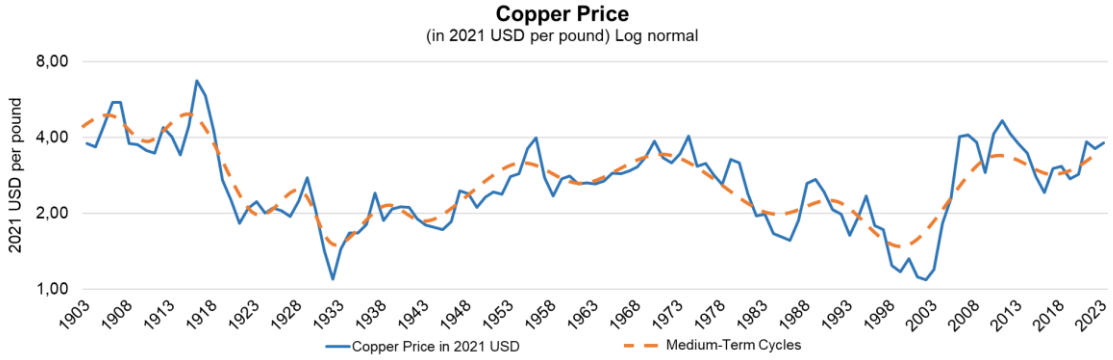

Figure 20: Real copper price in 2021 USD per pound, from 1903 to 2023, authors creation, based on (World Bank, 2023)

Fluctuations and Cycles in Investments and Capital Expenditures

As Kuznets and Juglar proposed, the cyclic behavior results in changes in investments in infrastructure and capital expenditures of companies. Figure 21Figure 20 shows the capital expenditures in copper mining of the top ten producing companies. Fluctuations in investments are influenced by different factors such as supply and demand dynamics, geopolitical events, or global economic conditions. Economic cycles can influence the demand which influences the price of copper and thus, influencing the capital expenditures in the exploration and extraction of copper. In 2012 the investments in copper mining reached a high which was followed by a decline of 70% in the following four years due to lower copper prices. Since the low in 2016 the investments in copper mining increases slowly but gradually.

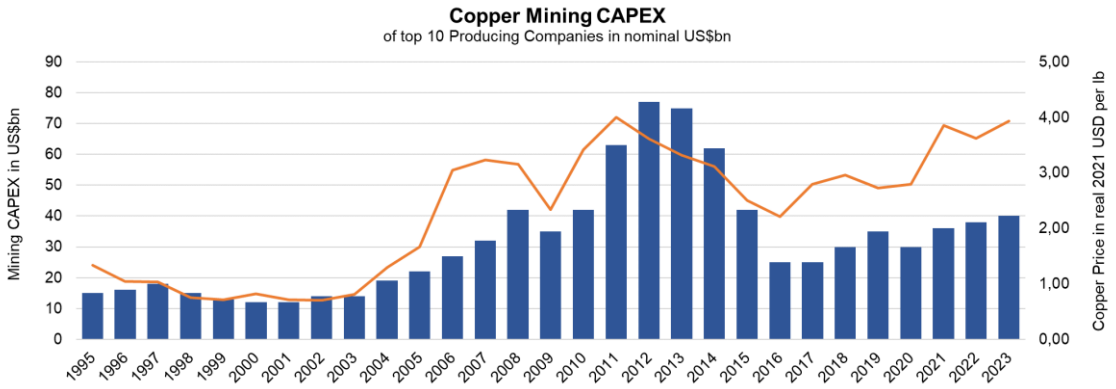

Figure 21: Copper mining capital expenditures of top 10 producing companies, in billion USD, from 1995 to 2023, authors creation, based on (BofA, 2023)

2.3.2 Short-term cycles and influencing factors of copper

Real copper prices declined in the 1900s due to high volatility and reached their bottom in 2001. The booms and busts in copper prices cycles occurred during major periods of industrialization which drove global demand for many metals. Since 2005 two major geopolitical events have spiked high losses in the copper price, Figure 22. The first one occurred during the financial crisis in 2008, followed by a steep recovery, and the second hit was due to Covid-19 shutdowns and the following rebound in 2021. Copper will further benefit from the geopolitical drive towards clean energy transition in solar panels, wind turbines, electric vehicles, grid connections and battery charging infrastructure.

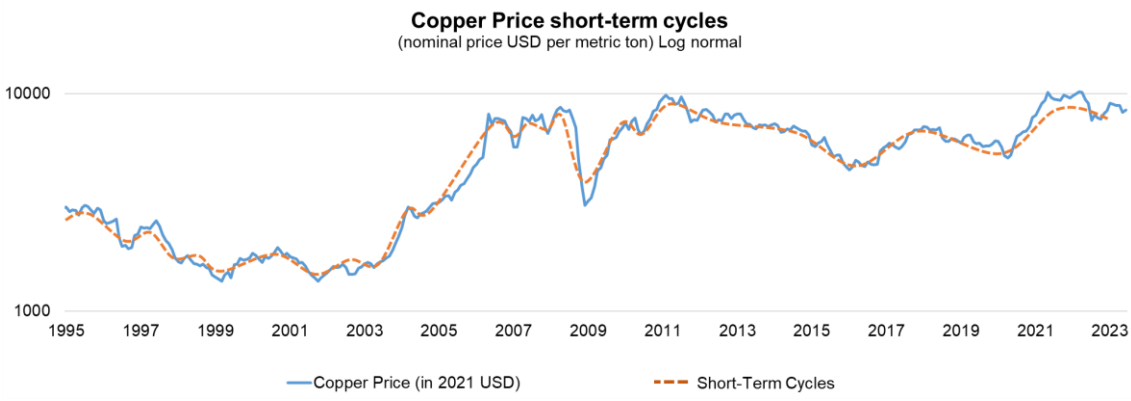

Figure 22: Copper price short-term cycles, nominal price in USD per metric ton, Log normal, from 1995 to 2023, authors creation, based on (World Bank, 2023)

As it is believed, the cyclic behavior results from the change in inventory. Figure 23 shows the change in total copper inventories and its 3 month moving average since May 2001. Changes in copper inventories are influenced by many different factors, including production levels, global demand, geopolitical events and supply disruptions, imports and exports, market speculation and sentiment, seasonal factors, and government policies and regulations. Inventory levels are directly affected by fluctuations in demand and supply disruptions caused by expanding or contracting economies. Seasonal fluctuations in demand and changing market sentiment also play a role.

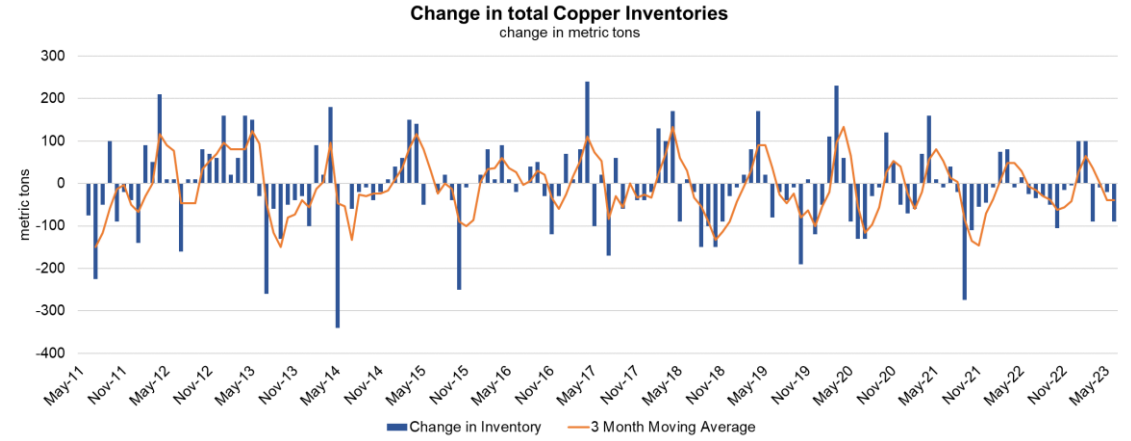

Figure 23: Change in total copper inventories in metric tons, from 2011 to 2023, authors creation, based on (Chiat, 2022)

By analyzing the total copper inventories shown in Figure 24, seasonal fluctuations can be recognized. During summer-time, on the northern hemisphere, the copper inventory rises, declines in fall and reaches its low in winter.

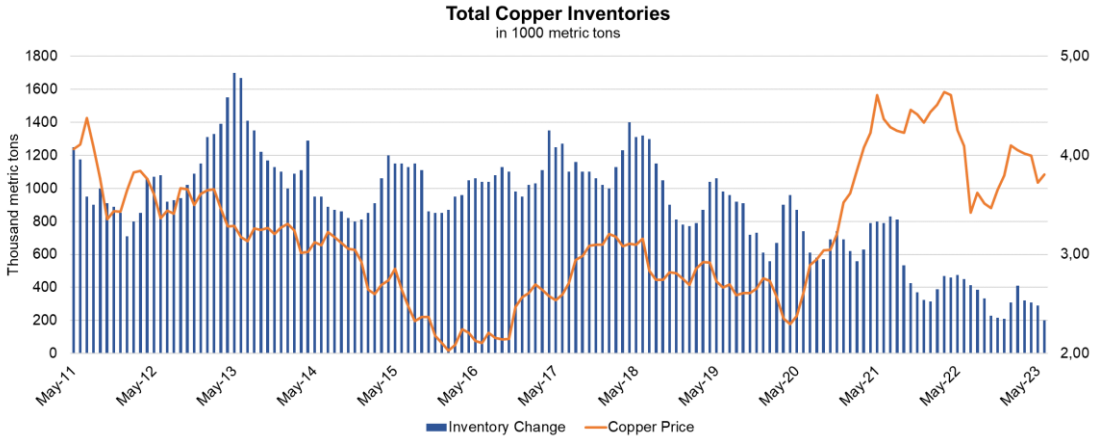

Figure 24: Total copper inventories in thousand metric tons, from 2011 to 2023, authors creation, based on (Chiat, 2022)

In recent years, there have been extreme challenges in copper discovery and extraction, resulting in a trend towards undersupply. The ending of the super cycle around 2000 increased these problems with mining companies decreasing investments in exploration and mining. The main reasons are the stricter environmental regulations for new mines, or the trauma after the excesses of the super cycle. Another reason is the declining copper grade in mines. 150 years ago, copper grades in open pits were around 5%, now they are around 1%. Chilean copper mines had to double their investments in copper mines to maintain the same production level. All these factors resulted in production delays and little discovery of new mines. Historically the copper demand was tied to industrial activity. In recent years, the copper demand increased over time and due to rising electrification of the economies. The energy transition has the potential to change the copper deficit as it overlays new demand. Forecasts show that the required amount of copper between 2022 and 2050 will exceed all the copper consumed back to 1900, Figure 25 (Flitton, 2023). This could change the historical balance in copper and create an indefinite deficit. In combination with the already low and decreasing inventory the deficit could lead to new capital expenditure investments in exploration and mining. To close the deficit, mining companies would have to invest about USD 150 billion. However, current prices make the resource uneconomic to extract. A copper price of USD 13,000 per ton (USD 6,8 per pound) by 2025 could ensure the economics of new projects. Copper plays an essential role in economic activity due to its unique conductive properties. No other metal can serve better as a conductor of electricity at the prevailing cost levels (Flitton, 2023).

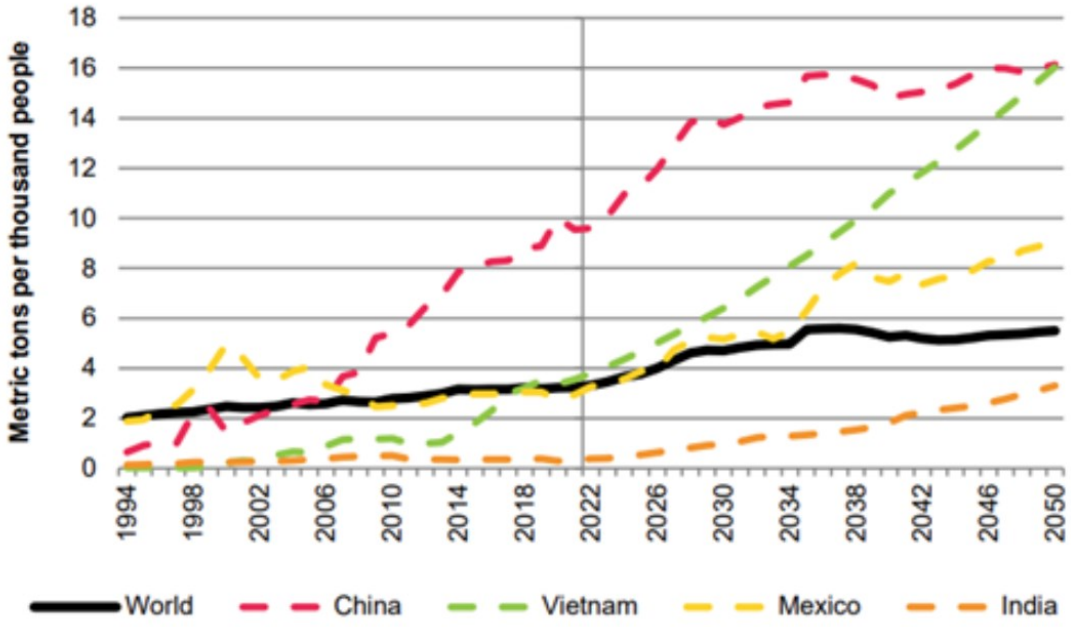

Figure 25: Refined copper consumption per Capita, for world, China, Vietnam, Mexico, and India (Flitton, 2023)

2.4 Literature review, analyzation and evaluation of business cycles in uranium

The uranium industry plays an important role in the global economy, and understanding the dynamics of business cycles in uranium is essential for investors, policymakers, researchers, and companies. This chapter aims to explore the long-term, as well as medium-term cycles of uranium prices, followed by an examination of the short-term cycles. By analyzing these cycles, we gain insights into the patterns, drivers, and macroeconomic implications of uranium price fluctuations.

Empirical studies have found that uranium prices follow cyclical behavior similar to other energy commodities, but the price peaks are much larger compared to other commodities. Additionally, the uranium market is subject to supply and demand shocks, which can lead to extreme price volatility. The sustainability of uranium as a fuel source is also an important topic, as the demand for freshly mined uranium experiences further pressure due to the fact that various secondary supplies, from stockpiles and down-blended nuclear weapons, are likely to decline as a share of world supply (Rooney, Nuttall and Kazantzis, 2015, p. 1) (Arnaut, 2022) .

As it can be seen in Figure 26 the price spikes and the long term volatility of the uranium price is extremely high. In real prices uranium reached its peak back in the 1950s with prices over 600 USD per pound in current 2023 inflation adjusted USD.

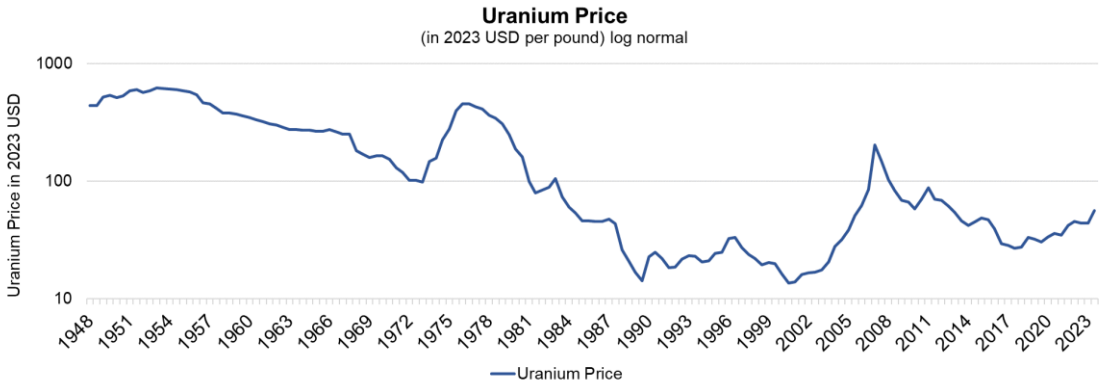

Figure 26: Uranium price in real 2023 USD per pound, log normal, from 1948 to 2023, authors creation, based on (Robinson, 2016)

Nuclear energy was first commercially used in the mid-1950s and started to grow rapidly in the 1960s. The oil price shock in the 1970 speeded things up and until the 1990s the installed capacity grew by about 20 % per year. The oil price shock caused the uranium price to multiply within two to three years as Figure 27 points out. In 2001 the share of nuclear energy peaked at under 7% of total global energy consumption. The United States account for about 30 % of global generation and are currently the world's largest producer of nuclear energy. After the Chernobyl accident in 1986 the installations declined and the accident in Fukushima accelerated this trend. Still, energy production from nuclear power plants has increased in the past decade due to growth in emerging markets and developing economies, especially China. The nuclear generation capacity in China grew on average by 17 % per year between 2010 and 2019. More recently, new attention and focus has been on the use of nuclear energy and its role it could play in the energy transition which requires a reliable source of net-zero carbon electricity (Baffes and Nagle, 2022, pp. 52–53).

2.4.1 From long-term cycles to medium-term cycles and influencing factors of uranium

Figure 27 shows that since the 1950s the uranium price has experienced three full long-term/super cycles of 30 years on average. The first peak was reached around 1950 followed by a decline and trough around 1965. The oil price shock started the second cycle which lasted until the mid-1990s. The third cycle reached its top around 2010 and bottomed in 2020 before the fourth cycle began to expand until today.

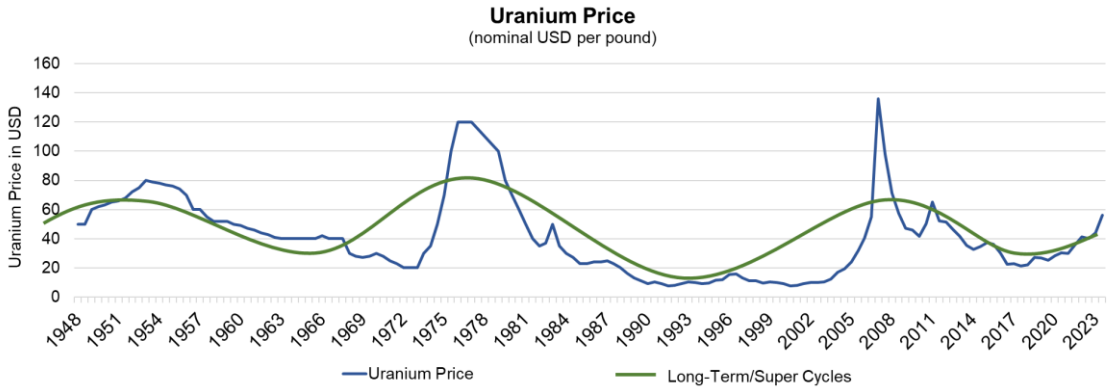

Figure 27: Uranium price in nominal USD per pound, from 1948 to 2023, authors creation, based on (Robinson, 2016)

Mineral commodity markets follow a cyclical pattern, witnessing significant fluctuations in prices over the years. However, these variations are overlaid with a long-term trend of declining real prices due to technological advancements that continuously reduce production costs. The uranium market, unlike other commodities, experienced a shift from high prices in the late 1970s to a period of depressed prices during the 1980s and 1990s. Spot prices plummeted below production costs for all but the most cost-efficient mines during this time. Subsequently, from 2003 to 2009, there was a recovery in spot prices, but they have since weakened. The majority of trade occurs through 3-15 year term contracts, where producers sell directly to utilities at higher prices than the spot market, ensuring a secure supply. The primary market participants, utilities and producers, dominated the spot market with a 95% share in 2000. Nevertheless, this share decreased to two-thirds in 2005 and further declined to one-third by 2011, remaining steady at 30-40% ever since. The remaining portion of the market has seen increased involvement from the financial community, contributing to enhanced liquidity and efficiency. Fluctuations in mineral prices primarily result from supply scarcity and demand. Eventually, prices cannot sustainably remain below production costs, and similarly, they cannot stay at exceptionally high levels for prolonged periods. The market tends to adjust with new producers entering and supply concerns gradually abating (World Nuclear Association, 2023).

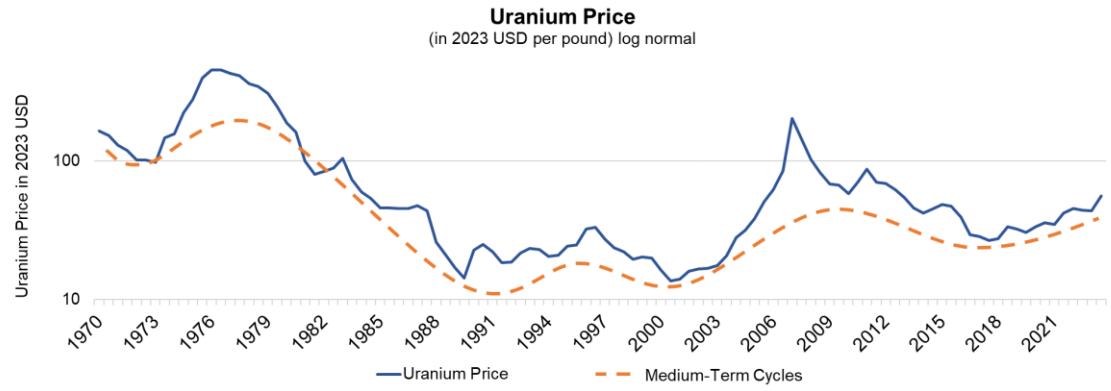

Figure 28: : Real uranium price in 2023 USD per pound, from 1970 to 2023, authors creation, based on (Robinson, 2016)

Fluctuations and cycles in investments and capital expenditures

The global uranium market is complex because contracts are negotiated bilaterally and due to the absence of a formal exchange. The primary price referenced in the international market for contract calls for the delivery of the product within 12 months is the uranium spot price. It is challenging to get a complete picture of the uranium market since most of the uranium sold is brokered through long-term private contracts between companies, occasionally with undisclosed price ceilings and floors. On the public financial market only a small share of uranium, about 15 %, is sold (Arnaut, 2022, p. 3). The global demand for uranium is currently rising, and if a combination of shocks to macroeconomic fundamentals pushes the spot price to pre-Fukushima levels, unprofitable uranium holdings could play a strategic relevance in the uranium supply. The supply chain for uranium is extremely vulnerable to geopolitical risks due to its deposits in crucial countries like Kazakhstan, Russia, Namibia, South Africa, or China. Also, changing weather conditions resulting from climate change have severe impact on the supply chain of uranium (Arnaut, 2022, p. 7). Due to Covid-19 restrictions many supplier have postponed their operations which leads to an increase in spot prices. The uranium price responds to changes in installed nuclear capacity, global production, and competing energy commodities such as coal, or to changes in exchange rates whereas a weak US dollar can lead to higher prices since uranium is usually traded and invoiced in US dollar and thus, exporters can adjust their purchasing power when the US dollar is low (Arnaut, 2022, p. 3). When uranium prices are sustainably high, the exploitation of uranium as a by-product of phosphates recycling and production starts to become economically feasible (Rooney, Nuttall and Kazantzis, 2015). Time lags play an important role in uranium price formation because the timing for investment expansion and realization of the nuclear fuel cycle is a lengthy process. Expectations of future market prices can also be an important factor influencing price volatility. Figure 29 shows the capital expenditures for exploration and development of uranium, and it can be seen that the price strongly increased from 2004 to 2007 which led to an increase capital expenditures with a certain delay.

