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Navigating Energy Market Cycles: Insights from a Comprehensive Analysis

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ABSTRACT

In this article, we investigate the dynamics the intricacies of fluctuations during periods of economic expansion and contraction, and examining the connections between the length of energy cycles and the influential factors could affect them. Utilizing the extended BBQ algorithm, we firstly identify turning points and, then apply the Cox hazard Model to analyze factors that affect the cycle phases, including geopolitical conflict and economic situations over the period from January 1990 to July 2022. The results reveal the presence of asymmetry in growth phases, highlighting the need for policymakers to understand the factors driving these phases. Market expansion is driven by positive interest rate and US dollar shocks, while stability relies on competent management. During economic contractions, energy costs are influenced by economic growth. Geopolitical risks and economic uncertainty require effective risk mitigation, and policy changes significantly impact the energy market during expansion phases. The study also suggests that Conferences of Parties (COP) meetings have a nuanced influence on the energy market, warranting further research.

Keywords: Energy Market Cycles, Duration Dependencies, Recessionary Phases, Asymmetric Behavior
JEL classification: Q40, G15, C61, C58, E32

1. INTRODUCTION

The convergence of financial deregulation and technological advancements has resulted in increased integration of financial markets. This integration has provided investors with improved opportunities to allocate international capital in a more efficient manner, allowing them to optimize their diversification and hedging strategies. This is particularly beneficial during periods of economic ascent (descent) (Fengler and Gisler, 2015; Tang and Xiong, 2012).

Meanwhile, financial products based on commodities have always received significant attention as a good diversification tool for investors (e.g., De Rosa, 2022; Gagnon et al., 2020). The importance of this imperative stems from a variety of factors. These include the intriguing historical context of the subject, its crucial role in fulfilling the everyday requirements of households and enabling smooth business operations, its impact on diverse markets, and its influence on decision-making processes and geopolitical concerns.

Energy prices are undoubtedly among the most essential commodities for the global economy as their supplies affect the short-term and long-term economic balance of almost all countries (Zhang and Wu, 2019; Kocaarslan and Soytas, 2019; Salisu and Obiora, 2021). Furthermore, energy commodities play a pivotal role in stimulating economic expansion due to their strategic and political significance in generating substantial contributions towards the creation of reserve assets (Jaffe, 2020; Ahmad et al., 2020). This dominance is derived from the direct influence of energy prices on transportation, production, and the expenses associated with power generation Furthermore, it is noteworthy to mention the growing significance of energy commodities in the realm of financial decision-making, particularly as a lucrative alternative instrument in the portfolio choices of financial institutions. This observation has been supported by the research conducted by Bampinas and Panagiotidis (2015; 2017).

It has, however, previously been observed that energy price shocks can jeopardize the growth prospect (Hamilton, 1983; Burbidge and Harrison, 1984; Mork, 1989; Hamilton, 1996). Studies such as that conducted by Hamilton (2008; 2009) have shown that almost all recessions in the US since World War II have been preceded by an increase in oil prices. Moreover, such shocks have exacerbated systematic risk, as well as economic uncertainty (Fengler and Gisler, 2015). The work of Jo (2014) infers that oil price fluctuations causes irregularity and uncertainty in the economies around the world (see also, Narayan and Narayan, 2007).

In light of the prevailing dominance in economic and financial decision-making, it is pertinent to highlight two significant themes that have resurfaced, rekindling the discourse on energy prices. First, how to evaluate energy price dynamics correctly to enhance the understanding of the pattern of spiking and falling energy prices which, in turn, contributed to increase of economic and financial uncertainty. Second, how do related factors drive the duration of the energy price cycle? And, Does the impact of this phenomenon differ between different phases? From the standpoint of policymakers, taking these factors into account aids in the implementation and optimization of policies aimed at mitigating the effects of the recessionary phase.

Unsurprisingly, the literature on modelling energy price behaviour is massive (Plakandaras et al., 2019; Hollander et al., 2019). This literature involves two relationships: (a) The oil market and economic activity (e.g., Bahloul and Gupta, 2018); and (b) The oil and stock markets (e.g., Geng et al., 2021; Gkillas et al., 2020; Gupta and Wohar, 2017). A strand of literature hypothesize that extreme risks help in forecasting returns in the oil market, especially during financial distress (Salisu et al., 2022; Qian et al., 2022; Salisu et al., 2021; Liu et al., 2019). Besides, a number of authors have attempted to examine whether the energy markets behave efficiently and rationally, or do speculators guide them? (Ajmi et al., 2021; Umar et al., 2021; Zhang and Yao, 2016; Zhang and Wang, 2015).