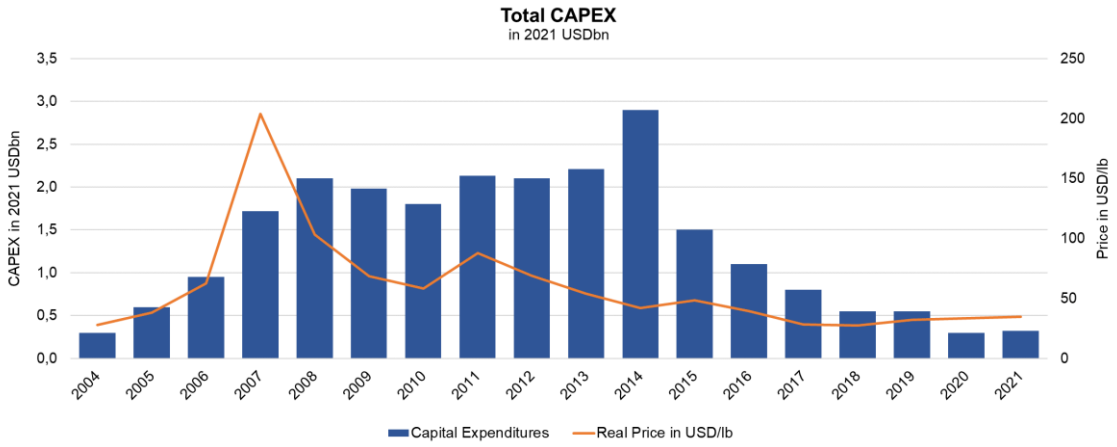

Figure 29: Capital expenditures in billion USD for exploration and development of uranium, from 2004 to 2021, authors creation, based on (IAEA & NEA, 2023, p. 52)

2.4.2 Short-term cycles and influencing factors of uranium

Uranium prices declined in the 1990s and reached their bottom in 2001. Short-term volatility and price fluctuations in uranium are not so strong compared to copper or oil. Short term cycles in uranium price were mainly caused by political and corporate decisions, or disasters. In 1995 the US-Swiss international uranium trading company NUEXCO filed for bankruptcy leading to a 50 % increase in uranium price. Another short term cycle was induced by the financial crisis in 2008 and the incident in Fukushima in 2011 resulted in a 30 % decline in uranium prices. Uranium could further benefit from the geopolitical drive towards clean energy transition as a stable producing energy source in a world full of solar panels and wind turbines.

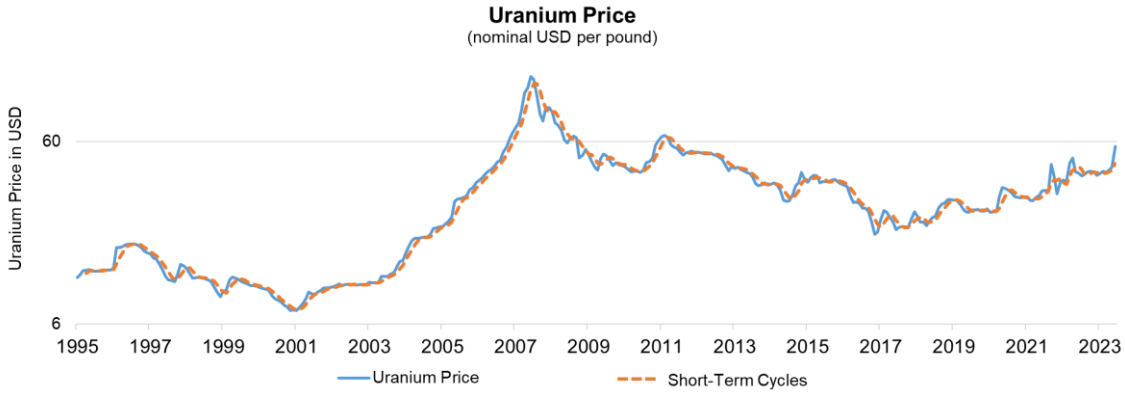

Figure 30: Uranium price short-term cycles in nominal USD per pound, from 1995 to 2023, authors creation, based on (Robinson, 2016)

As it is believed, the cyclic behavior results from the change in inventory, but uranium is slightly different. Figure 31 shows the change in total uranium inventories and its 3 month moving average since 1992. The change in uranium inventories is influenced by many different factors, including production levels, global demand, geopolitical events and supply disruptions, imports and exports, market speculation and sentiment, seasonal factors, and government policies and regulations. Inventory levels are directly influenced by fluctuations in demand, and supply disruptions caused by expanding or contracting economies. The seasonal variations in demand and changing market sentiment also plays a role.

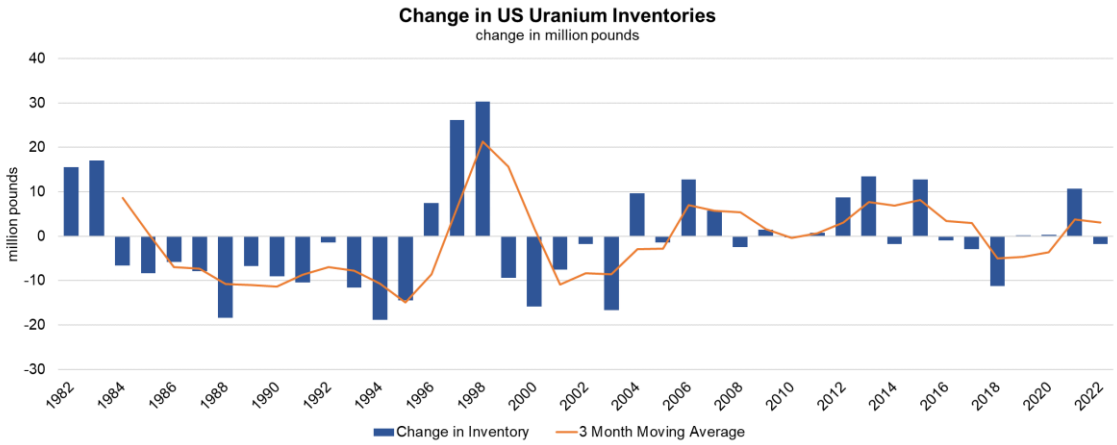

Figure 31: Change in US uranium inventories in million pounds, from 1982 to 2022, authors creation, based on (EIA, 2023)

By analyzing the total uranium inventories shown in Figure 32, weaker fluctuations can be recognized, compared to oil or copper. It has to be mentioned that this inventory data only represents the inventory of the U.S., China or other countries like Russia, Kazakhstan, and other are not included since the published data is not usable or no data at all is published.

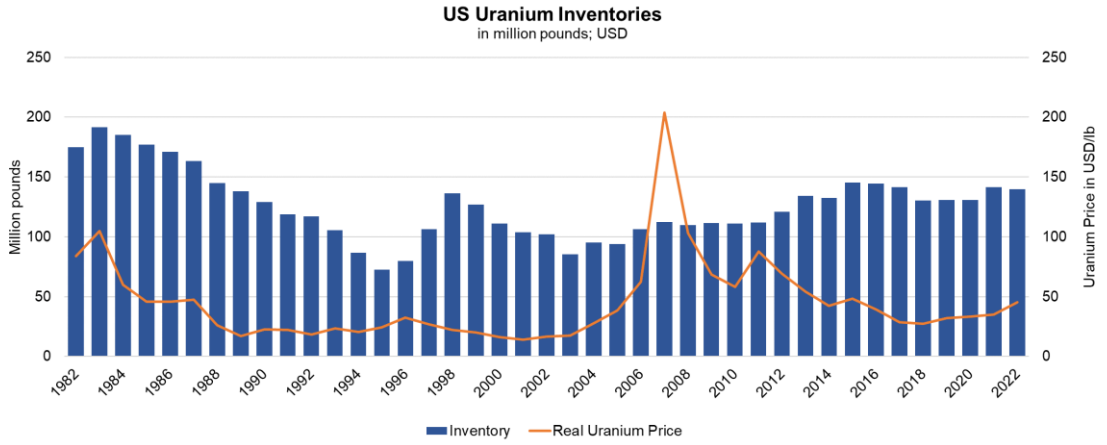

Figure 32: US Uranium inventory in million pounds, from 1982 to 2022, authors creation, based on (EIA, 2023)

Uranium prices show cyclical behavior similar to other energy commodities, but with larger peaks and lower short-term volatility. Supply and demand shocks lead to extreme volatility. Sustainability of uranium as fuel is crucial due to declining secondary supplies. Uranium prices experienced three cycles of around 30 years each. The uranium market's complexities include private contracts and geopolitical risks. Short-term cycles influenced by political decisions, disasters, and clean energy transition.

2.5 Potential analysis of technical and macroeconomic leading indicators for commodity trading

Indicators are used as variables designed to provide valuable insights into the performance or behavior of specific systems or processes. In the area of finance and

economics, these indicators play a crucial role in monitoring and analyzing diverse aspects of the economy, such as inflation, employment, and economic growth. Based on their intended purpose and the nature of data they provide, indicators can be categorized into different types. Leading indicators, for instance, are used in forecasting future economic activity, while lagging indicators validate or disprove trends that have already occurred. This section covers various indicators, outlines the importance of leading indicators, covers commonly used leading indicators in macroeconomic analysis and briefly describes the leading ability of each indicator.

The topic on predictability of commodity prices using financial and macroeconomic indicators and variables has only been undertaken a few times so far (Gargano and Timmermann, 2014, p. 825). Studies find evidence that currencies and exchange rates can predict commodity prices by using five commodity currencies and an aggregate commodity price index which includes more than 40 traded products. Another study concluded the contrary, namely that neither a broad range of macroeconomic indicators, nor commodity exchange rates produce a strong evidence of spot price predictability. This result was compared to autoregressive benchmarks or random walk (Gargano and Timmermann, 2014, p. 826). (Bessembinder and Chan, 1992) concluded that the dividend yield, junk bond premium, and treasury bill yield have limited predictive ability over movements in metal, agricultural, and currency futures prices.

An example of time-shifted movement can be seen in Figure 33. The blue line represents the “producer price index by commodity: All commodities”, which is a measure of the change in prices that domestic producers receive for their goods and services, also known as inflation for producers. The other three graphs represent crude oil price, uranium price and copper price. As it can be seen, rising commodity prices of oil, copper, and uranium lead to a rise in the producer price index, or inflation. The decline in producer price index is delayed by up to several months.

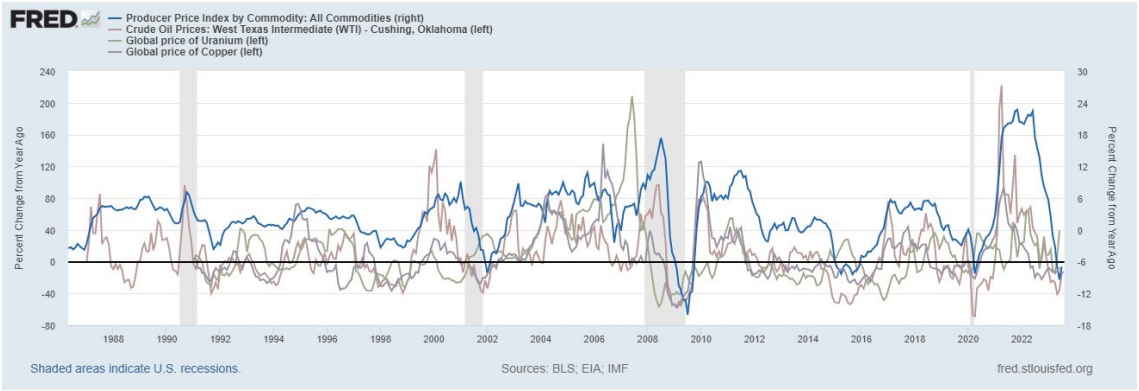

Figure 33: Producer price index by commodity: all commodities (right); global price of copper (left); crude oil prices: west Texas intermediate (WTI) - Cushing, Oklahoma (left); global price of uranium (left) (Federal Reserve Bank of St. Louis, 2023)

2.5.1 Influencing factors of commodity prices

Starting with supply and demand dynamics, which are the primary driver of commodity prices and result from changes in global consumption and production levels, market expectations also can impact on the price. To understand the supply and demand

dynamics, changes in production or inventory levels, as well as changes in consumption need to be monitored and analyzed. Production costs play an important role in commodity prices and are influenced by labor costs, energy prices, commodity prices or taxes. To understand price dynamics, changes in labor costs, energy prices, raw material costs or taxes on CO2 or the import/export of goods must be taken into account. Economic growth and general market conditions can have an impact on commodity prices. Strong economic growth requires resources and therefore leads to an increase in demand for commodities, which drives up prices. On the other hand, economic downturns or recessions reduce the demand for commodities and thus commodity prices fall. Economic growth can be measured by the GDP (gross domestic product) growth rate of specific countries or the world, or by economic performance indicators such as unemployment rates, inflation, interest rates, and others. Changes in mine production and warehousing can also have a significant impact on commodity prices. Geopolitical events can disrupt supply chains, trade deals, mine production or even entire economies and can result from political instability or change, trade disputes, political instability, sanctions or wars and have a significant impact on commodity prices. Geopolitical events are difficult to predict in terms of their severity and occurrence, making them even more difficult to index in order to measure. The same applies to natural disasters, which can affect commodity prices, especially agricultural commodities. Speculative trading can have an impact on short-term price volatility and can be triggered by certain trading behaviors of hedge funds or institutional investors. Therefore, technical indicators can be used to analyze the price of commodities based on trends, volume, volatility, momentum or simple moving averages, where the moving average of a given period is superimposed over the commodity price and deviations from the moving average can indicate a possible buy - or points of sale. Government policies can have long-term effects on commodity prices. These can be subsidies, regulations, trade policies with foreign countries or taxes, which can be related to imports, exports, production or environmental regulations(Chiaie, Ferrara and Giannone, 2017; Hu *et al.*, 2020).

2.5.2 Definition and use of lagging indicators

Lagging Indicators provide insights about economics, or performances after they have happened. They can give information on trends in the past, conditions of the general economy, or company results such as financial results. Lagging indicators are also used as key performance indicators, or KPI´s, which are monitored and can indicate deviations from the preset plan or schedule. Businesses track their balance sheet and derive indicators form it like the return on investment (ROI), return on capital employed (ROCE), or margins to identify their performance. But these indicators are lagging, or time-delayed due to the fact that they are results from events and outcomes which have already happened and thus cannot indicate future performance (Charles Potters, 2023). Lagging indicators can be used for assessing long-term trends and for financial forecasting by providing information about the performance of economies or businesses. They are also used in performance management and can be used for multiple purposes such as: measurement of past performance, to confirm trends and changes in trends, show where targets have been met or not met and point out areas of improvement. They are best used in combination with leading indicators to provide a more comprehensive view.

2.5.3 Definition, use and importance of leading indicators

Leading indicators are forward-looking measures which can forecast future economic trends and changes in business cycles. They tend to foresee changes in the economy by several months, making them valuable tools for identifying potential turning points in the economy. These indicators, when combined with the analysis of cyclic behavior, offer insights into future movement and behavior of the economy. There are different types of leading indicators, and they can be divided into two groups: fundamental and technical indicators. Fundamental indicators are based on factors of supply and demand, like geopolitical events, inventory stock weather forecasts. Therefore, bond yields, interest rates, currency exchange rates, housing starts, consumer confidence or jobless claims can be used as indicators for example. Technical indicators refer to the past volume and data of a stock, bond or commodity. They are used to identify certain patterns to predict future behavior of prices. Therefore, moving averages, trading volume, or support and resistance lines can be used. These measurable economic factors are significant because they provide early warning signals of potential future economic activity (Charles Potters, 2023). By analyzing leading indicators, economists and policymakers can make informed monetary and fiscal policy decisions that can help stabilize the economy and mitigate economic downturns. Companies can use this information for inventory and production capacity planning or for investment decisions. Especially in capital-intensive industries like oil, copper or uranium, this information can help gain an advantage when to increase capital expenditures and prepare for possible future demand. Therefore, analysts and investors use these indicators to predict future economic and market conditions, thereby making informed investment decisions (Long *et al.*, 2022, p. 2).

An example of a leading indicator can be seen in Figure 34 showing the “Producer Price Index by Industry: Nitrogen Fertilizer Manufacturing” (left and blue) and the “Henry Hub Natural Gas Spot Price” (right and red) (PPI). When comparing the two peaks of natural gas, which occurred in December 2000 and February 2003, with the peaks of nitrogen fertilizer, which occurred in January 2001 and March 2003, a peak delay of one month can be recognized, thus the natural gas spot price here can be seen and used as a leading indicator.

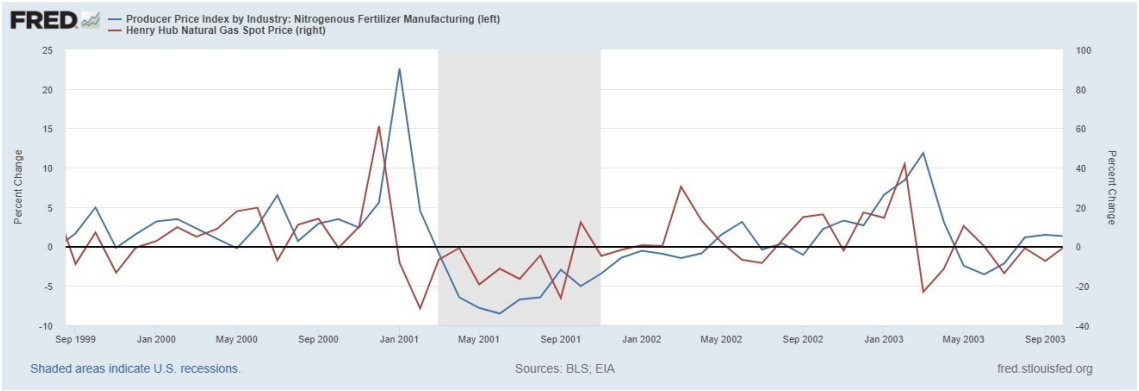

Figure 34: Producer Price Index by Industry: Nitrogen fertilizer manufacturing (left); Henry Hub Natural gas spot price (right) (Federal Reserve Bank of St. Louis, 2023)

2.5.4 Evaluation of potential economic leading indicators for commodity price analysis

There are various different indicators used to predict certain behavior, hereafter some of the most commonly used economic indicators are listed.

Purchasing Managers´ Index (PMI)

Can be used to gain insights into the health of the economy. The data is derived from surveys of senior managers at private sector companies across various sectors. It features the overall health of the economy which can provide insights into key economic drivers like inflation, gross domestic product (GDP), employment, exports, capacity utilization, and inventories (S&P Global, 2023). The index provided by S&P Global has its reference base at 50, which means values higher than 50 indicate an improvement in the economy referred to the previous month and a value below 50 indicates a deterioration. Its leading ability is weak since it is based on a survey from the past and the ability of the participants surveyed to give a rational future assessment is limited.

Consumer Sentiment Index (CSI)

The Consumer Sentiment Index surveys individuals about their views on the current state of the economy and their expectations for future economic trends and is provided by the Organization for Economic Cooperation and Development (OECD). It plays a crucial role in stimulating consumer spending, which is an important part of economic activity. Increased consumer confidence is often associated with higher spending and economic expansion, while a decline in confidence could indicate lower consumer spending and potential economic troubles ahead. Changes in the CSI can provide valuable insights into future consumer behavior and overall economic performance (OECD, 2023). Its leading ability is weak since the confidence of consumers changes after a tipping point or trend reversal is reached and in most cases, consumer obtain their information from the news.

Jobless Claims and Unemployment Rate

Jobless Claims measures the number of individuals who have filed for unemployment benefits. A rise in jobless claims suggests an increasing number of people losing their jobs, which may indicate a weakening economy and potential negative impacts on the stock market. Often corporations are laying off people when expecting a decline in order volume due to a decline in market growth. On the contrary, a decrease in jobless claims signals fewer people filing for unemployment benefits, which can be seen as a positive sign of job growth and economic recovery. (Uhler, 2018). The unemployment rate for the United States of America, which can be seen in Figure 35, represents the number of unemployed people as a percentage of the labor force and shows the cyclical trend in employment, the grey areas mark recessions and show that the unemployment rises in times of economic declines of recessions. This indicator has some leading tendencies since the unemployment rate is, among other information, the basis for decisions felt by the federal reserve such as interest rates increases or decreases or quantitative easing or tightening programs. Quantitative easing describes a fiscal policy where the central bank purchases securities on the open market, mostly government bonds, using new bank reserves (additional new printed money) to support the economy. Quantitative tightening describes a fiscal policy where the central bank sells securities on the open

market, mostly government bonds, and thus increases liquidity on the open market. Quantitative easing leads to favorable economic conditions on the financial markets and often goes hand in hand with decreasing or low interest rates. Quantitative tightening on the other hand leads to less favorable conditions on the financial markets and often goes hand in hand with rising or high interest rates.

Figure 35: Unemployment Rate (Federal Reserve Bank of St. Louis, 2023)

Treasury Yield Curve

The Yield Curve stands for the yields of government bonds one gets if investing in a US government issued treasury security. There are different types of bonds with different duration, like 6 months, one-, two-, five-, or ten years. Of particular interest is the spread between two-year and 10-year Treasury yields as shown in Figure 36. If the spread shows an inverted yield curve, this happens when short-term yields exceed long-term yields, it has been historically correlated with both recession and short-term market volatility. As it can be seen in Figure 36, every time since the 1980s if the yield spread is near or under zero a recession followed. This inverted yield curve has preceded every recession in the past five decades and as Mike Cudzil, a portfolio manager at Pimco said: ”With every inverted yield curve, you tend to see a slowdown in credit creation.” (Duguid, 2023). An inversive yield curve typically indicates an upcoming recession in the next six months to two years. Considering the historical data, the spread between the two-year and 10-year treasury yield can be used as leading indicator.

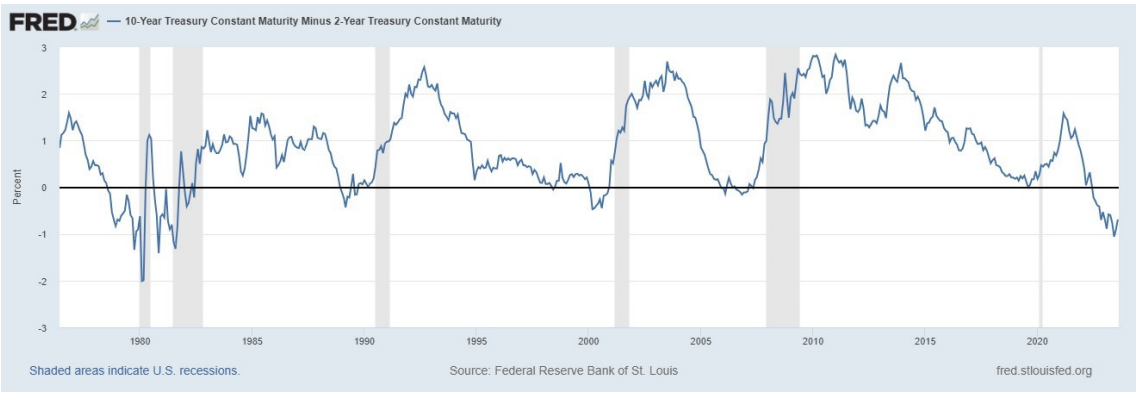

Figure 36: 10-Year Treasury Constant Maturity Minus 2-Year Treasury Constant Maturity (Federal Reserve Bank of St. Louis, 2023)

Producer Price Index

The producer price index measures the price change from the seller's perspective, or the average change in prices received by domestic producers for their goods and services over time. Significant changes in the PPI can signal potential inflationary pressures in the economy and provide insights into price developments at the output level (U.S. Bureau of Labor Statistics, 2023). As producers experience changes in input costs, such as raw materials and labor, they have two choices. Either they pass the higher price on to consumers, which fuels inflation and risks a decline in sales volume, or they accept a lower profit margin and risk a lower NPV valuation. Its leading ability is given since companies and producer notice price changes often long before consumers do.

Consumer Price Index (CPI)

The Consumer Price Index is a measure of the average change over time in prices of a basket of goods and services purchased by households and urban consumers. It is a lagging indicator with limited leading/predictive ability for future inflation, as Figure 37 shows. Here we can see that the Producer Price Index leads the Consumer Price Index and also shows higher volatility. The CPI reflects the past price changes experienced by consumers and indicates the current level of inflation. It is crucial for understanding the cost of living and adjusting various economic variables, such as wages and social benefits, to maintain the purchasing power of consumers.

Figure 37: Producer price index by commodity: all commodities; consumer price index for all urban consumers: all items in U.S. city average (Federal Reserve Bank of St. Louis, 2023)

Money Supply

The money supply refers to the total amount of money circulating in the economy, including cash, coins, and balances in bank accounts. Rapid growth in the money supply can lead to increased spending and inflationary pressures. Conversely, a decline in the money supply can be an indication of a contracting economy or deflationary pressures. The money supply can affect interest rates and overall economic activity and can be divided into main categories M1, M2, and M3. M1 includes all banknotes and coins in circulation that can be easily converted into cash. The money can be stored in wallets,

bank accounts or other monetary equivalents. M2 equals M1 plus savings deposits and retail money, and M3 equals M2 plus large time deposits, or institutional money market funds (Federal Reserve, 2015). Figure 38 shows the M1, and M2 money supply of the United States from the 1960s and Figure 39 shows the log normal M1, and M2 money supply in combination with the log normal Consumer Price Index. The Consumer Price Index, or inflation rises with increasing money supply. Even though money supply can have some predictive power, it is unlikely to determine the time when a trend reversal might happen and needs to be combined with other indicators to provide sufficient data. Thus money supply is a weak leading indicator.

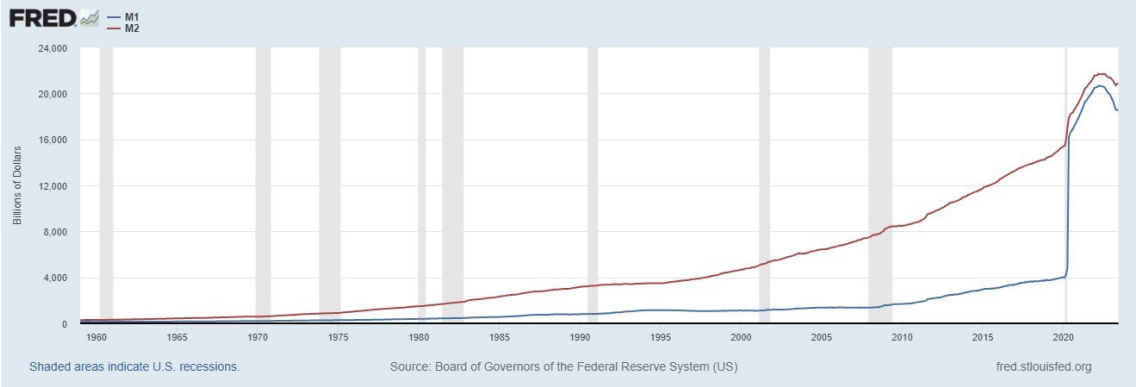

Figure 38: M1 and M2 money supply for the US in billions of USD (Federal Reserve Bank of St. Louis, 2023)

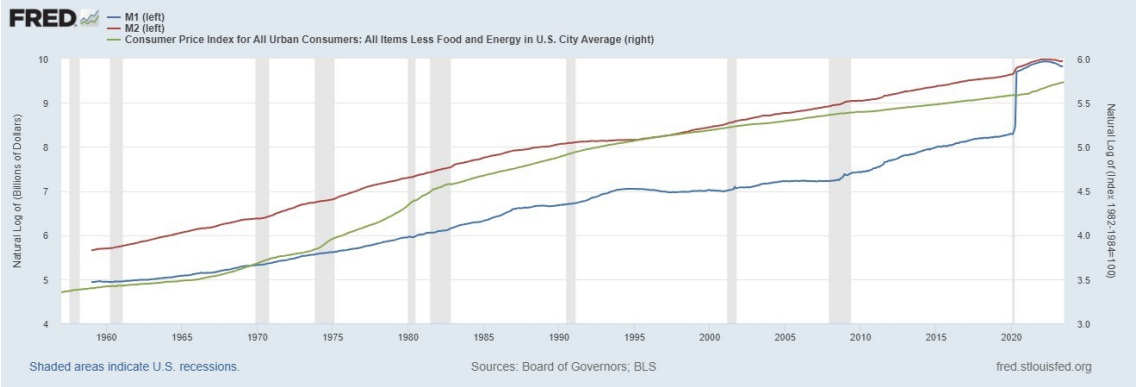

Figure 39: M1 and M2 money supply for the US in billions of USD (left), and the Consumer Price Index for All Urban Consumers: All Items Less Food and Energy in U.S. City Average (right) (Federal Reserve Bank of St. Louis, 2023)

Inventory

Inventory refers to the stock of goods or raw materials held by businesses or organizations. Inventory levels can be used as an indicator of supply and demand dynamics in the market. High inventory levels can indicate oversupply and potentially lead to lower prices, while low inventory levels can indicate undersupply and potentially lead to higher prices. Inventory levels are directly influenced by fluctuations in production, demand, and supply disruptions, while decisions made by major oil-producing nations can influence global supply dynamics. Also, government policies and regulations can have an influence on the markets supply and demand balance (Kenton, 2022). Total inventory can indicate shifts in middle and long term trends due to possible demand scarcity and thus can have leading ability. The change in inventory has low predictive

ability since it influences the price of a commodity right after it was published by organizations.

Capital Expenditures

Capital expenditure refer to the spent capital by companies or organizations on long-term assets such as real estate, equipment or infrastructure. High capital expenditures can indicate a positive economic outlook and potentially lead to job creation and economic growth. Typically, when oil and gas prices increase by 10 percent, global investments in the sector also rises by 3 percent in the same year and by 5 percent cumulatively after two years (International Monetary Fund, 2022). Due to a broader range of factors influencing their investment decisions, national oil companies tend to exhibit less reactivity. (International Monetary Fund, 2022, p. 33). Considering this, capital expenditure can be used as leading indicators for middle and long term trend prediction of commodity prices.

Currency Exchange

The term "exchange rate" refers to the rate at which one currency can be exchanged for another. Exchange rates can be used as an indicator of global economic conditions and trade relations. They can affect companies b changing the cost of raw material or supplying products purchased from a different country. Foreign exchange rates can be monitored by observing data on foreign exchange markets, trade balances, and central bank policies (Chen, 2022).

GDP Growth

GDP growth refers to the total value, monetary or market, of finished goods and services produced in a country in a given period of time. GDP growth can be used as an indicator of economic growth and general market conditions. High GDP growth can indicate a positive outlook for the economy, potentially leading to job creation and increased consumer spending (Fernando, 2023). GDP growth alone only has weak leading tendencies but can give in combination with for example total inventory, an overview of possible increase or decrease on the demand side. This results due to the fact that rising GDP often goes hand in hand with rising raw material demand and thus, boosting the demand side.

Industrial Production Growth (IPG)

Industrial production growth refers to the rate at which industrial production increases or decreases and measures levels of production in e.g. mining, or other industries. High industrial production growth can indicate a positive outlook for the economy, potentially leading to job creation and economic growth (Kenton, 2021). IPG shows leading ability since an increase in a nation’s production growth can indicate higher demand for goods, services, and commodities.

3-Month Yield Curve

The 3-month yield curve is a measure of the interest rates of 3-month Treasury bills It shows the yield in percent when buying a U.S. bond and can be used as an indicator of market expectations about future economic conditions The 3-Month yield curve can have leading abilities due to its sensitivity and it can offer valuable information about market expectations, investor sentiment, and economic outlook. In economic downturns government bonds tend to rise since an asset allocation from riskier assets like stocks

to less riskier assets like bonds takes place. So when treasury yields start to rise, market participants believe that they can get better returns from bonds than from stocks.

Interest Rates

Interest rates refer to the cost of borrowing money and the return on lending money.. Central banks adapt interest rates according to the economic condition. High inflation and strong economic growth often leads to rising interest rates to temper inflation and economic growth. Low inflation, or even deflation and low economic growth lead to low interest rates. The principle is as follows. If the central bank interest rate is low, saving bank accounts to not provide any return on saved money, resulting in increased expanding and vice versa Interest rates have weak leading ability since the federal reserve fells interest rate decisions based on market data such as the producer and consumer price index, GDP growth outlook, and many more.

2.5.5 Evaluation of potential technical leading indicators for commodity price analysis

Additionally to economic indicators, technical indicators can play a key role in technical analysis of price charts, which is another option to determine possible price changes and reversal points.

Moving Averages

Moving averages are technical indicators that calculate the average price of a commodity over a specific period. The simple moving average (SMA) which can be seen in Figure 40 where the SMA 12, 48, and 120 are seen. One principle the prices are following is the regression to the mean (RTM) is a statistical phenomenon which states, that if a variables deviation from the average is extreme, it will tend to be closer and less deviated to the average on its next measure (Thomas *et al.*, 2020). The SMA 12 in this figure for example calculates and shows the average price over the last 12 months, same is true for the SMA 48, and SMA 120 for 48, and 120 months respectively.

Figure 40: Monthly oil price in USD and SMA 12, 48, 120, from 1974 to 2023 (*Tradingview.com*, 2023)

When analyzing the price with the moving average on a logarithmic scale as Figure 41 shows, it can be seen that a deviation of the oil price of over 60% on the upside, and a deviation of -40% or less on the downside from the SMA 48 leads to a setback to the SMA 48, which represents the average movement of two years and thus the short term cycle, which was already evaluated in chapter 2.2. The results for the SMA 12, one year, and SMA 120, ten years, show the same pattern with different deviation percentages. This method may not predict future price movements of oil, but it can indicate whether or not the oil price might have reached a tipping point or shorth term cycle high, when the price deviation from the SMA 48 is too big.

Figure 41: Monthly oil price in USD log normal and SMA 12, 48, 120, from 1974 to 2023 (*Tradingview.com*, 2023)

Similar but less strong trends can be seen for the copper commodity price, and for uranium the trend is even weaker, and less data has been found to analyze it in more detail.

Relative Strength Index (RSI)

The RSI is a momentum oscillator that measures the speed and change of price movements. It ranges from 0 to 100 and indicates overbought conditions when above 70 and oversold conditions when below 30. The RSI can be used to identify potential reversal points and trading opportunities. Figure 42 shows the oil price chart from 1980 to 2023 and underneath the chart the RSI can be seen. As it can be seen every time the price index reaches or tops the 70 mark on the monthly chart, the oil price started to decline in the following two to four months. Same holds true for the lower range of 30 where the oil price started to increase in the following two to four months after the index reached 30 or fell below it.

Figure 42: Monthly oil price in USD and Relative Strength Index from 1980 to 2023 (*Tradingview.com*, 2023)

When analyzing the cyclicity of the RSI, as shown in Figure 43, medium term cycles of four to 10 years can be seen as proposed by Clement Juglar who was one of the first to discover and describe business cycles. According to Juglar, the business cycle, which has a period of between 7 and 11 years includes investment in fixed capital, including the renovation of production machinery.

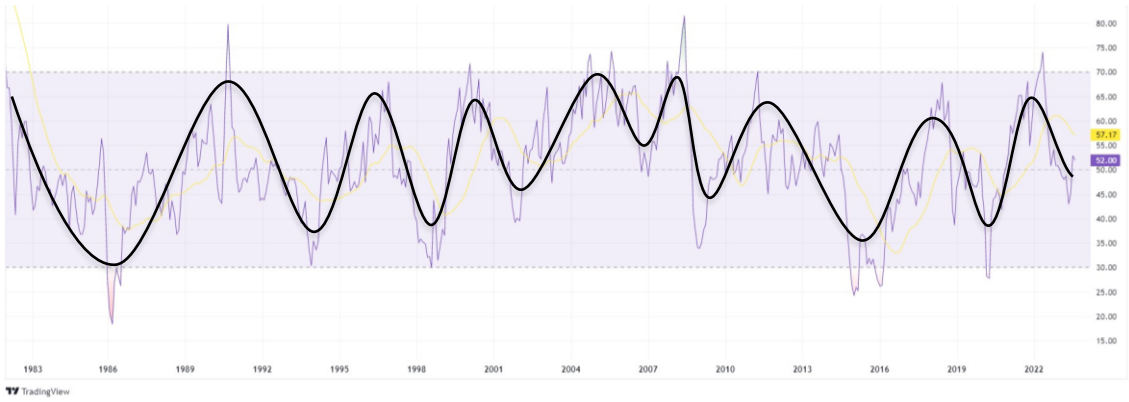

Figure 43: Cyclic behavior analyzation of the Relative Strength Index on Crude Oil WTI (*Tradingview.com*, 2023)

Moving Average Convergence Divergence (MACD)

MACD is another momentum oscillator that compares two moving averages to identify shifts in trend momentum. Traders watch for MACD line crossovers with the signal line, which can indicate potential buying or selling opportunities (*Tradingview.com*, 2023). The indicator is considered bullish (if the market trend is upwards and investors think that the price for an asset goes up) when the MACD crosses above the zero line. When the MACD crosses below the zero line the indicator is considered bearish (if the market trend is downwards and investors think that the price for an asset class goes down). Figure 44 shows the Moving Average Convergence Divergence (MACD), and a detailed analysis shows that this indicator has more lagging characteristics than leading since every time

the MACD crosses the zero line, the price has already reached its tipping point. To conclude, this indicator is of less relevance to further investigate in this thesis.

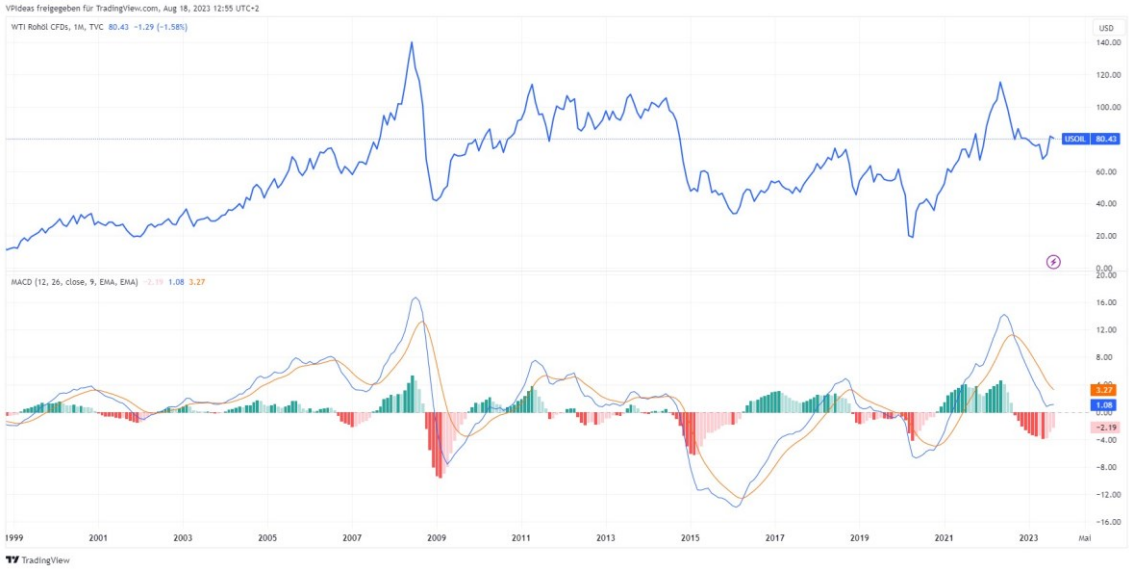

Figure 44: Monthly oil price in USD and Moving Average Convergence Divergence (MACD) from 2000 to 2023 (*Tradingview.com*, 2023)

Commodity Channel Index (CCI)

The Commodity Channel Index (CCI) shown in Figure 45 measures the distance between the price and their moving average and thus allows the trend strength or trend intensity to be measured. The borders are set between +100 and -100, if the CCI is in-between it indicates a trendless market. When the CCI crosses these borders, long position (if an investor opens a long position he or she thinks that the price of the asset will go up) is said to be opened and vice versa. As a general rule, a steep rise/fall of the CCI line indicates high strength in the trend that is establishing itself. A slow rise/fall indicates a decrease in trend intensity (boerse.de, 2023).

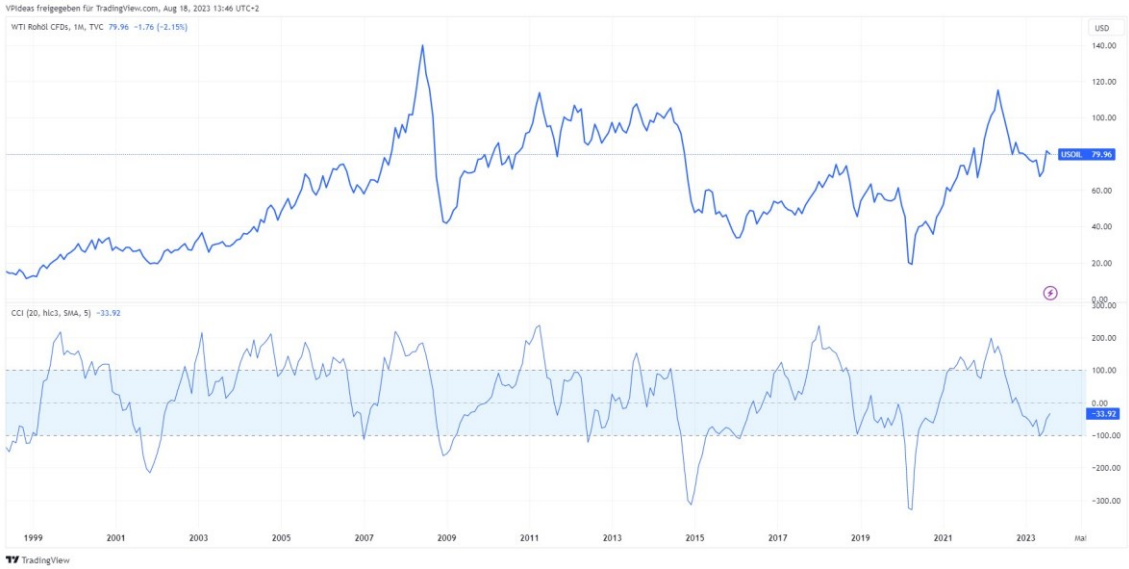

Figure 45: Monthly oil price in USD and Commodity Channel Index (CCI) from 2000 to 2023 (*Tradingview.com*, 2023)

Williams Percent Range (W%R)

Williams %R (W%R) or Williams Percent Range is a momentum based oscillator to identify overbought and oversold conditions and is shown in Figure 46. “The W%R is based on a comparison between the current close and the highest high for a user-defined number of bars.” (*Tradingview.com*, 2023) The indicator fluctuates between zero and -100 representing overbought or oversold levels respectively. The indicator shows high leading responses, and it might start to move to highs or lows, even if the actual market price does not follow suit. Due to its leading nature the Williams %R signals can be premature and less reliable than other entry signals.