Most of the studies in this field have only concurred that the energy market (proxied by oil price), the stock market, and economic activity affect each other. However, researchers have not treated energy prices in much detail. In light of this perspective, it is imperative to take into account the overall price of energy, as it has a substantial impact on the prices of competing alternative energy sources, such as coal or natural gas. These alternative energy sources are also utilized as predictor variables in the resource allocation decision-making process for these substitute energy sources. In addition, no research has been found that inspected the primary features of the energy market cycles. Finally, in order to gain a deeper comprehension of the ramifications of this cycle, it is imperative to analyze the influence of uncertainty conditions and monetary policy on mitigating the contraction phase.

In the presented context, this article delves into the analysis of the asymmetric behaviour observed in energy market cycles. The primary objective of this study is to investigate this phenomenon in two stages. In the beginning of our research, we intend to explore a number of relevant inquiries. Our primary objective is to identify the key characteristics that define energy market cycles. Additionally, we aim to determine if the periods of economic growth are longer than the periods of economic decline in these cycles. To address these inquiries, we draw upon techniques commonly utilised in the field of business and financial cycle research. We employ the algorithm proposed by Harding and Pagan (2002) to expand upon the BBQ algorithm introduced by Bry and Boschan (1971). This algorithm allows us to identify the turning points in the log-differences of energy prices series, a crucial aspect of our analysis.

Once the characteristics of the energy market cycle are captured, the next steps involving identify duration dependencies between energy price turning points and the related factors. To this end, important questions need to be answered (i) whether the cycle phase exhibits duration dependence, and (ii) to what extent these dependencies are driven by a shock to related factors such as interest rate, change in US dollar, Economic and financial conditions, and Geopolitical Risk Index (iii) how the role of these variables may change during the contraction compared to the expansion phases. To answer these questions, the Cox hazard Model (HM) with time-varying covariates (Strasak et al., 2009) is used. One of the main takeaways from this analysis is that by examining the distribution of actual series data, we can determine the likelihood of an event occurring at any given time. This approach is particularly useful in understanding the duration of a current phase in the economic cycle. Additionally, these findings offer valuable guidance for policymakers seeking to implement effective policies that can impact the duration of these phases.

In this study, we offer the subsequent contributions. Firstly, as we analyse the characteristics of energy market cycles, this helps us record the turning points in the energy cycle. The latter is of particular interest for several reasons, (i) it permits to contextualize modern slumps and recoveries in terms of past experience; (ii) The cycle chronologies could be useful for highlighting periods of expansion and contraction (Mountford and Uhlig, 2009; Auerbach and Gorodnichenko, 2012; Broadberry et al., 2022) and for studying non-linearities over booms and busts (Tenreyro and Thwaites, 2016; Ramey and Zubairy, 2018); and (iii) The analysis of historical expansions and contractions enables us to ascertain the unconditional and conditional probabilities associated with each event. This information is crucial in addressing inquiries pertaining to the causes of recessions.

Second, we identify durational dependence between the energy prices cycle and the related factors including Geopolitical Risk Index (GPR) to control for the uncertainty condition, while other variables include US dollar index (USDX) and interest rate (IR) to control the effect of monetary policy. Finally, Index of Global Real Economic Activity (IGREA) and National Financial Conditions Index (NFCI) to stand for economics and financials conditions, respectively. To address the asymmetric response in duration dependence, we differentiate between the impact of a positive shock in both the interest rate and the US dollar, and the impact of a negative shock. Theortically, the energy market react asymmetrically to shocks in interest rates and the US dollar. In details, a positive shock in interest rates, for example, may indicate a tightening of monetary policy, which could potentially lead to a decrease in energy demand. Conversely, a negative shock in interest rates may stimulate economic activity and resulting in increased energy consumption. Considering such asymmetric response, The current paper seeks to enhance the understanding of durational dependence and provide further insights into the impact of interest rate changes and the US dollar on the energy market in various economic contexts.