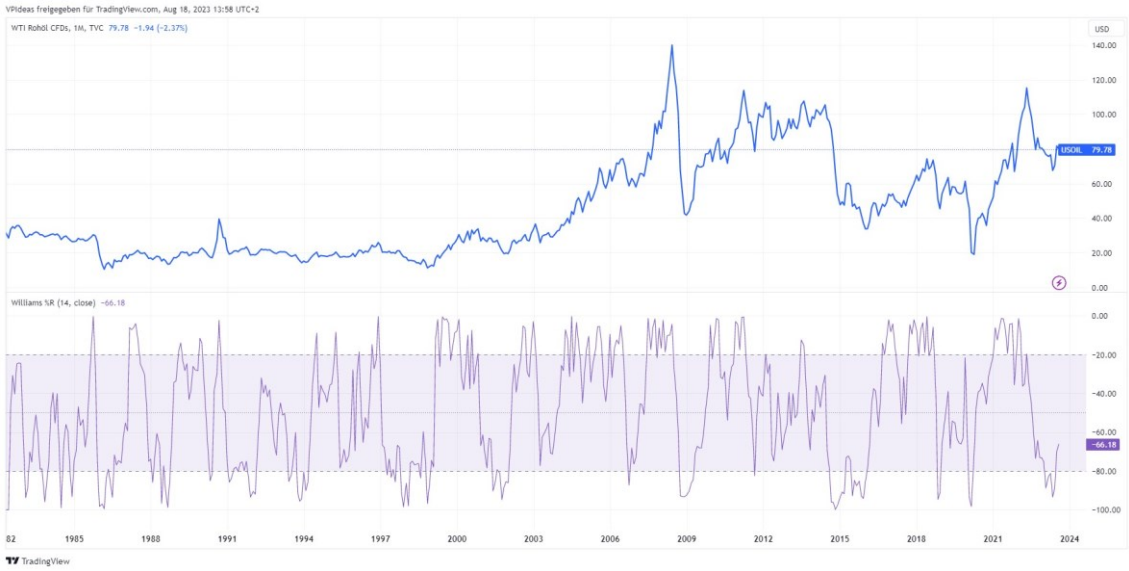

Figure 46: Monthly oil price in USD and Williams %R from 1980 to 2023 (*Tradingview.com*, 2023)

Stochastic Oscillator (SO)

The stochastic oscillator compares the closing price of a given commodity to its price range over a specific time period. It ranges from 0 to 100 and helps to identify potential trend reversals or tipping points and is used to identify overbought or oversold conditions as the sample in Figure 47 shows.

Figure 47: Monthly oil price in USD and Stochastic Oscillator from 1980 to 2023 (*Tradingview.com*, 2023)

Fear and Greed Index (F&G)

The Fear & Greed Index is a way to measure the stock market movements and identify whether stocks are over-, under-, or fairly priced. The theory is based on the physiological behavior of market participants that extreme fear tends to drive down share prices. On the contrary, too much greed of market participants tends to have the opposite effect which leads to an increase in prices. The Fear & Greed Index includes seven different indicators that measure different aspects of stock market behavior. These seven indicators are stock price strength, market momentum, stock price breadth, junk bond demand, put and call options, safe haven demand, and market volatility. The index tracks the deviation of these indicators from their average values. Each indicator is equally weighted with a score from zero to 100, with zero signaling maximum fear and 100 representing maximum greed. In combination with other analytical tools and fundamentals, the Index can be a helpful way to assess market sentiment (CNN.com, 2023). Figure 48 shows the monthly oil price and the Fear & Greed Index.

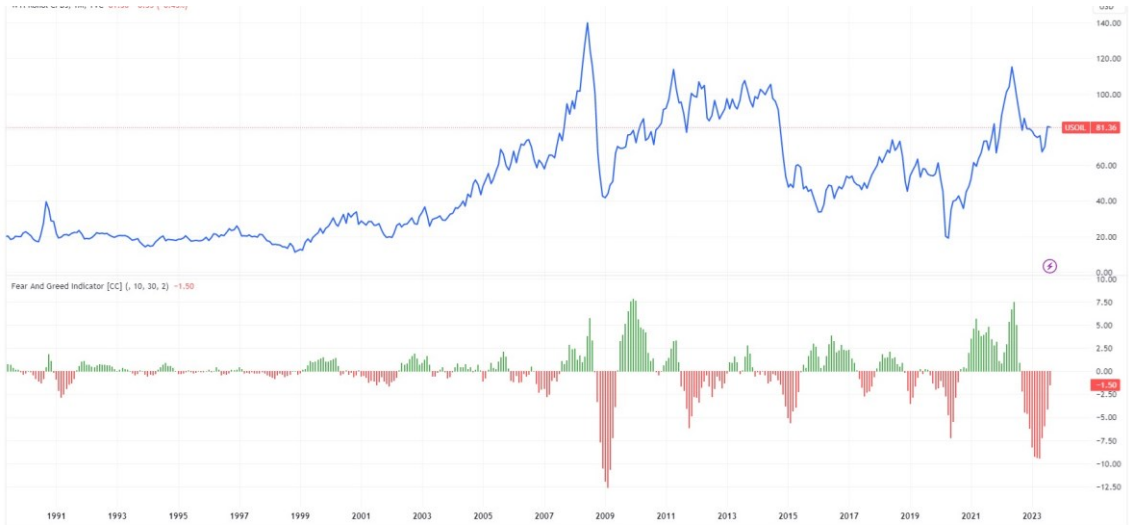

Figure 48: : Monthly oil price in USD and Fear & Greed Index from 1980 to 2023 (*Tradingview.com*, 2023)

Bollinger Band (BB)

Bollinger Bandwidth is a technical indicator which is based on a price volatility tool and suitable to identify possible trend reversals. The Bollinger Bands consist of three main components, including the mean, a simple moving average (SMA 20), the upper Bollinger Band, which is twice the standard deviation added upwards by the SMA, and the lower Bollinger Band, which is twice the standard deviation added downwards from the SMA. The resulting trend channel between the two standard deviations can be used as a guideline for trend changes, as Figure 49 shows (*Tradingview.com*, 2023).

Figure 49: Monthly oil price in USD and Bollinger Bandwidth from 1980 to 2023 (*Tradingview.com*, 2023)

In this chapter, different types of indicators such as lagging and leading indicators have been analyzed and evaluated. In summary, indicators are important tools for understanding the performance of systems, especially in finance and economics. They include measures that shed light on various economic facets such as inflation, employment trends, and economic growth. These indicators are classified into several categories, with leading indicators being particularly important because they provide a preview of future economic activity, while lagging indicators confirm past trends. The chapter addressed leading indicators in detail, providing a comprehensive overview of their role and highlighting commonly used examples in macroeconomic analysis. While the study of the use of financial and macroeconomic indicators to predict commodity prices is a new field, past research has concluded mixed results and outcomes. Some studies suggest potential predictive relationships, while others are limited in comparison to established benchmarks. Leading indicators are important for decision making by economists, policy makers, businesses, analysts, and investors. These indicators help shape economic policy, investment strategies, production planning, and market forecasts. By using leading indicators, stakeholders can proactively respond to changing economic conditions, potentially minimizing risks and capitalizing on opportunities.

3 Model development and evaluation of leading indicators characteristics

This chapter covers a brief overview of the used technical and economic indicators, their ability to detect reversal points and price changes, their leading ability and their correlation to each other. It covers the analyzation of short- and medium-term crude oil cycles, as well as short- and medium-term copper cycles and short- and medium-term uranium cycles. The result will be the identification of indicators with leading ability and their correlation with other indicators so specific indicators can be overlayed to better forecast price changes and reversal points.

3.1 Model description, principle, and usage

To evaluate dependencies, abilities, and effects of possible leading indicators different models can be used. Time series models can be used to analyze variables over time, here it could be used to monitor suitable indicators over time to forecast their future behavior. Another option would be a correlation model which can be used to analyze the relationship between two or more variables. This model is of interest for this thesis since it can be used to analyze the relationship and their possible predictive ability between leading indicators. Prior to the correlation model an evaluation model is conducted to identify the individual predictive ability of each indicator.

Commodity spot prices are forecasted by (Drachal, 2021, 2 ff.) with the help of Bayesian dynamic finite mixtures. Most successful models in the past were based on variables from supply and demand, on the impact of currency exchange rates, or on financial variables. In Bayesian econometrics, a fundamental concept involves starting with an initial assumption regarding the predicted variable, represented by the prior distribution. As fresh data becomes accessible, the model is recalculated, causing a contraction in the information contained within the distribution (now known as the posterior distribution). This process leads to more precise approximations in forecasting. Consequently, Bayesian modeling proves valuable in scenarios where the time-series is relatively short, yet the array of explanatory variables is substantial (Drachal, 2021).The authors conclude successful forecasting of one-month ahead coal and oil spot prices, but not for natural gas (Drachal, 2021, p. 12). Since this paper considered one month forecasts of prices but not possible reversal points, this model is not further used in this thesis. Another option is proposed by (Ferrari, Ravazzolo and Vespignani, 2021, p. 3). The authors propose a two-component modeling approach. The first component is a latent factor model which reduces the dimensionality of a large number of potentially useful macroeconomic predictors. The second component comprises a simple bridge linear equation which uses the sparse factors to forecast commodity prices. The authors employ the techniques of factor analysis and latent factor models to summarize a substantial number of correlated macroeconomic predictors by identifying a few common latent factors that encompass the majority of the significant information in the data. They find that this approach is appealing due to its ability to avoid model over-parametrization, which often requires introducing a dimension reduction of the predictor set. The authors

also note that classical estimators for factor analysis models, such as the maximum likelihood estimator, are not generally trustworthy when the number of variables is large compared to the number of observations (Ferrari, Ravazzolo and Vespignani, 2021).

The proposed model in this thesis aims to detect reversal points prior to their occurrence by using different leading indicators and applying them to reversal points in the past. The goal is to identify indicators with leading ability. Via a correlation matrix the correlation between different indicators will then be evaluated to identify highly correlating indicators with leading tendency. The result, in combination with cyclic trend evaluation, can be used to overlay different leading indicators and thus better forecast price changes and reversal points. The findings can then be used to better anticipate commodity trading and cycle movements, to improve inventory level management, or level of employment. Therefore, the main focus is on the short term cycles and medium term cycles of the already covered commodities oil, copper and uranium.

The medium term business cycles according to Juglar are business cycles with a period of between 7 and 11 years, and are based on fixed capital, including the renovation of production machinery, and not just changes in the level of employment or fixed capital (Korotayev and Tsirel, 2010). Kuznets swings, also known as demographic or building cycles/swings, are medium cycles with a duration of 15-25 years and refer to investments in construction and infrastructure (Korotayev and Tsirel, 2010).

Short-term business cycles, proposed by Joseph Kitchin in 1923, are brief and repetitive fluctuations in economic activity that typically occur within a period of less than two years or 8 quarters and are influenced by various factors, including changes in interest rates, inventory levels, and consumer sentiment (David White, 2006).

3.1.1 Quantification of technical indicators in the evaluation analysis

The following model analyzes the short term business cycles with a duration of up to eight quarters or two years, as well as medium term business cycles with a duration of 7 to 25 years by using different technical and economic indicators to identify their leading ability. To evaluate whether or not an indicator is suitable and fulfils its leading ability various reversal points of cycles in the past are analyzed. Each indicator is then compared to the respective time of the reversal point, and it is examined how strong the indicator deflects at this point. The range used to obtain information about the indicator's leading ability is from zero to 100, whereas 0 stands for no leading correlation and 100 stands for strong leading correlation of the given indicator relative to the commodity or index. To get rid of the background noise resulting from short-term fluctuation and short-term volatility a one month chart is used as it can be seen in Figure 50 for Oil.

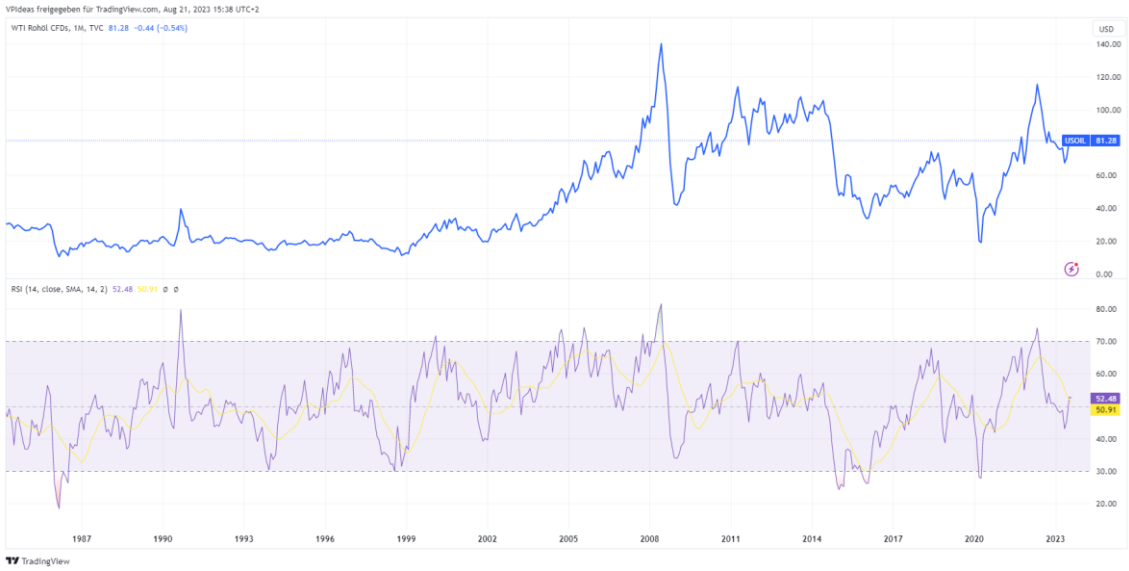

Figure 50: Oil price monthly chart and Relative Strength Index (RSI) from 1985 to 2023 (*Tradingview.com*, 2023)

In the upper half the chart of the oil price can be seen whereas in the lower half the RSI is shown which measures the speed and change of price movements. The RSI indicates overbought conditions when above 70 and oversold conditions when below 30.

Here, when the RSI is above 70, indicating overbought conditions, and a trend reversal occurred leading to a decrease in price for a given time, the value obtained for this indicator is 100. On the contrary, when the RSI is below 30, indicating oversold conditions, and a trend reversal occurred leading to an increase in price for a given time, the value obtained is also 100 because the indicator indicates the reversal and the right direction of the reversal. If the RSI is at 50 during a price reversal, it indicates no leading or predictive ability and thus the value obtained is 0. The same principle is used for Stochastic Oscillator (SO), Bollinger Band (BB), Commodity Channel Index (CCI) and Williams %R (W%R). The indicators Moving Average Convergence Divergence (MACD), Simple Moving Average of 48 months (SMA48), and Fear & Greed Index (F&G) use a different evaluation method. These indicators are evaluated based on patterns as shown in Figure 51, where the green and red bars, which represent the fear and greed of market participants respectively, are used to decide whether to buy or sell a stock or commodity.

3.1.2 Quantification of economic indicators in the evaluation analysis

Economic indicators are also valued with a range from zero to 100 whereas again, 0 stands for no leading correlation and 100 stands for strong leading correlation of the given indicator relative to the commodity or index. Whether it is for change in inventory, industrial production growth, production levels, or producer price index, the indicators are valued at 100 if the correlation of the given indicator is high when compared to a specific time in the past. It could be that the consumer price index is valued at 0 and the producer price index is valued at 70 when considering the same time due to the fact that the CPI only shows little leading ability whereas the PPI shows higher leading ability. This could be due to the fact that the CPI measures the price consumers have to pay for goods and services whereas the PPI measures the price organizations have to pay for

raw materials and semi-finished parts. So the CPI is dependent on the PPI. Additionally, a price correlation matrix is created showing the correlation between the commodity price and the used economic indicators.

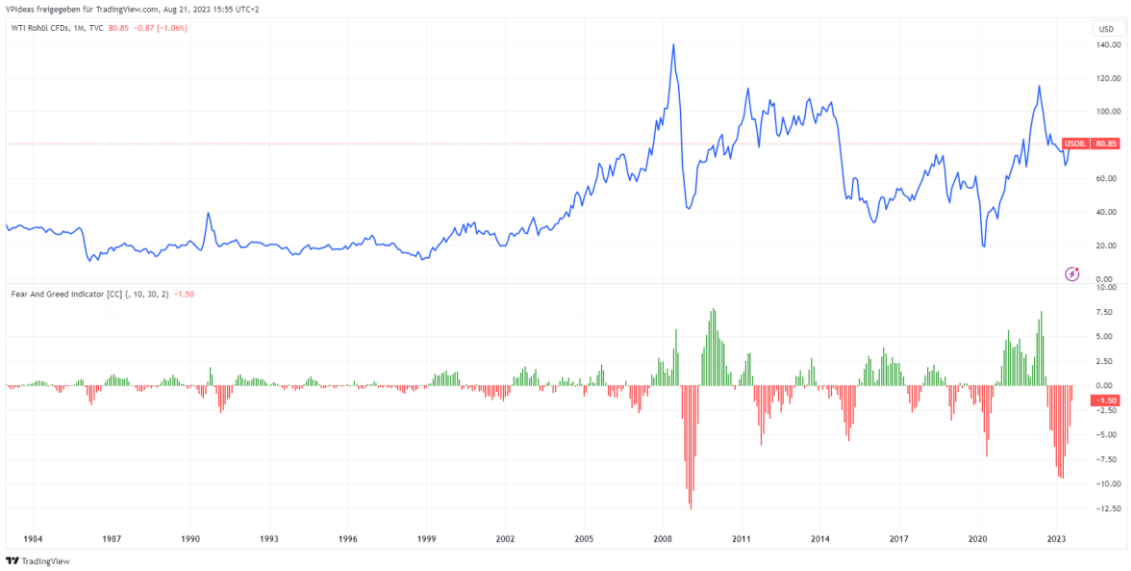

Figure 51: Oil price chart 1 month and Fear and Greed Index from 1994 to 2023 (*Tradingview.com*, 2023)

3.1.3 Problems with the evaluation method

The problem or downside with these indicators is that one can never exactly tell how far the indicator will go up. When taking a closer look at Figure 50 extreme overbought conditions can be seen in 1990, 2008, and 2022. Strong overbought conditions can be detected in 2000, 2011, or 2018 where the RSI does not go beyond the 70 mark. Thus the range can also be seen as influential between 25 and 65. The same principle can be used for the other oscillators. When having a look at the Fear and Greed Index in Figure 51 it can be seen that it is even harder to determine when there is extreme greed or fear since no range is given to adhere. The critical point here is that one never knows if the next bar is higher or lower than the previous one. So these indicators must be treated with caution.

3.1.4 Used indicators for further evaluation of leading indicators

The proposed model uses a total of 18 indicators of that eight technical and 10 economic indicators, are used to evaluate the leading ability for commodity trading in the short-, and medium term cycles. The following indicators are used: Relative Strength Index (RSI), Stochastic Oscillator (SO), Moving Average Convergence Divergence (MACD), Bollinger Band (BB), Commodity Channel Index (CCI), Williams %R (W%R), Simple Moving Average of 48 months (SMA48), Fear & Greed Index (F&G), Change in Inventory (Inventory), Capital Expenditures (CAPEX), Currency Exchange Rate (CER), Industrial Production Growth (IPG), Unemployment Rate (UR), Consumer Price Index (CPI), Producer Price Index (PPI), 10-Year Treasury Yield Minus 2-Year Treasury Yield Spread

(YCS), 3-Month Yield curve of U.S. Government bonds (3MYC), and Interest Rate (IR). All these indicators are obtained from the software (*Tradingview.com*, 2023). A brief description of each indicator can be found in 2.5.4 and 2.5.5.

3.2 Oil price evaluation of short-, medium-, and long-term cycles

This sub-chapter deals with the analyzation and evaluation of short-, medium- and long-term cycles of the oil price. The model is used to identify indicators with possible leading tendency and then compares the indicators with each other in a correlation matrix to identify suitable indicators which can be overlayed to better forecast price changes, cyclic movements or reversal points.

3.2.1 Oil price short-term cycle evaluation and result discussion

For the evaluation and analyzation of the short term predictability, the oil price chart was divided into short term cycles up to two years as far as possible, Figure 52. For in detail analyzation the following cycle reversal points were chosen: May 2023, May 2022, May 2020, August 2019, December 2018, July 2018, February 2016, August 2013, December 2012, September 2011, September 2010, January 2009, and July 2008. For each date, the 18 indicators were analyzed and values from 0 to 100 were distributed.