Third, the ongoing research aims to examine the primary factors behind the fluctuations in energy levels from January 1990 to July 2022. This analysis encompasses a range of economic and financial stress events, both historical and recent, such as the significant impact of the COVID-19 pandemic.

The findings underscore a deep understanding of the intricacies within the energy market. To start with the elongation of the duration of expansion phases compared to the contraction one, signifying an asymmetry in the market cycle. Henc, Policymakers need to focus on investment, innovation, and sustainability to address the asymmetry in the oil market. They should prioritize flexible strategies (e.g. strategic reserves and diversification) to manage market volatility. Another remarkable outcome is that a positive shocks to interest rates and the US dollar are recognized as drivers of market expansion, requiring prudent management for stability. By contrast, During contractions, the positive impact of economic growth on energy prices is highlighted, along with the importance of effective risk mitigation strategies. Additionally, the introduction of a variable related to COP meetings shed light on the influence of climate policies on energy markets, suggesting the need for further research to uncover nuanced channels for policymaking. Policymakers may use the study's thorough research to better understand and navigate the complex dynamics of the energy industry.

This paper is organised into several sections. It begins with an introduction and then proceeds to examine the literature in section 2. The third section focuses on the data and economic benchmarks, while the fourth section discusses the methodology. The fifth section presents the empirical findings, and the final section provides the conclsion.

2. REVIEW OF THE LITERATURE

The remarkable patterns of global oil-price fluctuations are intricately connected to the broader global economic cycle. During periods of robust global economic growth, there is a logical increase in the demand for energy. However, it is important to note that this demand cannot be immediately met by the existing above-ground inventories and under-ground recoverable reserves. Consequently, there may be a delay in translating this increased demand into oil production, as highlighted by Barsky and Kilian (2004). Over time, the escalation in energy prices serves as a catalyst for energy companies to actively explore additional energy resources. During this period of delay, the global economy becomes increasingly vulnerable to disruptions in energy supply. These disruptions are often accompanied by economic downturns, a shift towards alternative fuels, and a greater emphasis on improving demand efficiency. In due course, a fresh stage of the oil price cycle emerged due to an excess resulting from a surge in supply and a slowdown or decrease in demand. Consequently, an extended duration of affordable fuel plays a role in the subsequent upswing of the worldwide business cycle, resulting in increased demand growth, and so forth.

Based on the above discussion, one should pay attention to the consequences of the energy price cycle, in view of the fact that studying these variations and disparities of energy prices provides a better sound evaluation and distinct prediction of the energy prices, which is of great importance to the policymakers and partakers alike.

Broadly, the noteworthy masterworks in the literature polarised two views about the behaviour of energy prices (epitomised by oil prices). One theoretical strand attributes this behaviour to the law of demand-supply through the structural transformations in the fundamentals of the oil market (e.g., Breitenfellner et al., 2009; Zhang et al., 2018). By contrast, other scholars highlight that the extreme cycles in energy prices over the recent years can be explained by substantial and volatile speculative financial flows.

The first sub-stream of the literature (among others, McNally, 2017a, b) has established that energy prices are rocked by wild price swings that seem to stream the global business cycle (measured by GDP). Mork (1989) demonstrated that the energy price cycle followed an asymmetric pattern that had an imperative consequence on the directionality of the economy. On one hand, although oil demand generally rises during the upturns phase of the global business cycle, new supplies of energy are often tardy as certain irreversible investment decisions are postponed (e.g., El-Gamal and Jaffe, 2009, Barsky and Kilian 2004). Conversely, a decrease in energy prices would not yield a favourable impact on the economy that mirrors the adverse repercussions of a rise in oil prices.

In line with these studies, Bernanke et al. (1997) ascertained that the energy market (especially crude oil) could be used to closely observe and analyse the economic cycles, mainly on a short-term scale (see also, Alvarez-Ramirez et al., 2012). El-Gamal and Jaffe (2009) highlighted that geopolitical events were endogenous to the oil price cycle.