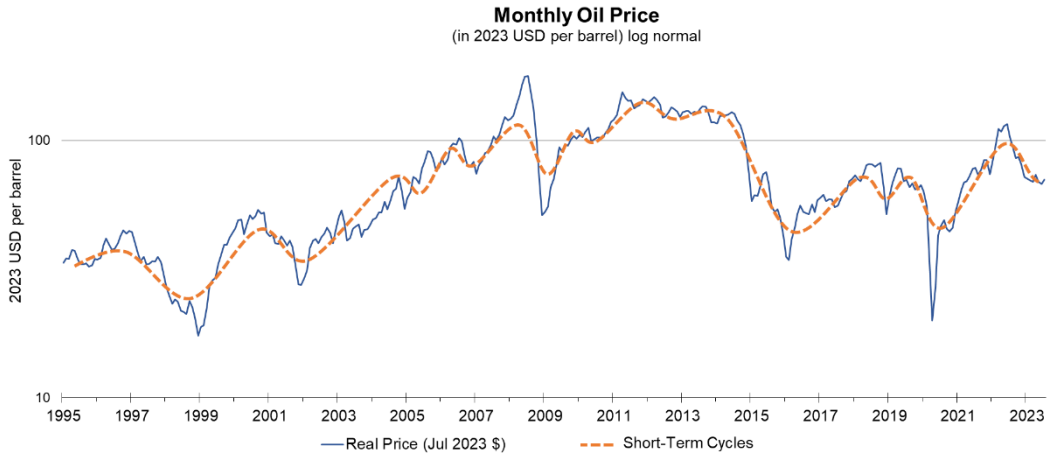

Figure 52: Monthly oil price in 2023 USD, log normal, from 1995 to 2023 based on (World Bank, 2023)

Table 1 shows the leading correlation for given indicators, zero to 100, whereas 0 stands for no leading correlation and 100 stands for strong leading correlation of the given indicator. The chart to analyze the technical correlation was obtained from the software (*Tradingview.com*, 2023) and was shown in 1-Month period. The economic data was obtained from (Federal Reserve Bank of St. Louis, 2023) and the charts there were also shown in 1-Month period. The short-term cycle analyzation revealed high leading ability for technical indicators and little to no leading ability for economic indicators. The indicator with the highest leading ability was concluded to be Commodity Channel Index (CCI), Relative Strength Index (RSI), Williams %R (W%R), Bollinger Band, and

Stochastic Oscillator (SO). All the indicators with high leading tendencies are an Oscillator, meaning they operate between a specific range of numbers or parameters. The indicators Moving Average Convergence Divergence (MACD), Simple Moving Average of 48 months (SMA48), and Fear & Greed Index (F&G) show fewer leading tendencies. An explanation can be that they are based on sentiments and historical chart patterns like the Fear & Greed index, or the MACD, respectively.

Table 1: Oil short-term leading correlation for given indicators, 1 month WTI crude oil price chart, data based on (Federal Reserve Bank of St. Louis, 2023; *Tradingview.com*, 2023)

Cycle	Indicator Leading Ability																	
Reversal Date	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
May-23	50	100	0	60	100	100	0	60	20	0	0	20	0	0	0	0	0	0
May-22	100	100	0	100	100	100	100	50	0	0	0	0	0	0	0	0	40	0
May-20	100	100	20	100	100	90	90	50	0	30	0	30	0	0	0	0	30	0
Aug-19	0	20	50	20	0	30	0	0	0	0	0	0	0	0	0	0	0	0
Dec-18	50	100	50	80	100	100	20	10	60	0	0	0	0	0	0	0	0	0
Jul-18	90	100	0	80	100	100	60	20	0	20	0	0	0	0	0	0	0	0
Feb-16	100	100	50	60	100	100	100	0	0	50	0	40	0	0	0	0	0	0
Aug-13	50	100	0	90	100	100	20	0	0	20	0	0	0	0	0	0	0	0
Dec-12	0	20	0	0	20	20	20	20	0	0	0	0	0	0	0	0	0	0
Sep-11	20	90	20	20	20	100	10	20	0	0	0	0	0	0	0	0	0	0
Sep-10	10	0	0	0	50	40	0	0	20	0	0	0	0	0	0	0	0	0
Mar-10	30	100	60	60	80	100	10	30	40	0	0	20	0	0	0	0	0	0
Jan-09	80	100	0	90	100	100	90	60	0	0	0	0	0	0	0	0	0	0
Jul-08	100	100	0	100	100	100	100	40	0	0	0	50	0	0	0	0	0	0

Since only the technical indicators show strong correlation Table 2 shows only the technical indicators of the correlation matrix. The full correlation matrix is attached in the appendix, Table 17. The RSI, SO, CCI, and BB, show good correlation results of over 0,8 and even 0,9. As this result shows, a combination of RSI, BB, and CCI could make a good leading indicator to predict cycle movement or reversal point determination.

Table 2: Correlation of used indices, -1 stands for negative correlation, zero stands for no correlation, and 1 stands for perfect correlation

	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G
RSI	1							
SO	0,74	1						
MACD	-0,18	0,05	1					
BB	0,86	0,83	-0,12	1				
CCI	0,83	0,78	-0,17	0,87	1			
W%R	0,70	0,96	0,02	0,78	0,78	1		
SMA48	0,90	0,50	-0,19	0,68	0,58	0,44	1	
F&G	0,46	0,47	-0,39	0,50	0,43	0,40	0,42	1
Inventory	-0,25	0,08	0,50	-0,02	0,17	0,14	-0,44	-0,11
CAPEX	0,52	0,31	0,20	0,27	0,38	0,26	0,46	-0,26

An overlying set of indicators of RSI, BB, and CCI is shown in Figure 53. The figure shows the oil price on top including the Bollinger Band, below the Relative Strength Index (RSI), and on the bottom the CCI can be seen from 2000 to 2023. As it can be seen, when a trend reversal happened, the oil price protrudes from the Bollinger Band range. Additionally, the RSI protrudes beyond the borders of 30 or 70, and the CCI protrudes beyond the borders of -100 and 100. It can be said that if these three indicators show a strong deviation beyond their ranges, the possibility of a trend reversal is given.

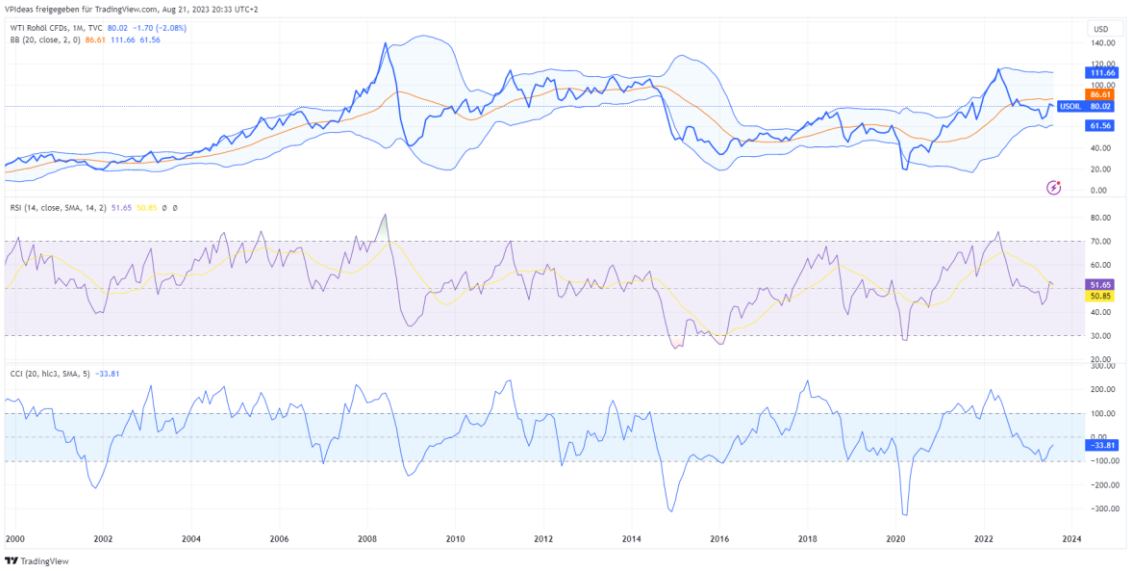

Figure 53: Oil price, Bollinger Band, Relative Strength Index, and Commodity Channel Index from 2000 to 2023 (*Tradingview.com*, 2023)

3.2.2 Oil price medium-term cycle evaluation and result discussion

For the evaluation and analyzation of the medium term predictability, the oil price chart was divided into medium term cycles from three up to 10 years, Figure 54. For in detail analyzation the following cycle reversal points were chosen: May 2022, April 2020, August 2018, January 2016, April 2012, January 2009, June 2008, December 2001, October 2000, December 1998, December 1996, December 1993, November 1990, and November 1988. For each date, the 18 indicators were analyzed and values from 0 to 100 were distributed.

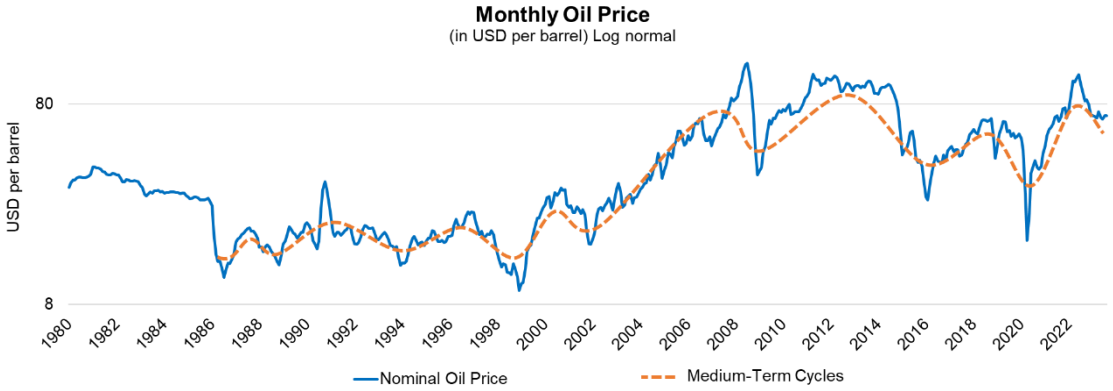

Figure 54: Monthly oil price in 2023 USD, log normal, from 1980 to 2023 based on (World Bank, 2023)

Table 3 shows the leading correlation for given indicators, zero to 100, whereas 0 stands for no leading correlation and 100 stands for strong leading correlation of the given indicator. The chart to analyze the technical correlation was obtained from (*Tradingview.com*, 2023) and was shown in 1-Month period. The economic data was obtained from (Federal Reserve Bank of St. Louis, 2023) and the charts also were shown in 1-Month period. The short-term cycle analyzation revealed high leading ability for technical indicators and little to no leading ability for economic indicators. The indicator

with the highest leading ability was concluded to be Commodity Channel Index (CCI), Relative Strength Index (RSI), Williams %R (W%R), Bollinger Band, Stochastic Oscillator (SO), and also the Simple Moving Average of 48 months (SMA48) showed higher leading tendencies. All the indicators, except the SMA48, with high leading tendencies are an Oscillator, meaning they operate between a specific range of numbers or parameters. The indicators Moving Average Convergence Divergence (MACD), , and Fear & Greed Index (F&G) show fewer leading tendencies. An explanation can be that they are based on sentiments and historical chart patterns like the Fear & Greed index, or the MACD, respectively.

Table 3: Oil medium-term leading correlation for given indicators, 1 month WTI crude oil price chart, data based on (Federal Reserve Bank of St. Louis, 2023; *Tradingview.com*, 2023)

Cycle	Indicator Leading Ability																	
Reversal Date	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
May-22	100	100	30	100	100	90	100	50	0	0	0	40	0	0	0	0	20	0
Apr-20	100	100	50	100	100	100	100	40	0	0	0	60	0	0	0	0	20	0
Aug-18	70	100	10	90	100	100	50	0	0	0	0	40	0	0	0	0	0	0
Jan-16	100	100	0	50	100	100	100	0	0	0	0	40	0	0	0	0	0	0
Apr-12	20	80	0	50	80	80	40	0	0	0	0	0	0	0	0	0	0	0
Jan-09	80	100	60	90	100	100	100	80	0	0	0	0	0	0	0	0	0	0
Jun-08	100	80	30	100	100	100	100	60	0	0	0	0	0	0	0	0	0	0
Dec-01	50	100	20	100	100	100	20	50	0	0	0	40	0	0	0	0	0	0
Oct-00	70	80	0	80	100	80	100	0	0	0	0	30	0	0	0	0	20	0
Dec-98	90	100	0	80	100	100	90	20	0	0	0	0	0	0	0	0	0	0
Dec-96	90	100	0	100	100	100	90	0	0	0	0	0	0	0	0	0	0	0
Dec-93	90	100	0	100	100	100	90	0	0	0	0	0	0	0	0	0	0	0
Nov-90	100	100	30	100	100	90	100	40	0	0	0	20	0	0	0	0	0	0
Nov-88	20	100	20	100	100	90	80	20	0	0	0	30	0	0	0	0	0	0

Since only the technical indicators show strong correlation Table 4 shows only the technical indicators of the correlation matrix, the full correlation matrix is attached in the appendix, Table 18. The RSI, SO, CCI, and W%R, show mediocre correlation results of over 0,5 to 0,6. The correlation of MACD and F&G is neglected here since the leading ability of each indicator only shows weak correlation. As this result shows, a combination of RSI, BB, and CCI could make a proper leading indicator to predict cycle movement or reversal point determination.

Table 4: Correlation of used indices, -1 stands for negative correlation, 0 stands for no correlation, and 1 stands for perfect correlation

	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G
RSI	1							
SO	0,26	1						
MACD	0,22	0,21	1					
BB	0,25	0,36	0,46	1				
CCI	0,58	0,53	0,26	0,62	1			
W%R	0,50	0,59	0,23	0,34	0,57	1		
SMA48	0,69	0,06	0,26	0,16	0,47	0,08	1	
F&G	0,23	0,11	0,88	0,46	0,27	0,26	0,17	1

Additionally, a price correlation matrix is created showing the correlation between the commodity price and the used economic indicators as shown in Table 5. The result shows that the oil price´s correlation compared to Industrial Production Growth (IPG), Producer Price Index (PPI), and Change in Inventory (Inventory) shows higher results. The IPG and PPI show positive correlation, which means that a positive change of the oil price goes hand in hand with a positive change of the IPG and PPI. Inventory shows

a negative correlation which means that an increase in oil price goes hand in hand with a decrease in inventory, which surely makes sense. All other indicators show only weak to no correlation.

Table 5: Price correlation between oil price and used economic indicators, except CAPEX, in percent chance from year ago, from 2000 to 2023

	Oil Price	IPG	UR	USD/EUR	IR	YCS	3MYC	PPI	CPI	Inventory
Oil Price	1									
IPG	0,60	1								
UR	-0,36	-0,73	1							
USD/EUR	0,28	0,12	0,07	1						
IR	-0,03	0,09	-0,15	-0,19	1					
YCS	-0,08	-0,01	0,01	-0,09	0,00	1				
3MYC	0,03	0,09	-0,18	-0,25	0,79	0,01	1			
PPI	0,79	0,61	-0,42	0,21	0,13	-0,06	0,23	1		
CPI	0,08	0,18	-0,31	-0,30	0,36	0,01	0,46	0,35	1	
Inventory	-0,63	-0,52	0,39	-0,33	0,03	0,02	-0,06	-0,71	-0,24	1

For more in depth evaluation and model confirmation, the price of oil was delayed for one, two, and three months, as well as forwarded for one month to investigate whether or not the correlation increases or decreases when shifting the values. The idea was to compare the price of oil, e.g. from January 2000, which is measured in percentage and year over year comparison, with the considered economic indicators from April 2000 to get further information if a change in indicator has an impact on the price, which can be seen in . The results for oil show arbitrary results as Table 6 shows. Although correlation increases for each of the three indicators if the price is one month delayed and decreases if the price is one month forwarded, the correlation does not show any valuable outcome when delaying the price for two or three months.

Table 6: Forward and delayed oil price correlation

	1M Forward	Actual	1M Delay	2M Delay	3M Delay
IPG	0,50	0,60	0,62	0,56	0,48
PPI	0,69	0,79	0,82	0,80	0,76
Inventory	-0,56	-0,63	-0,66	-0,66	-0,63

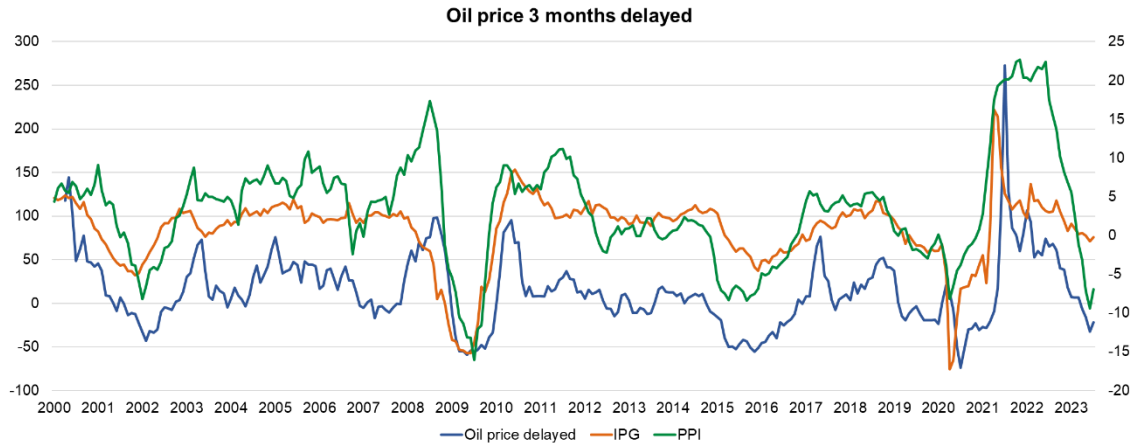

Figure 55: Oil price delayed by 3 months

3.2.3 Oil price long-term cycle evaluation and result discussion

It was to be expected that inventory stocks, CAPEX, PPI, or Industrial Production Growth show some leading tendencies, but the study showed that this is not the case. One might argue that inventories and capital expenditures do have influence on the price of a commodity, thus a further analysis is conducted. As Table 5 shows, Production Growth, Producer Price Index, and changes in inventory show higher correlation in price changes. Figure 56 shows the negative correlation between oil price and inventory, a decreasing inventory stock often goes hand in hand with rising prices and vice versa. Although this correlation is shown here, it does not mean that the change in inventory has leading tendencies and is able to predict possible price movements. Yes, if inventory is extremely low and about to rise, a falling oil price could be assumed, but one cannot say when the price change or reversal will happen. Again, data shows no information that a change in inventory has substantial forecasting possibilities for the oil price.

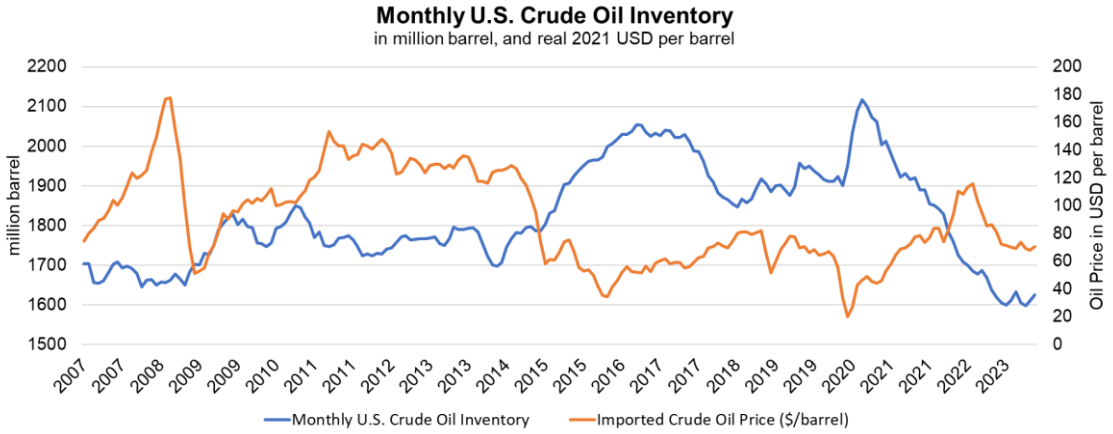

Figure 56: Monthly US crude oil inventory, and price per barrel in 2023 USD, based on (eia.gov, 2023)

Also capital expenditures do not show leading tendencies and were excluded from the correlation matrix since no data on monthly year over year change was available. As Figure 57 shows, and as it was already covered in detail in chapter 2.1.1 the price of oil leads CAPEX. But a trend can be seen here, namely if CAPEX are too low over a longer period of time, the price of oil starts to rise. Again, data shows no information that a change in CAPEX has substantial forecasting possibilities for the oil price.

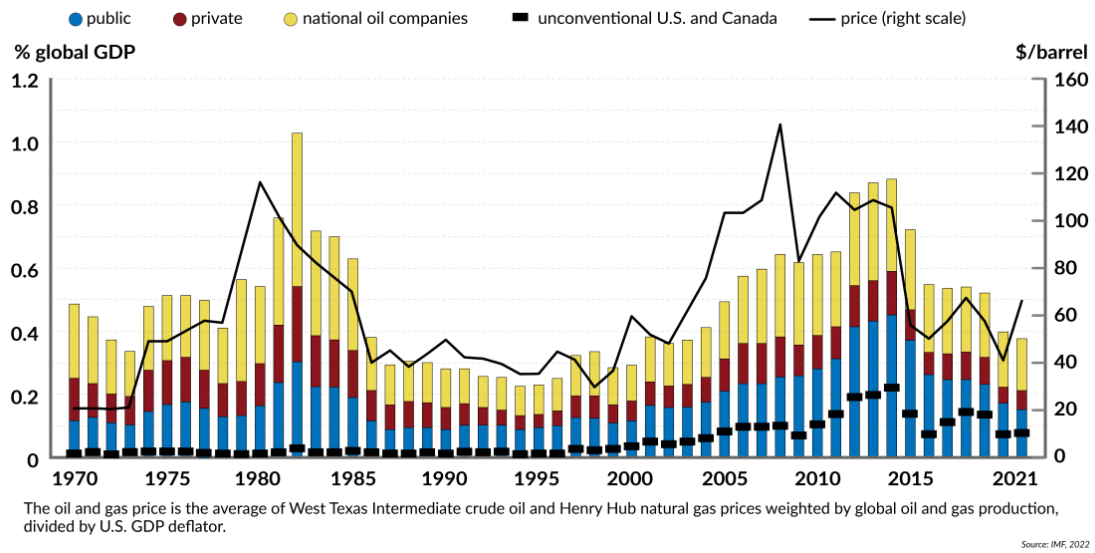

Figure 57: Oil and gas investment as a share of world GDP and USD per barrel, from 1970 to 2021 (Nakhle, 2022)

3.2.4 Discussion of short-, medium-, and long-term results

It was to be expected that economic indicators are not very good at predicting price changes. This may result from the fact that indicators such as CAPEX, GDP growth, Industrial Production Growth, Unemployment Rate, or Interest Rates do not change gradually and not so fast to trigger a sharp cycle reversal. In most cases changes in GDP growth, interest rates, unemployment rate, or bond yields are known prior to their release date. Thus, the market adapts its price as soon as these information is made public.