A deal of literature conducted to address to what extent uncertainty really matter in energy price dynamic. Existing research recognises a bidirectional connexion between economic policy uncertainty and energy prices (measured by oil price). At first instance, increased oil prices have a detrimental effect on the overall economy. Such economic conditions, however, press policymakers to lessen these negative effects. These policies, in turn, give rise to concerns about their effectiveness (e.g., Montoro, 2012; Filis and Chatziantoniou, 2014; Balke and Brown, 2018). The contrary, economic policy uncertainty exerts an impact on oil prices through firms' investment and output decisions. Concretely, uncertainty surrounding economic policy decisions negatively reduces investment and output levels and, thus, lowering oil demand which causes downward pressure on oil prices (among others, Wang and Zhang, 2014; Antonakakis et al., 2014; Pan et al., 2017; Miao et al., 2017).

Another closely related aspect of the literature indicates that geopolitical factors played a significant role in driving energy price fluctuations (Kaufmann and Connelly, 2019). Balcilar et al. (2017) enhanced that the economic policy uncertainty (EPU) and equity market uncertainty (EMU) present strong predictability of oil returns. Kang and Ratti (2013) evident that when global real aggregate demand experiences positive shocks, there is a notable decrease in economic policy uncertainty and a substantial rise in the real oil price. Khan (2017) shows that the geopolitical strategies employed by the United States are believed to result in a decrease in overall output. Su et al., (2021) heightened that the oil market exhibits a noteworthy correlation with geopolitical occurrences (see also Lee et al., 2021; Adebayo et al., 2022).

Other studies have highlighted other variables that can fluctuate oil prices, including policy-related factors. Literature suggests, insofar as that U.S. policy factors considerably affect the international oil market for two main reasons. First, the born of Petrodollar Hegemony system legalised the U.S. controlling the oil trade, and thus consolidated the position of the dollar in the international monetary system (Spiro, 1999; Waltz, 1999; Haberly and Wójcik, 2022). Second, the Federal Reserve System's (Fed) interest rate hikes may cause the dollar to appreciate or depreciate, which would cause the U.S. dollar index (USDX) to fluctuate. Since the oil price (OP) is denominated in U.S. dollars, the interest rate may have a close relationship with the OP through the USDX channel. Together, oil-exporting (importing) countries can maximise their revenue (reduce their costs) by mentoring the OP according to the U.S. policy factors.

Much of this strand of literature emphasises the existence of a negative relationship between USDX and oil price. In a study by Yousefi and Wirjanto (2003), the authors highlight that the depreciation of the U.S. dollar rises the OP in the considered oil exporting countries. Similar results were also found in De Schryder and Peersman, (2016) and Brahmasrene et al. (2014). Reboredo et al. (2014) examined the oil price–exchange rate relationship at different time scales. They provide evidence of both contagion and interdependence. By contrast, Zhang et al. (2008) found volatility and risk spillover effects from the dollar to the oil market in the long term. Recently, Su et al. (2020) concluded that there are important roles that U.S. factors play in the oil market, especially those of partisan conflicts and the dollar value. Liu et al. (2020) ascertain that since the international oil market is dominated by the U.S. dollar is the main currency and the U.S. has become a major exporter of crude oil, the transmission of price shocks to the U.S. exchange rate becomes complicated.

Studies paid special attention to price bubbles of energy market due to their sharp rises and falls. Shi and Arora (2012) establish that a bubble existed in late-2008/early-2009 and was short-lived. (See also, Phillips and Yu, 2011). Lammerding et al. (2013) investigate whether the oil price has been driven by speculative bubbles. The authors introduce two Markov-regimes to distinguish between stable and explosive phases in the bubble process. Their finding further supports the existence of speculative bubbles in oil price dynamics. Similar methods were used in Zhang and Wang (2015) and highlight existence of significant oil price bubbles during 2003–2012. Moreover, these bubbles seem to evolve between upheaval and stable states. In their study, Zhang and Yao (2016) analysed the fluctuations in oil prices between 2001 and 2015, specifically focusing on the presence of oil price bubbles. Their findings indicate that these bubbles were observed from November 2001 to July 2008. Figuerola-Ferretti et al. (2020) identified a period of moderate volatility that occurred close to the height of the Global Financial Crisis, as well as a subsequent episode during the price decline between 2014 and 2016.

From Econometrics point of view, the aforementioned studies typically analyse energy price series by categorising them into three broad categories: (1) Structural models are utilised to analyse the intricate relationship between fundamental supply and demand conditions and the various factors that influence them. These models primarily concentrate on longer time-horizons and encompass macro-type models that are employed for forecasting purposes. (2) Models that are constructed based on assumptions about the stochastic behaviour of oil prices, and (3) Techniques in econometrics used to model different types of energy price time series behaviour. These two latter groups primarily emphasise the short-term dynamics of the subject.