The indicator correlation for medium-term cycles is lower compared to indicator correlation for short-term cycles. This may be due to the fact that medium term cycles are more affected by other additional indicators, such as supply chain, geopolitical and others and thus, the quality in predicting the price of technical indicators decreases.

3.3 Copper price evaluation of short-, medium-, and long-term cycles

This sub-chapter deals with the analyzation and evaluation of short-, medium- and long-term cycles of the copper price. The model is used to identify indicators with possible leading tendency and then compares the indicators with each other in a correlation matrix to identify suitable indicators which can be overlayed to better forecast price changes, cyclic movements or reversal points. To summarize, the structure in this chapter follows the same procedure as chapter 3.2 thus this chapter focuses on the results only.

3.3.1 Copper price short-term cycle evaluation and result discussion

For the evaluation and analyzation of the short term predictability, the copper price chart was divided into short term cycles up to two years as far as possible, Figure 58. For in

detail analyzation the following cycle reversal points were chosen: January 2022, April 2020, February 2018, January 2016, August 2014, June 2012, March 2011, July 2010, December 2009, January 2009, May 2008, December 2007, July 2007, and February 2007.. For each date, the 18 indicators were analyzed and values from 0 to 100 were distributed.

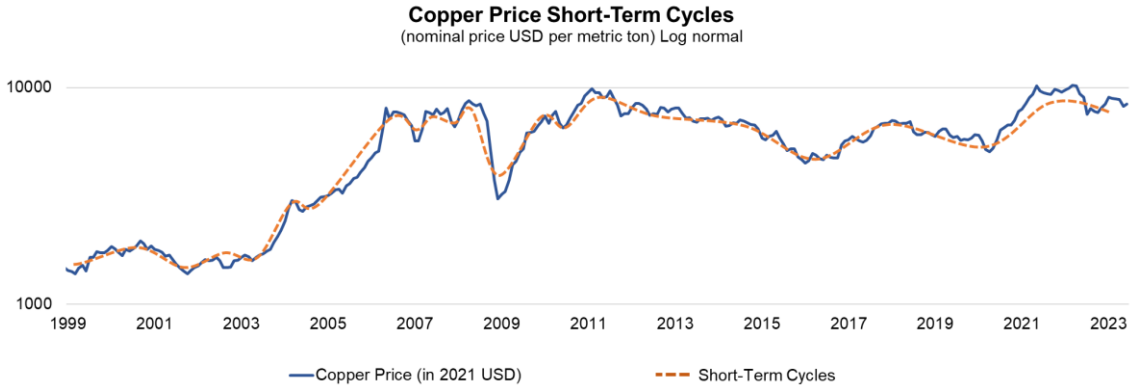

Figure 58: Monthly copper price in USD, log normal, from 1999 to 2023 based on (World Bank, 2023)

Table 7 shows the leading correlation for given indicators and revealed high leading ability for technical indicators and no leading ability for economic indicators. The indicators with the highest leading ability were concluded to be RSI, SO, BB, CCI, and W%R.

Table 7: Copper short-term leading correlation for given indicators, 1 month copper price chart, data based on (Federal Reserve Bank of St. Louis, 2023; *Tradingview.com*, 2023)

Cycle	Indicator Leading Ability																	
Reversal Date	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
Jan-22	100	90	60	40	90	80	60	20	0	0	0	0	0	0	0	0	0	0
Apr-20	70	100	0	100	100	20	20	0	0	0	0	0	0	0	0	0	0	0
Feb-18	80	100	10	60	100	100	30	0	0	0	0	0	0	0	0	0	0	0
Jan-16	100	100	10	80	100	100	50	0	0	0	0	0	0	0	0	0	0	0
Aug-14	30	0	0	20	40	50	20	0	0	0	0	0	0	0	0	0	0	0
Jun-12	20	30	0	50	90	0	60	0	0	0	0	0	0	0	0	0	0	0
Mar-11	100	100	20	90	100	100	80	50	0	0	0	0	0	0	0	0	0	0
Jul-10	0	0	0	40	60	60	10	20	0	0	0	0	0	0	0	0	0	0
Dec-09	50	100	0	50	80	100	10	80	0	0	0	0	0	0	0	0	0	0
Jan-09	100	100	20	100	100	100	60	70	0	0	0	0	0	0	0	0	0	0
May-08	70	100	0	80	90	50	50	20	0	0	0	20	0	0	0	0	0	0
Dec-07	0	0	0	40	70	50	50	10	0	0	0	0	0	0	0	0	0	0
Jul-07	80	100	0	50	80	100	60	10	0	0	0	0	0	0	0	0	0	0
Feb-07	0	80	0	0	0	70	50	80	0	0	0	0	0	0	0	0	0	0

Since only the technical indicators show strong correlation Table 8 shows only the technical indicators of the correlation matrix, the full correlation matrix is attached in the appendix, Table 19Table 18. The RSI, BB, SO, and CCI show higher to strong correlation results of over 0,7 to 0,85. As this result shows, a combination of RSI, CCI, and BB could make a proper leading indicator to predict cycle movement or reversal point determination.

Table 8: Correlation of used indices, -1 stands for negative correlation, 0 stands for no correlation, and 1 stands for perfect correlation

	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G
RSI	1							
SO	0,78	1						
MACD	0,58	0,31	1					
BB	0,70	0,54	0,12	1				
CCI	0,73	0,45	0,32	0,85	1			
W%R	0,55	0,53	0,34	0,13	0,15	1		
SMA48	0,40	0,30	0,42	0,22	0,23	0,17	1	
F&G	-0,02	0,32	0,08	-0,08	-0,31	0,43	0,09	1

3.3.2 Copper price medium-term cycle evaluation and result discussion

For the evaluation and analyzation of the medium term predictability, the copper price chart was divided into medium term cycles from 3 up to 10 years, Figure 59.For in detail analyzation the following cycle reversal points were chosen: February 2022, March 2020, January 2018, February 2016, July 2011, December 2008, May 2008, November 2001, and September 2000. For each date, the 18 indicators were analyzed and values from 0 to 100 were distributed.

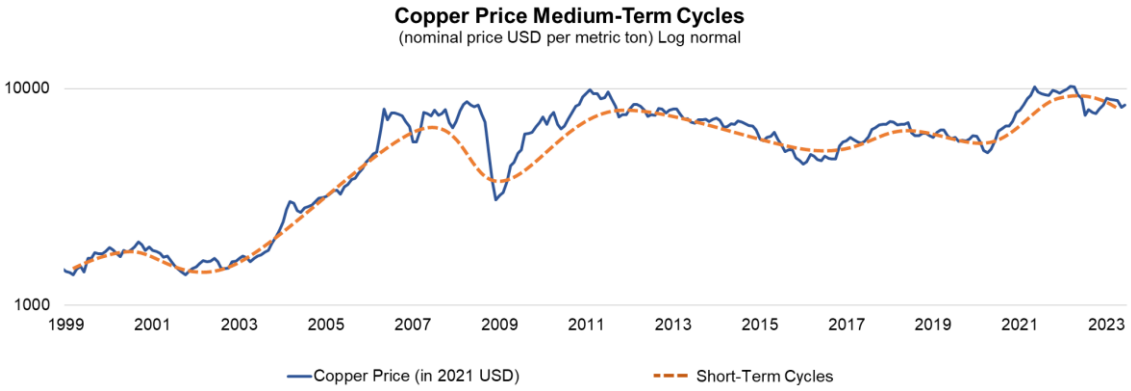

Figure 59: Monthly copper price in USD, log normal, from 1999 to 2023 based on (World Bank, 2023)

Table 9 shows the leading correlation for given indicators and revealed high leading ability for technical indicators and no leading ability for economic indicators. The indicators with the highest leading ability were concluded to be RSI, SO, BB, CCI, and W%R.

Table 9: Copper medium-term leading correlation for given indicators, 1 month copper price chart, data based on (Federal Reserve Bank of St. Louis, 2023; *Tradingview.com*, 2023)

Cycle	Indicator Leading Ability																	
Reversal Date	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
Feb-22	100	90	60	40	90	80	60	20	0	0	0	0	0	0	0	0	0	0
Mar-20	70	100	0	100	100	20	20	0	0	0	0	0	0	0	0	0	0	0
Jan-18	80	100	10	60	100	100	30	0	0	0	0	0	0	0	0	0	0	0
Feb-16	100	100	10	80	100	100	50	0	0	0	0	0	0	0	0	0	0	0
Jul-11	80	100	20	60	90	100	60	0	0	0	0	0	0	0	0	0	0	0
Dec-08	90	100	50	100	100	70	100	60	0	0	0	0	0	0	0	0	0	0
May-08	50	90	0	50	90	50	60	20	0	0	0	0	0	0	0	0	0	0
Nov-01	20	80	0	70	100	40	0	0	0	0	0	0	0	0	0	0	0	0
Sep-00	60	100	0	80	100	100	0	0	0	0	0	0	0	0	0	0	0	0

Since only the technical indicators show strong correlation Table 10Table 4 shows only the technical indicators of the correlation matrix, the full correlation matrix is attached in the appendix Table 20. The RSI, SO, BB, CCI, and W%R show higher to strong correlation results of over 0,65 to 0,76. The F&G and SMA48 correlation is neglected since the F&G indicator shows very little leading ability. As this result shows, a combination of RSI, CCI and BB could make a proper leading indicator to predict cycle movement or reversal point determination.

Table 10: Correlation of used indices, -1 stands for negative correlation, 0 stands for no correlation, and 1 stands for perfect correlation

	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G
RSI	1							
SO	0,78	1						
MACD	0,58	0,31	1					
BB	0,70	0,54	0,12	1				
CCI	0,73	0,45	0,32	0,85	1			
W%R	0,55	0,53	0,34	0,13	0,15	1		
SMA48	0,40	0,30	0,42	0,22	0,23	0,17	1	
F&G	-0,02	0,32	0,08	-0,08	-0,31	0,43	0,09	1

Additionally, a price correlation matrix is created showing the correlation between the commodity price and the used economic indicators as shown in Table 11. The result shows that the copper price´s correlation compared to IPG, and PPI shows higher results and no correlation to inventory was shown.

Table 11: Price Correlation between copper price and used economic indicators, except CAPEX, in Percent Chance from year ago, from 2000 to 2023

	Copper Price	IPG	UR	USD/EUR	IR	YCS	3MYC	PPI	CPI	Inventory
Copper Price	1									
IPG	0,45	1								
UR	-0,17	-0,73	1							
USD/EUR	0,38	0,12	0,07	1						
IR	-0,13	0,09	-0,15	-0,19	1					
YCS	-0,01	-0,01	0,01	-0,09	0,00	1				
3MYC	-0,16	0,09	-0,18	-0,25	0,79	0,01	1			
PPI	0,48	0,61	-0,42	0,21	0,13	-0,06	0,23	1		
CPI	-0,18	0,18	-0,31	-0,30	0,36	0,01	0,46	0,35	1	
Inventory	0,04	-0,01	-0,05	0,17	-0,22	0,10	-0,32	-0,22	-0,46	1

For more in depth evaluation and model confirmation, the price of copper was delayed for one, two, and three months, as well as the price was forwarded for one month to investigate whether or not the correlation increases. The results for copper show proper

results, but since the results for oil were so arbitrary the results for copper must be taken with caution, as Table 12 shows.

Table 12: Forward and delayed copper price comparison

	1M Forward	Actual	1M Delay	2M Delay	3M Delay
IPG	0,37	0,45	0,51	0,54	0,54
PPI	0,39	0,48	0,54	0,57	0,58

3.3.3 Copper price long-term cycle evaluation and result discussion

Neither inventory stocks, CAPEX, PPI, or Industrial Production Growth show leading tendencies, As Table 11 shows, IPG and PPI show some correlation in price changes and no correlation is shown between copper price and inventory. But as Figure 60 shows, some correlations can be seen between the price and CAPEX. After times of little capital expenditures in copper mining, the copper price tends to increase which entails new and delayed capital expenditures in copper mining. A similar behavior could be observed with oil.

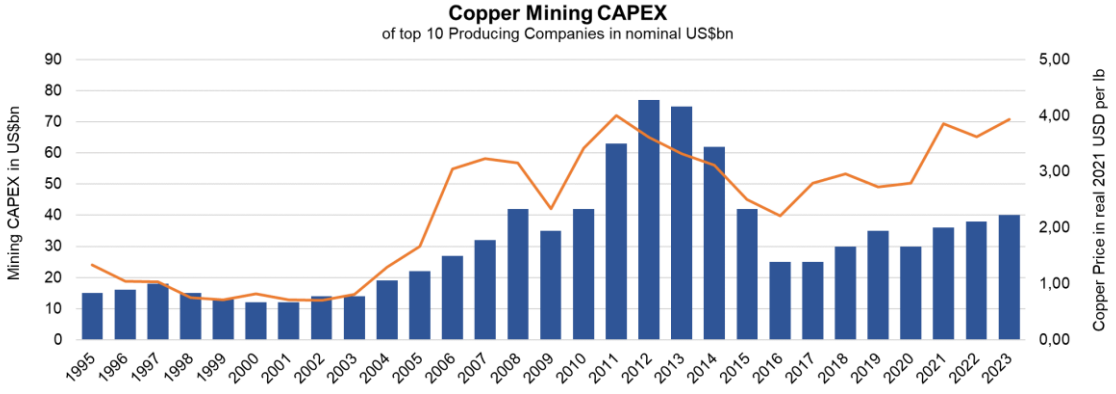

Figure 60: Copper mining capital expenditures of top 10 producing companies, in billion USD, from 1995 to 2023, authors creation, based on (BofA, 2023)

3.3.4 Discussion of short-, medium-, and long-term results

It was to be expected that economic indicators are not very good at predicting price changes. This may result from the fact that indicators such as CAPEX, GDP growth, Industrial Production Growth, Unemployment rate, or Interest Rates do not change gradually and not so fast to trigger a sharp cycle reversal. In most cases changes in GDP growth, interest rates, unemployment rate, or bond yields are known prior to their release date. Thus, the market adapts its price as soon as these information is made public.

The indicator correlation for medium-term cycles is lower compared to indicator correlation for short-term cycles. This may be due to the fact that medium term cycles are more affected by other additional indicators, such as supply chain, geopolitical and others and thus, the quality in predicting the price of technical indicators decreases.

3.4 Uranium price evaluation of short- and long-term cycles

This sub-chapter deals with the analyzation and evaluation of short- and long-term cycles of the uranium price. For the medium-term uranium price were not enough data available to conduct a proper cycle evaluation with the used indicators. The model is used to identify indicators with possible leading tendency and then compares the indicators with each other in a correlation matrix to identify suitable indicators which can be overlayed to better forecast price changes, cyclic movements or reversal points. To anticipate, the structure in this chapter follows the same procedure as chapter 3.3, thus this chapter focuses on the results only.

3.4.1 Uranium price short-term cycle evaluation and result discussion

For the evaluation and analyzation of the short term predictability, the uranium price chart was divided into short term cycles up to two years as far as possible, Figure 61. For in detail analyzation the following cycle reversal points were chosen: March 2021, December 2018, December 2016, April 2015, July 2014, March 2011, April 2010. For each date, the 18 indicators were analyzed and values from 0 to 100 were distributed.

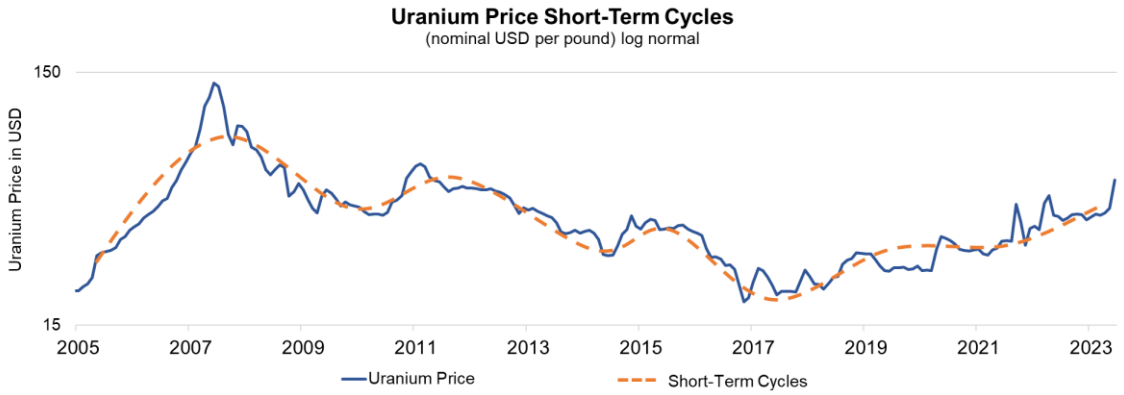

Figure 61: Monthly uranium price in USD, log normal, from 2005 to 2023 based on (World Bank, 2023)

Table 13 shows the leading correlation for given indicators and revealed mediocre leading ability for technical indicators and no leading ability for economic indicators. The indicators with the highest leading ability were concluded to be RSI, SO, BB, CCI, and W%R.

Table 13: Uranium short-term leading correlation for given indicators, 1 month uranium price chart, data based on(Federal Reserve Bank of St. Louis, 2023; *Tradingview.com*, 2023)

Cycle	Indicator Leading Ability																	
Reversal Date	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
Mar-21	40	60	0	20	20	40	0	10	0	0	0	0	0	0	0	0	0	0
Dec-18	70	100	40	90	100	100	0	0	0	0	0	0	0	0	0	0	0	0
Dec-16	100	100	40	90	100	100	40	50	0	0	0	0	0	0	0	0	0	0
Apr-15	0	50	10	40	80	20	0	40	0	0	0	0	0	0	0	0	0	0
Jul-14	100	100	0	90	100	100	70	0	0	0	0	0	0	0	0	0	0	0
Mar-11	30	100	40	60	90	90		80	0	0	0	0	0	0	0	0	0	0
Apr-10	100	100	0	50	90	100			0	0	0	0	0	0	0	0	0	0

Since only the technical indicators show strong correlation Table 14 shows only the technical indicators of the correlation matrix, the full correlation matrix is attached in the

appendix, Table 21. The RSI, W%R, SO, CCI, and BB higher to strong correlation results of over 0,75 to 0,99. As this result shows, a combination of RSI, SO, and W%R could make a proper leading indicator to predict cycle movement or reversal point determination.

Table 14: Correlation of used indices, -1 stands for negative correlation, 0 stands for no correlation, and 1 stands for perfect correlation

	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G
RSI	1							
SO	0,76	1						
MACD	-0,03	0,43	1					
BB	0,62	0,76	0,53	1				
CCI	0,44	0,70	0,46	0,83	1			
W%R	0,82	0,99	0,38	0,77	0,67	1		
SMA48	0,77	0,62	-0,15	0,61	0,50	0,62	1	
F&G	-0,37	0,08	0,52	-0,12	0,18	-0,02	-0,07	1

The price correlation matrix for uranium shows no correlation to the used economic indicators as shown in Table 15.

Table 15: Price correlation between uranium price and used economic Indicators, except CAPEX, in percent chance from year ago, from 2000 to 2023

	Uranium Price	IPG	UR	USD/EUR	IR	YCS	3MYC	PPI	CPI
Uranium Price	1								
IPG	0,23	1							
UR	-0,06	-0,73	1						
USD/EUR	0,18	0,12	0,07	1					
IR	0,01	0,09	-0,15	-0,19	1				
YCS	-0,01	-0,01	0,01	-0,09	0,00	1			
3MYC	0,00	0,09	-0,18	-0,25	0,79	0,01	1		
PPI	0,17	0,61	-0,42	0,21	0,13	-0,06	0,23	1	
CPI	0,04	0,18	-0,31	-0,30	0,36	0,01	0,46	0,35	1

For the medium-term uranium price were not enough data available to conduct a proper cycle evaluation with the used indicators.

3.4.2 Uranium price long-term cycle evaluation and result discussion

By analyzing the total uranium inventories weaker fluctuations can be recognized, compared to oil or copper. It has to be mentioned that this inventory data only represents the inventory of the Unites States. China or other countries like Russia, Kazakhstan, and other are not included since the published data is not usable or no data at all is published. Figure 62 shows no correlation between price and inventory, as concluded in Table 15.

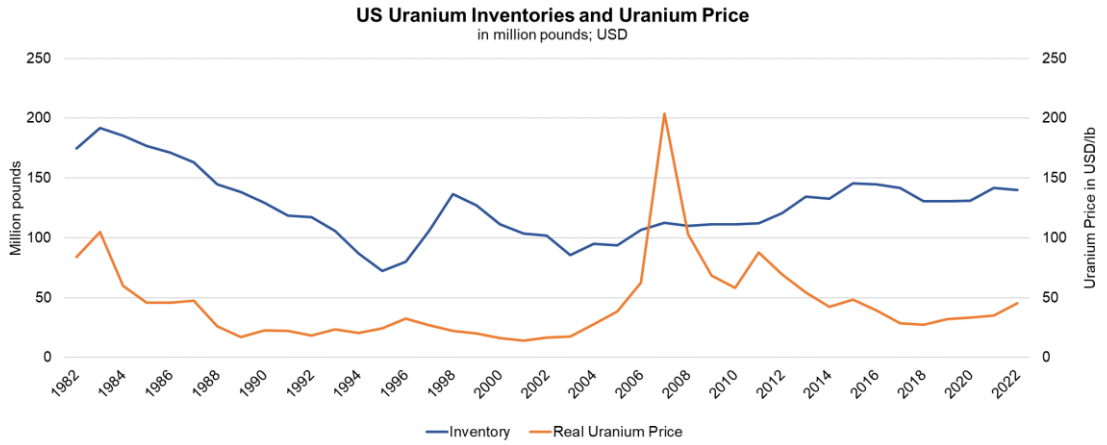

Figure 62: US uranium inventories and uranium price

When analyzing the CAPEX/Price correlation, similar results as with oil and copper can be seen. Long periods of low investment in exploration and production lead to an increase in price, as seen in Figure 63.

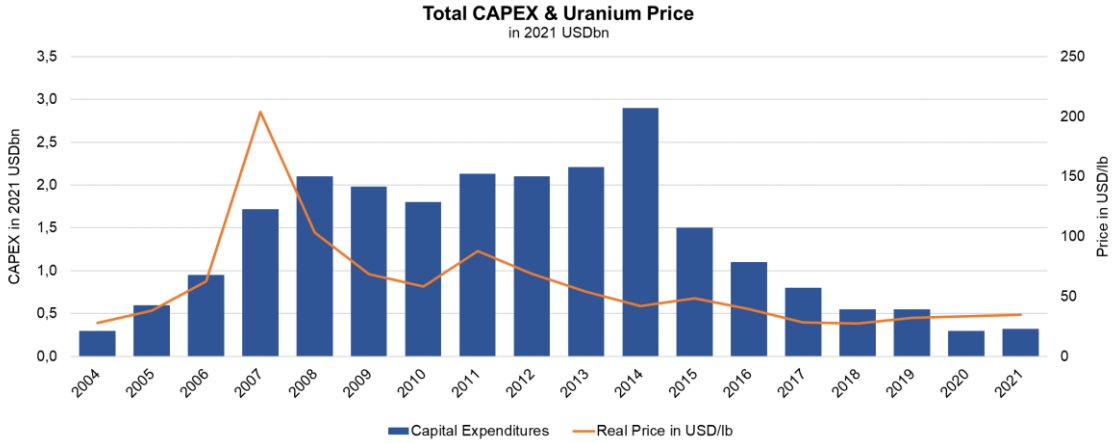

Figure 63: Capital expenditures in billion USD for exploration and development of uranium, from 2004 to 2021, authors creation, based on (IAEA & NEA, 2023)

3.4.3 Discussion of short-, medium-, and long-term results

Only few data were available for the analyzation of uranium price cyclicity. Economic indicators do not have any real predicting ability and the ability of technical indicators is also limited. Similar to oil and copper, the capital expenditures and price correlation can indicate changes in long term prices. But the timespan can range up to several year of low CAPEX until a price change happens.

3.5 Findings and results obtained from the proposed model

The data obtained from the model show that it is possible to use technical indicators to predict trend reversals and price changes to a certain degree. Economic indicators are not sufficient in predicting possible reversals even though the correlation of some indicators such as the Industrial Production Growth (IPG), Producer Price Index (PPI),

or inventory stock (for oil and copper) are very high. Indicators such as the Consumer Price Index (CPI), Unemployment Rate (UR), or the 3-Month Yield Curve and others can be used in addition to confirm trend reversals or price changes. Since economic indicators are either obtained from surveys, other economic data such as production output, supply and demand, or from geopolitical or policy changes which cannot be quantified in a sufficient manner to be used as indicators, economic indicators do not really show leading tendencies. This conclusion matches with the findings of (Gargano and Timmermann, 2014, p. 826) that neither a broad range of macroeconomic indicators, nor commodity exchange rates produce a strong evidence of spot price predictability.

3.5.1 Most suitable indicators with highest leading ability

Technical indicators may have some leading tendencies. For oil, the indicators with the highest leading ability are the Relative Strength Index (RSI), Bollinger Band (BB), and the Commodity Channel Index (CCI). A combination of these three indicators could eventually be helpful in predicting short-, to medium-trend reversals. For Copper, the indicators with the highest leading ability are also the Relative Strength Index (RSI), Bollinger Band (BB), and the Commodity Channel Index (CCI). A combination of these three indicators could eventually be helpful in predicting short-, to medium-trend reversals. For uranium, the indicators with the highest leading ability are Relative Strength Index (RSI), Stochastic Oscillator (OS), and Williams Percent Range (W%R). A combination of these three indicators could eventually be helpful in predicting short-, to medium-trend reversals.

The following chapter gives an outlook for oil, copper, and uranium prices by considering relevant indicators as well as short-, medium- and long-term cycles. The goal is to predict possible trend reversals, if there are such upcoming, to forecast the price change for the near future of up to eight quarters or even predict possible long term prices based on long-term trends.

3.5.2 Ranking of the leading indicators according to their forecasting ability

This section provides a ranking of the used leading indicators in this thesis. The indicators are ranked according to their ability to predict future price movements and reversal points. Each indicator is ranked according to its results from Table 7, Table 9, and Table 13. If an indicator showed high correlation with the examined event dates it was ranked higher. The procedure was conducted for short- and medium-term cycle evaluation for each commodity. The result, shown in Table 16 concludes that the CCI has the highest correlation to go beyond the set border line when a reversal point is coming up. The CCI is followed by SO, W%R, RSI and BB. These four indicators also all show high correlation among each other in the correlation matrix for oil, copper, and uranium. For the outlook in Chapter 4 the indicators RSI, W%R, and BB are used since they show the highest correlation .among themselves, as concluded earlier.

Table 16: Indicator ranking from best to worst in its predictive ability

Indicator	Ranking
CCI	1
SO	2
W%R	3
RSI	4
BB	5
SMA48	6
MACD	7
F&G	8
Inventory	9
CAPEX	10

4 Price outlook on oil, copper, and uranium

This chapter should give an outlook on possible future price behavior for oil, copper and uranium. Therefore, the most suitable indicators are used, in combination with current short-, middle-, and long-term price cycles. Capital expenditures are also considered to obtain the best result from this study.

4.1 Outlook for oil

This forecast starts with a brief analyzation of the long term cycle. As already described, the oil price is currently in its fifth long-term cycle since 1863 and when considering a cyclic duration of 40 to 60 years as proposed by (Kondratieff, 1925) the cycle is about to hit its peak in the next five years. When analyzing the medium term cycles, it can be seen that in 2020 a new cycle started to expand. Considering the declining CAPEX over the last five to 10 years it could be possible that the medium term cycle just started its expansion. Figure 64 shows the oil price chart with the three indicators RSI, BB, and CCI as well as the orange line which represents the short-term cycles, and the green line which represents the medium-term cycles. Back in Mach 2020 RSI, BB, and CCI show extremely oversold conditions, this was the time the currently decreasing short-term cycle started. CCI and BB already indicated a short-term trend reversal in May 2023 while the RSI showed only little valuable information.

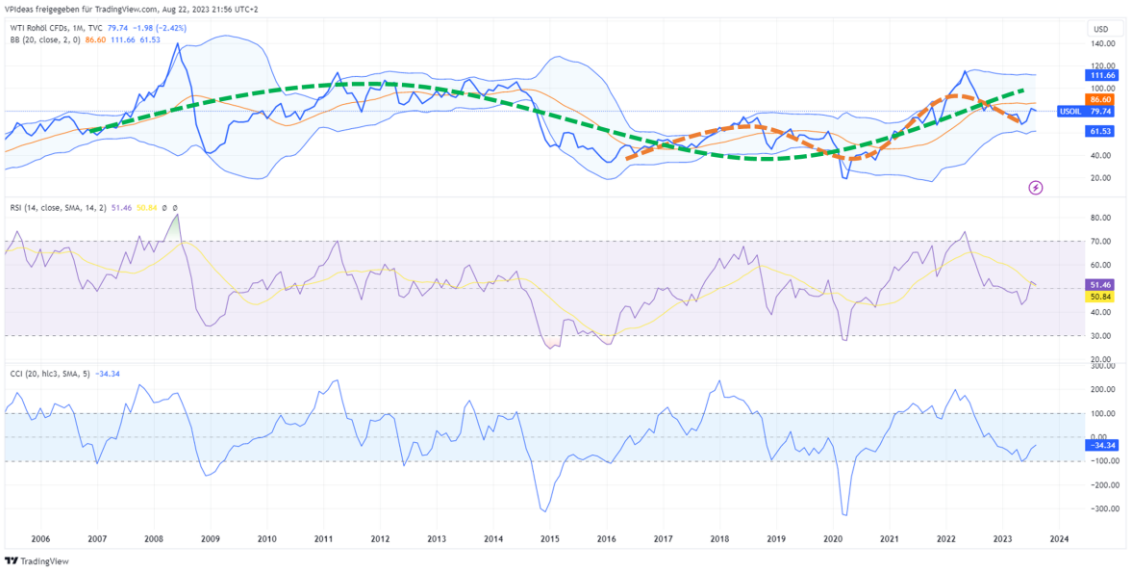

Figure 64: Analyzation of oil price with RSI, BB, and CCI (*Tradingview.com*, 2023)

To conclude this outlook, it might be possible that the oil price has reversed its course in the short term cycle to follow the upward trend of the medium-term cycle and thus it could rise again for the next one to two years, eventually reaching prices of 120 USD per barrel.

4.2 Outlook for copper

Again, the forecast starts with a brief analyzation of the long term cycle. The copper price is currently on an upward trend of a super cycle similar to the oil price. Considering the medium-term cycles, the copper price is also on the expansion of a cycle which reached its reversal point in 2016. Considering the slightly increasing but still lower CAPEX over the last five to 10 years it can be seen that the medium term price cycle reached its trough in 2016 when the capital expenditures were the lowest since 2005. This trend confirms the assumption that the medium term business cycle is still expanding and could reach its peak in the following two to five years. The current short-term trend reached its peak in 2022 and is currently expanding. Figure 65 shows the copper price chart with the three indicators RSI, BB, and CCI as well as the orange line which represents the short-term cycles, and the green line which represents the medium-term cycles. Back in Mach 2020 RSI, BB, and CCI show strong to extremely oversold conditions, this was the time the previous short-term cycle started. At the beginning of 2021 the RSI, CCI, and BB indicated a peak of the previous short-term trend and in September 2023 the indicators RSI and BB strongly indicated the beginning of a new short-term cycle while the RSI showed only little valuable information.

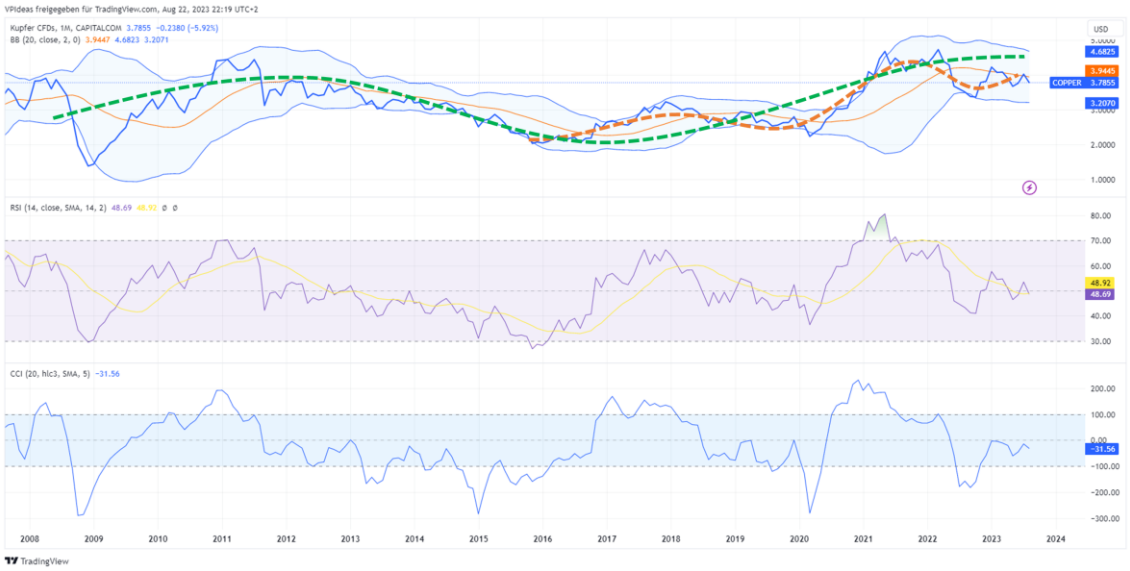

Figure 65: Analyzation of copper price with RSI, BB, and CCI (*Tradingview.com*, 2023)

To conclude this outlook, it might be possible that the copper price is on the rise with its current short-term cycle following the medium term cycle. Technical indicators confirm this trend, which could eventually last for up to five years with short-term ups and downs before reaching a long-term cycle reversal point at possible prices of up to USD 5 per pound. Or as (Flitton, 2023) stated, a copper price of USD 13,000 per ton (USD 6,8 per pound) by 2025 would be needed to ensure the economics of new projects.

4.3 Outlook for uranium

The forecast for uranium starts again with a brief analyzation of the long term cycle. The uranium price is currently at the beginning of a new long-term cycle which started in 2017 and slowly expanded from 17 USD per pound to currently 58 USD per pound. A current short-term cycle cannot be properly detected, thus the analysis is conducted based on medium-, and long-term cycles, although the current medium-term cycle is so long that it can be seen as long-term cycle. Considering the strong decreasing CAPEX over the last five to 10 years it is suggested that an increase in uranium price is just a matter of time, especially if the demand is slightly increasing. The trend of the decreasing CAPEX confirms the assumption that the medium term business cycle is at the beginning of its expansion and could reach its peak around 2030 or later. Figure 66 shows the uranium price chart with the three indicators RSI, OS, and W%R as well as the orange line which represents the short-term cycles, and the green line which represents the medium-term cycles. Back in 2016 RSI, OS, and W%R showed extremely oversold conditions, at this time the current medium-term cycle started. At the beginning of 2021, all three indicators showed oversold condition which led to a decrees in price from 58 USD per pound to 48 USD per pound or 17%.

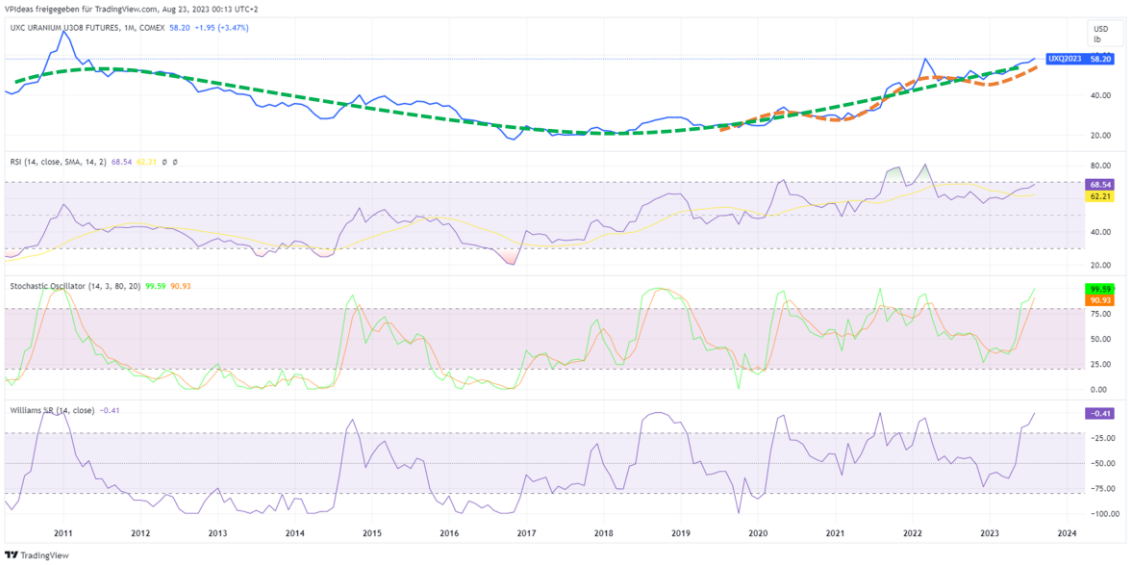

Figure 66: Analyzation of uranium price with RSI, SO, and W%R (*Tradingview.com*, 2023)

To conclude this outlook, it is possible that the long-term cycle of the uranium price could rise until 2030 or beyond. All three indicators indicate strong overbought conditions, which could be a sign of a decrease in price in the next couple of months. But the long-term trend is upwards and prices of 100 USD per pound or more could be possible in the next five years.

5 Conclusion

Business cycles can be divided into long-, medium- and short-term cycles each of them shows a historical duration of around 50, 10 to 20, and up to two years respectively. Long term cycles are influenced by a combination of factors including technological advances, global economic conditions, demographic shifts, and major policy changes. Medium-term cycles are influenced by factors such as investment in fixed capital, or investments in construction and infrastructure. Also monetary policy, consumer behavior, and investment dynamics can have an influence. Short-term cycles re believed to result from the fluctuations of enterprises' inventories, interest rates, and consumer sentiment. Business cycles have a significant impact on organizations and business decisions and should be considered in future planning..

Commodity prices experienced two large medium-term cycles in the 1970s and 2000s and energy prices are on an upward trend in the long term. The oil price is influenced by changes in investments in infrastructure and capital expenditures of companies. It also shows that the oil price negatively correlates with inventory stocks. The copper price is also influenced by changes in investments in infrastructure and capital expenditures. Inventories are constantly decreasing since 2018 and capital expenditures are limited. This combination could lead to new capital expenditure investments in exploration and mining. Empirical studies have found that uranium prices follow cyclical behavior similar to other energy commodities, but the price peaks are much larger compared to other commodities. Additionally, the uranium market is subject to supply and demand shocks, which can lead to extreme price volatility. Also capital expenditures play a crucial role as we have seen between 2004 and 2007 after years of low investments. Currently we see a similar trend with low CAPEX and a rising uranium price.

To be able to predict future business cycle movements it was necessary to determine which types of indicators show leading tendencies. Leading indicators are forward-looking measures which can forecast future economic trends and changes in business cycles. Economic indicators such as PPI, IPG, or Inventories showed only little to no leading ability, whereas technical indicators such as the RSI, BB, W%R, OS, or CCI showed a strong ability to predict trend reversal points and possible future price movements.

The proposed model evaluated 18 different indicators of which 8 were technical and 10 were economic indicators. Via a correlation matrix the correlation between each indicator was evaluated to identify highly correlating indicators with leading tendency. For oil and copper a combination of RSI, CCI, and BB show the most promising results. For uranium, a combination of RSI, SO, and W%R showed the most promising result. The model showed high ability for these technical indicators to forecast trend reversals. Inventory stock and CAPEX have limited forecast ability since they do not indicate when a trend reversal might occur, only that it could be possible. Economic indicators showed high correlation with the commodity prices but no ability to forecast prices or trend reversals.

At the end, a price outlook for oil, copper, and uranium was conducted which concluded that the oil price has reversed its course in the short term cycle to follow the upward trend of the medium-term cycle and thus it could rise again for the next one to two years,

eventually reaching prices of 120 USD per barrel. The copper price is on the rise with its current short-term cycle following the medium term cycle. Technical indicators confirm this trend, which could eventually last for up to five years with short-term ups and downs before reaching a long-term cycle reversal point at possible prices of up to USD 5 per pound. It is possible that the long-term cycle of the uranium price could rise until 2030 or beyond. For uranium, all three indicators indicate strong overbought conditions, which could be a sign of a decrease in price in the next couple of months. But the long-term trend tends upwards and prices of 100 USD per pound or more could be possible in the next five years.

To conclude, business cycles are important to consider. It is eventually possible to predict short- and medium-term trend reversals with the use of the right technical indicators in combination with business cycles, and inventory and CAPEX data. Tracking leading indicators and analyzing historical patterns can support proper decision making and as a result companies can improve their competitiveness, and chances of success

Appendix

Table 17: Oil short-term cycle analysis, leading correlation for given indicators, and correlation matrix result

Cycle	Indicator Leading Ability																	
Reversal Date	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
May-23	50	100	0	60	100	100	0	60	20	0	0	20	0	0	0	0	0	0
May-22	100	100	0	100	100	100	100	50	0	0	0	0	0	0	0	0	40	0
May-20	100	100	20	100	100	90	90	50	0	30	0	30	0	0	0	0	30	0
Aug-19	0	20	50	20	0	30	0	0	0	0	0	0	0	0	0	0	0	0
Dec-18	50	100	50	80	100	100	20	10	60	0	0	0	0	0	0	0	0	0
Jul-18	90	100	0	80	100	100	60	20	0	20	0	0	0	0	0	0	0	0
Feb-16	100	100	50	60	100	100	100	0	0	50	0	40	0	0	0	0	0	0
Aug-13	50	100	0	90	100	100	20	0	0	20	0	0	0	0	0	0	0	0
Dec-12	0	20	0	0	20	20	20	20	0	0	0	0	0	0	0	0	0	0
Sep-11	20	90	20	20	20	100	10	20	0	0	0	0	0	0	0	0	0	0
Sep-10	10	0	0	0	50	40	0	0	20	0	0	0	0	0	0	0	0	0
Mar-10	30	100	60	60	80	100	10	30	40	0	0	20	0	0	0	0	0	0
Jan-09	80	100	0	90	100	100	90	60	0	0	0	0	0	0	0	0	0	0
Jul-08	100	100	0	100	100	100	100	40	0	0	0	50	0	0	0	0	0	0

	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
RSI	1																	
SO	0,74	1																
MACD	-0,18	0,05	1															
BB	0,86	0,83	-0,12	1														
CCI	0,83	0,78	-0,17	0,87	1													
W%R	0,70	0,96	0,02	0,78	0,78	1												
SMA48	0,90	0,50	-0,19	0,68	0,58	0,44	1											
F&G	0,46	0,47	-0,39	0,50	0,43	0,40	0,42	1										
Inventory	-0,25	0,08	0,50	-0,02	0,17	0,14	-0,44	-0,11	1									
CAPEX	0,52	0,31	0,20	0,27	0,38	0,26	0,46	-0,26	-0,31	1								
CER	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1							
IPG	0,53	0,37	0,17	0,35	0,40	0,33	0,50	0,23	-0,09	0,43	#DIV/0!	1						
UR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1					
CPI	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1				
PPI	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1			
3MYC	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1		
YCS	0,47	0,22	-0,16	0,44	0,27	0,16	0,50	0,45	-0,22	0,11	#DIV/0!	0,03	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1	
IR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1

Table 18: Oil medium-term cycle analysis, leading correlation for given indicators, and correlation matrix result

Cycle	Indicator Leading Ability																	
Reversal Date	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
May-22	100	100	30	100	100	90	100	50	0	0	0	40	0	0	0	0	20	0
Apr-20	100	100	50	100	100	100	100	40	0	0	0	60	0	0	0	0	20	0
Aug-18	70	100	10	90	100	100	50	0	0	0	0	40	0	0	0	0	0	0
Jan-16	100	100	0	50	100	100	100	0	0	0	0	40	0	0	0	0	0	0
Apr-12	20	80	0	50	80	80	40	0	0	0	0	0	0	0	0	0	0	0
Jan-09	80	100	60	90	100	100	100	80	0	0	0	0	0	0	0	0	0	0
Jun-08	100	80	30	100	100	100	100	60	0	0	0	0	0	0	0	0	0	0
Dec-01	50	100	20	100	100	100	20	50	0	0	0	40	0	0	0	0	0	0
Oct-00	70	80	0	80	100	80	100	0	0	0	0	30	0	0	0	0	20	0
Dec-98	90	100	0	80	100	100	90	20	0	0	0	0	0	0	0	0	0	0
Dec-96	90	100	0	100	100	100	90	0	0	0	0	0	0	0	0	0	0	0
Dec-93	90	100	0	100	100	100	90	0	0	0	0	0	0	0	0	0	0	0
Nov-90	100	100	30	100	100	90	100	40	0	0	0	20	0	0	0	0	0	0
Nov-88	20	100	20	100	100	90	80	20	0	0	0	30	0	0	0	0	0	0

	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
RSI	1																	
SO	0,26	1																
MACD	0,22	0,21	1															
BB	0,25	0,36	0,46	1														
CCI	0,58	0,53	0,26	0,62	1													
W%R	0,50	0,59	0,23	0,34	0,57	1												
SMA48	0,69	0,06	0,26	0,16	0,47	0,08	1											
F&G	0,23	0,11	0,88	0,46	0,27	0,26	0,17	1										
Inventory	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1									
CAPEX	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1								
CER	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1							
IPG	0,05	0,29	0,23	0,09	0,29	0,00	-0,09	0,01	#DIV/0!	#DIV/0!	#DIV/0!	1						
UR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1					
CPI	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1				
PPI	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1			
3MYC	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1		
YCS	0,25	-0,15	0,24	0,14	0,14	-0,36	0,35	0,08	#DIV/0!	#DIV/0!	#DIV/0!	0,56	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1	
IR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1

Table 19: Copper short-term cycle analysis, leading correlation for given indicators, and correlation matrix result

Cycle	Indicator Leading Ability																	
Reversal Date	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
Jan-22	100	90	60	40	90	80	60	20	0	0	0	0	0	0	0	0	0	0
Apr-20	70	100	0	100	100	20	20	0	0	0	0	0	0	0	0	0	0	0
Feb-18	80	100	10	60	100	100	30	0	0	0	0	0	0	0	0	0	0	0
Jan-16	100	100	10	80	100	100	50	0	0	0	0	0	0	0	0	0	0	0
Aug-14	30	0	0	20	40	50	20	0	0	0	0	0	0	0	0	0	0	0
Jun-12	20	30	0	50	90	0	60	0	0	0	0	0	0	0	0	0	0	0
Mar-11	100	100	20	90	100	100	80	50	0	0	0	0	0	0	0	0	0	0
Jul-10	0	0	0	40	60	60	10	20	0	0	0	0	0	0	0	0	0	0
Dec-09	50	100	0	50	80	100	10	80	0	0	0	0	0	0	0	0	0	0
Jan-09	100	100	20	100	100	100	60	70	0	0	0	0	0	0	0	0	0	0
May-08	70	100	0	80	90	50	50	20	0	0	0	20	0	0	0	0	0	0
Dec-07	0	0	0	40	70	50	50	10	0	0	0	0	0	0	0	0	0	0
Jul-07	80	100	0	50	80	100	60	10	0	0	0	0	0	0	0	0	0	0
Feb-07	0	80	0	0	0	70	50	80	0	0	0	0	0	0	0	0	0	0

	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
RSI	1																	
SO	0,78	1																
MACD	0,58	0,31	1															
BB	0,70	0,54	0,12	1														
CCI	0,73	0,45	0,32	0,85	1													
W%R	0,55	0,53	0,34	0,13	0,15	1												
SMA48	0,40	0,30	0,42	0,22	0,23	0,17	1											
F&G	-0,02	0,32	0,08	-0,08	-0,31	0,43	0,09	1										
Inventory	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1									
CAPEX	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1								
CER	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1							
IPG	0,09	0,19	-0,15	0,22	0,11	-0,17	0,09	-0,05	#DIV/0!	#DIV/0!	#DIV/0!	1						
UR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1					
CPI	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1				
PPI	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1			
3MYC	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1		
YCS	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1	
IR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1

Table 20: Copper medium-term cycle analysis, leading correlation for given indicators, and correlation matrix result

Cycle	Indicator Leading Ability																	
Reversal Date	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
Feb-22	100	90	60	40	90	80	60	20	0	0	0	0	0	0	0	0	0	0
Mar-20	70	100	0	100	100	20	20	0	0	0	0	0	0	0	0	0	0	0
Jan-18	80	100	10	60	100	100	30	0	0	0	0	0	0	0	0	0	0	0
Feb-16	100	100	10	80	100	100	50	0	0	0	0	0	0	0	0	0	0	0
Jul-11	80	100	20	60	90	100	60	0	0	0	0	0	0	0	0	0	0	0
Dec-08	90	100	50	100	100	70	100	60	0	0	0	0	0	0	0	0	0	0
May-08	50	90	0	50	90	50	60	20	0	0	0	0	0	0	0	0	0	0
Nov-01	20	80	0	70	100	40	0	0	0	0	0	0	0	0	0	0	0	0
Sep-00	60	100	0	80	100	100	0	0	0	0	0	0	0	0	0	0	0	0

	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
RSI	1																	
SO	0,66	1																
MACD	0,65	0,05	1															
BB	0,02	0,45	-0,17	1														
CCI	-0,13	0,23	-0,33	0,76	1													
W%R	0,53	0,47	0,23	-0,28	-0,08	1												
SMA48	0,61	0,26	0,71	-0,04	-0,41	0,17	1											
F&G	0,28	0,04	0,68	0,20	-0,08	-0,11	0,79	1										
Inventory	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1									
CAPEX	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1								
CER	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1							
IPG	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1						
UR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1					
CPI	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1				
PPI	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1			
3MYC	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1		
YCS	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1	
IR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1

Table 21: Uranium short-term cycle analysis, leading correlation for given indicators, and correlation matrix result

Cycle	Indicator Leading Ability																	
Reversal Date	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
Mar-21	40	60	0	20	20	40	0	10	0	0	0	0	0	0	0	0	0	0
Dec-18	70	100	40	90	100	100	0	0	0	0	0	0	0	0	0	0	0	0
Dec-16	100	100	40	90	100	100	40	50	0	0	0	0	0	0	0	0	0	0
Apr-15	0	50	10	40	80	20	0	40	0	0	0	0	0	0	0	0	0	0
Jul-14	100	100	0	90	100	100	70	0	0	0	0	0	0	0	0	0	0	0
Mar-11	30	100	40	60	90	90	0	80	0	0	0	0	0	0	0	0	0	0
Apr-10	100	100	0	50	90	100	0	0	0	0	0	0	0	0	0	0	0	0

	RSI	SO	MACD	BB	CCI	W%R	SMA48	F&G	Inventory	CAPEX	CER	IPG	UR	CPI	PPI	3MYC	YCS	IR
RSI	1																	
SO	0,76	1																
MACD	-0,03	0,43	1															
BB	0,62	0,76	0,53	1														
CCI	0,44	0,70	0,46	0,83	1													
W%R	0,82	0,99	0,38	0,77	0,67	1												
SMA48	0,77	0,62	-0,15	0,61	0,50	0,62	1											
F&G	-0,37	0,08	0,52	-0,12	0,18	-0,02	-0,07	1										
Inventory	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1									
CAPEX	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1								
CER	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1							
IPG	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1						
UR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1					
CPI	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1				
PPI	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1			
3MYC	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1		
YCS	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1	
IR	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1

Bibliography

Ahmadi, Manera and Sadeghzadeh (2019a) *The investment-uncertainty relationship in the oil and gas industry*. 63rd edn. Resources Policy. Available at: https://www.sciencedirect.com/science/article/pii/S0301420719303769 (Accessed: 31 July 2023).

Ahmadi, Manera and Sadeghzadeh (2019b) *The investment-uncertainty relationship in the oil and gas industry*. 63rd edn. Resources Policy. Available at: https://www.sciencedirect.com/science/article/pii/S0301420719303769 (Accessed: 30 July 2023).

Arnaut (2022) *The importance of uranium prices and structural shocks: Some implications for Greenland*. 161st edn. Energy Policy. Available at: https://www.sciencedirect.com/science/article/pii/S0301421521006236 (Accessed: 5 August 2023).

Baffes and Nagle (2022) *The Evolution of Commodity Markets over the Past Century*. Commodity Markets: Evolution, Challenges, and Policies. Available at: https://www.worldbank.org/en/research/publication/commodity-markets (Accessed: 28 July 2023).

Bessembinder and Chan (1992) *Time-varying risk premia and forecastable returns in futures markets*. Journal of Financial Economics. Available at: https://www.sciencedirect.com/science/article/abs/pii/0304405X9290017R (Accessed: 16 August 2023).

boerse.de (2023) *Commodity Channel Index CCI Erklärung – Technische Analyse*. boerse.de. Available at: https://www.boerse.de/technische-indikatoren/Commodity-Channel-Index-(CCI)-8 (Accessed: 19 August 2023).

BofA (2023) *Bank of America 2023 Global Metals, Bank of America 2023 Global Metals, Mining & Steel Conference*. Available at: https://www.bhp.com/-/media/documents/media/reports-and-presentations/2023/230516_bofaconferencespeakernotes.pdf (Accessed: 4 August 2023).

Charles Potters (2023) *Leading vs. Lagging vs. Coincident Indicators: What's the Difference?,* 20 August. Available at: https://www.investopedia.com/ask/answers/what-are-leading-lagging-and-coincident-indicators/#:~:text=Leading%20indicators%20are%20considered%20to,the%20state%20of%20the%20economy. (Accessed: 20 August 2023).

Chen (2022) *Exchange Rates: What They Are, How They Work, Why They Fluctuate,* 24 August. Available at: https://www.investopedia.com/terms/e/exchangerate.asp.

Chiaie, Ferrara and Giannone (2017) *Common factors of commodity prices*. Eurosystem. Available at: https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2112.en.pdf (Accessed: 16 August 2023).

Chiat (2022) *Are these copper stocks in pole position to move once China gets over its Covid hang-up?,* 4 August. Available at: https://stockhead.com.au/resources/are-these-copper-stocks-in-pole-position-to-move-once-china-gets-over-its-covid-hang-up/.

CNN.com (2023) *Fear & Greed Index,* 20 August. Available at: https://edition.cnn.com/markets/fear-and-greed (Accessed: 20 August 2023).

David White (2006) *Key to business cycles*. IPE Magazin. Available at: https://www.ipe.com/key-to-business-cycles/18964.article#:~:text=The%20Kitchin%20cycle%20in%20consumer,the%20US%20and%20the%20UK. (Accessed: 26 July 2023).

Díaz, Hansen and Cabrera (2021) *Economic drivers of commodity volatility: The case of copper*. Resources Policy (Volume 73). Available at: https://www.sciencedirect.com/science/article/pii/S030142072100235X (Accessed: 3 August 2023).

Drachal (2021) *Forecasting selected energy commodities prices with Bayesian dynamic finite mixtures*. Energy Economics. Available at: https://www.chatpdf.com/c/F5VCKyIv3bsbSfVrOtrz6 (Accessed: 29 August 2023).

Duguid (2023) *Treasury investors bet on US falling into recession*: Financial Times. Available at: https://www.ft.com/content/d696cca8-a15c-461f-a97c-76df02f0a10f (Accessed: 18 August 2023).

EIA (2023) *Uranium Overview*. eia.gov. Available at: https://www.eia.gov/totalenergy/data/monthly/pdf/sec8_5.pdf (Accessed: 6 August 2023).

eia.gov (2023) *Weekly U.S. Ending Stocks of Crude Oil and Petroleum Products,* 22 August. Available at: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=WTTSTUS1&f=W (Accessed: 22 August 2023).

Energy Information Administration (2022) *Oil and petroleum products explained,* 31 July. Available at: https://www.eia.gov/energyexplained/oil-and-petroleum-products/prices-and-outlook.php.

Eriksen (2015) *Business Cycles and Expected Returns*. Available at: https://pure.au.dk/ws/files/95130627/PhD_thesis_Jonas_Nygaard_Eriksen.pdf (Accessed: 29 July 2023).

Federal Reserve (2015) *What is the money supply? Is it important?,* 23 August. Available at: https://www.federalreserve.gov/faqs/money_12845.htm.

Federal Reserve Bank of St. Louis (2023) *Economic Data,* 17 August. Available at: https://fred.stlouisfed.org/.

Fernando (2023) *Gross Domestic Product (GDP): Formula and How to Use It,* 24 August. Available at: https://www.investopedia.com/terms/g/gdp.asp.

Ferrari, Ravazzolo and Vespignani (2021) *Forecasting energy commodity prices: A large global dataset sparse approach*. Energy Economics. Available at: https://www.sciencedirect.com/science/article/pii/S0140988321001730.

Flitton (2023) *The case for copper*. Available at: https://cernocapital.com/the-case-for-copper (Accessed: 4 August 2023).

Gargano and Timmermann (2014) *Forecasting commodity price indexes using macroeconomic and financial predictors*. International Journal of Forecasting. Available at: https://www.sciencedirect.com/science/article/pii/S016920701300099X?casa_token=kitBsV_joTgAAAAA:R8h7KHJzzYvMmOgUOuVzYquhUUA6eP4V_lGMwI6u5Nsmk-xdVvGDjimO9GclDZ3rXKd4j7jycFc#a000005 (Accessed: 8 August 2023).

Haltom *et al.* (2019) *Moving Macroeconomic Analysis beyond Business Cycles* (19-04). Available at: https://www.richmondfed.org/publications/research/economic_brief/2019/eb_19-04 (Accessed: 26 July 2023).

Hu *et al.* (2020) *Macro factors and the realized volatility of commodities: A dynamic network analysis*. Elsevier. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7409805/ (Accessed: 16 August 2023).

IAEA & NEA (2023) *Uranium 2022 - Resouces, Production and Demand*. Available at: https://www.oecd-nea.org/upload/docs/application/pdf/2023-04/7634_uranium_-_resources_production_and_demand_2022.pdf (Accessed: 6 August 2023).

International Monetary Fund (2022) *Market Developments and the Pace of Fossil Fuel Divestment*. Available at: https://www.imf.org/-/media/Files/Research/CommodityPrices/WEOSpecialFeature/SFApril2022.ashx (Accessed: 31 July 2023).

Investing.com (2023) *U.S. Crude Oil Inventories,* 31 July. Available at: https://www.investing.com/economic-calendar/eia-crude-oil-inventories-75.

Kabundi, Vasishtha and Zahid (2022) *The Nature and Drivers of Commodity Price Cycles*. Commodity Markets: Evolution, Challenges, and Policies (Chapter 3). Available at: https://thedocs.worldbank.org/en/doc/b4ff84b2d5dc4d0963a5074102460cc1-0350012022/related/Commodity-Markets-Chapter-3.pdf (Accessed: 27 July 2023).

Kenton (2021) *What Is Industrial Production Index (IPI)? How It Measures Output,* 24 August. Available at: https://www.investopedia.com/terms/i/ipi.asp.

Kenton (2022) *What Is Inventory? Definition, Types, and Examples,* 23 August. Available at: https://www.eia.gov/energyexplained/oil-and-petroleum-products/prices-and-outlook.php.

Kondratieff (1925) *The Major Economic Cycles*. Available at: https://scholar.google.com/scholar_lookup?title=The%20Major%20Economic%20Cycles&publication_year=1925&author=N.D.%20Kondratiev (Accessed: 31 July 2023).

Korotayev and Tsirel (2010) *A Spectral Analysis of World GDP Dynamics: Kondratieff Waves, Kuznets Swings, Juglar and Kitchin Cycles in Global Economic Development, and the 2008–2009 Economic Crisis*. Available at: https://escholarship.org/content/qt9jv108xp/qt9jv108xp.pdf?t=lnref7 (Accessed: 26 July 2023).

Long *et al.* (2022) *Macroeconomics matter: Leading economic indicators and the cross-section of global stock returns*. Journal of Financial Markets. Available at: https://

www.sciencedirect.com/science/article/pii/S1386418122000295#sec6 (Accessed: 6 August 2023).

McMinn (2018) *BENNER CYCLES & THE 9/56 YEAR GRID*. Available at: https://www.researchgate.net/profile/David-Mcminn/publication/314417628_Benner_Cycles_the_956_year_grid/links/5b9873a5299bf14ad4d0a447/Benner-Cycles-the-9-56-year-grid.pdf (Accessed: 26 July 2023).

Milašauskaitė (2023) *Importance of business cycles and how it affects business decisions,* 29 July. Available at: https://islucid.com/importance-of-business-cycles-and-how-it-affects-business-decisions/.

Nakhle (2022) *Oil and gas: The investment gap dilemma,* 30 July. Available at: https://www.gisreportsonline.com/r/oil-gas-investment/.

Narkus (2012) *Kondratieff, N. and Schumpeter, Joseph A. long-waves theory: Analysis of long-cycles theory*. Master thesis. UNIVERSITETET I OSLO. Available at: https://core.ac.uk/download/pdf/30907274.pdf (Accessed: 26 July 2023).

Nasdaq Data Link (2021) *Crude Oil Prices from 1861,* 29 July. Available at: https://data.nasdaq.com/data/BP/CRUDE_OIL_PRICES-crude-oil-prices-from-1861.

Obstfeld, Milesi-Ferretti and Arezki (2016) *Oil Prices and the Global Economy: It's Complicated,* 31 July. Available at: https://www.imf.org/en/Blogs/Articles/2016/03/24/oil-prices-and-the-global-economy-its-complicated.

OECD (2023) *Consumer Confidence Index,* 17 August. Available at: https://data.oecd.org/leadind/consumer-confidence-index-cci.htm.

OPEC (2023) *Member Countries,* 29 August. Available at: https://www.opec.org/opec_web/en/about_us/25.htm.

Posch (2017) *Cyclic Strategic Patterns of the Oil Industry and Implications of Peal Oil Demand*. Oil Gas European Magazine.

Robinson (2016) *Uranium Prices Fall to their Lowest Level In More than Ten Years*. Available at: http://www.sric.org/mining/docs/20161116_WMAN_U_Market_Presentation.pdf (Accessed: 5 August 2023).

Rooney, Nuttall and Kazantzis (2015) *A dynamic model of the global uranium market and the nuclear fuel cycle*. Resources Policy. Available at: https://www.sciencedirect.com/science/article/pii/S0301420714000828 (Accessed: 5 August 2023).

S&P Global (2023) *Purchasing Managers' Index*. Available at: https://www.spglobal.com/marketintelligence/en/mi/products/pmi.html (Accessed: 6 August 2023).

Saunders, Lewis and Thornhill (2019) *Research Methods for Business Students*. 8th edn. Pearson. Available at: https://www.pearson.com/nl/en_NL/higher-education/subject-catalogue/business-and-management/Research-methods-for-business-students-8e-saunders.html (Accessed: 1 August 2023).

Ševčík and Tsasa (2021) *Medium–Term Business Cycles and Labor–Market Search*. Available at: https://economie.esg.uqam.ca/wp-content/uploads/sites/54/2021/10/SevcikTsasa_25oct2021_CMSG.pdf (Accessed: 26 July 2023).

Su *et al.* (2020) *Testing for multiple bubbles in the copper price: Periodically collapsing behavior*. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7147841/v (Accessed: 2 August 2023).

Tapia, Coulton and Saydam (2020) *Using entropy to assess dynamic behaviour of long-term copper price*. 66th edn.. Available at: https://www.sciencedirect.com/science/article/pii/S0301420719303046 (Accessed: 2 August 2023).

Thomas *et al.* (2020) *Best (but oft-forgotten) practices: identifying and accounting for regression to the mean in nutrition and obesity research*. The American Journal of Clinical Nutrition. Available at: https://www.sciencedirect.com/science/article/pii/S0002916522010024#:~:text=Regression%20to%20the%20mean%20(RTM)%20is%20a%20statistical%20phenomenon%20that,posttest%20value%20%E2%80%93%20pretest%20value). (Accessed: 18 August 2023).

Thunder Said Energy (2022) *Exploration capex: long-term spending from Oil Majors?,* 31 July. Available at: https://thundersaidenergy.com/downloads/exploration-capex-long-term-spending-from-oil-majors/.

Tradingview.com (2023): Tradingview.com (Accessed: 18 August 2023).

U.S. Bureau of Labor Statistics (2023) *Producer Price Index,* 23 August. Available at: https://www.bls.gov/ppi/overview.htm.

Uhler (2018) *Why Are Unemployment Claims a Useful Economic Indicator?,* 17 August. Available at: https://lao.ca.gov/LAOEconTax/article/Detail/290.

USGS (2018) *Copper Price since 1900*. Available at: https://www.usgs.gov/centers/national-minerals-information-center/historical-statistics-mineral-and-material-commodities (Accessed: 3 August 2023).

von Thienen (2023) *Looking at long-term cycle patterns, what might 2023 hold for equity markets?,* 26 July. Available at: https://lars.cycles.org/p/looking-at-long-term-cycle-patterns (Accessed: 26 July 2023).

Wilenius and Casti (2015) *Seizing the X-events. The sixth K-wave and the shocks that may upend it*. Technological Forecasting and Social Change (94). Available at: https://doi.org/10.1016/j.techfore.2014.12.003 (Accessed: 26 July 2023).

World Bank (2023) *Copper Commodity Prices,* 2 August. Available at: https://www.worldbank.org/en/research/commodity-markets.

World Nuclear Association (2023) *Uranium Markets*. Available at: https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/uranium-markets.aspx (Accessed: 5 August 2023).