Although extensive research has been carried out on the dynamic of the energy market, almost all the studies limited their work to the crude oil price, and to our awareness, no single study exists which considers other related energy markets (Gas and Coal). Another gap needs to be bridged concerning the cyclical components of the considered commodity prices. The adopted durational dependence methodology allows researchers to capture asymmetric impact in cyclical behaviour. Thus, it is able to capture whether the effect is due to upside (bullish) or downside (bearish) cycles. Last but not least, we distinguish our work by taking into account the asymmetric response in such duration dependence by distinguishing between the impact of a positive shock in the interest rate and the US dollar from the impact of the negative shock.

3. DATA AND ECONOMIC BENCHMARKS

3.1. Economic Benchmarks

This study examines the given equation, allowing for an analysis of the relationship between the energy cycle and various variables.

$$Cycle=f(GPR,USDX,IR,IGREA,NFCI)$$

Aligned with similar research, several variables are incorporated to assess the significance of the adopted factors. In this section, an overview of the selected variables and thier expected signs.

3.1.1. Geopolitical risk index (GPR)

Geopolitical conflicts between countries could end up in with severe disruptions to the energy resource production and transportation systems, causing supply shortages and uncertainties on a global scale (Gong and Xu, 2022; Qin et al., 2020; Alqahtani and Taillard, 2020; Yin, 2016). In the seminal work of Khan (2017), the author assertian that the United States' geopolitical strategies may result in a decrease in overall output. Further, Su et al. (2021) emphasize the significant correlation between the oil market and geopolitical events. Accordingly, incorporating the Geopolitical Risk Index (GPR) permit us to comprehend the association between energy price fluctuations and geopolitical factors. In this vein, one may hypothesis that a rise in geopolitical risk frequently results in elevated energy prices as concerns about potential supply disruptions arise.

3.1.2. US dollar index (USDX)

Several studies (Sun et al., 2017; Zhang and Yan, 2020) have found a negative relationship between the U.S. Dollar Index (USDX) and the oil price (OP). Yousefi and Wirjanto (2003) ascertain that a depreciation of the U.S. dollar increases their oil export prices. Zhang et al. (2008) suggest that the volatility of the USDX affects OP fluctuations, with spillover effects from the dollar to the oil market. Overall, the increase in the USDX reduces oil demand and decreases the OP, with the negative effect intensifying after the global economic crisis. The USDX has a stronger negative impact on the oil market in the short term. The relationship between the USDX and OP is negative, except when the U.S. dollar is high. Consequently, incorporating the USDX into an analysis allows for better management of the impact of currency fluctuations on energy prices. Therefore, it is anticipated that there will be a negative correlation between USDX and the energy market cycle.

3.1.3. Interest rate (IR)

The energy sector is significantly impacted by interest rates. One way through affecting monetary policy (Qin et al., 2020; Zhang and Yan, 2020). Here, increasing interest rate indicating a more restrictive monetary policy, which in turn can potentially lead to a decrease in energy demand and prices. By contrast, lower interest rates stimulate economic activity and energy demand, resulting in a positive correlation in certain economic scenarios. Another signficent connection can be attributed to the execution and termination of quantitative easing measures, along with the Federal Reserve System's adjustments to interest rates, have the potential to result in either an increase or decrease in the value of the dollar. This, in turn, would lead to fluctuations in the U.S. dollar index (USDX). Given that the oil price (OP) is expressed in U.S. dollars as explained before, it is possible that there is a strong correlation between the U.S. Dollar Index (USDX) and the OP.

It may be postulated that increased interest rates have the capacity to reduce energy demand and prices, hence impacting the energy market cycle. Nevertheless, it is crucial to acknowledge that the correlation between interest rates and the energy market cycle can fluctuate based on economic circumstances and contexts.

3.1.4. Index of global real economic activity (IGREA) and national financial conditions index (NFCI)

For analysing the financial and economic conditions influencing the energy market cycle, the National Financial Conditions Index (NFCI) and the Index of Global Real Economic Activity (IGREA) serve as vital indicators. Considering how it is impacted by variations in the state of the world economy, the IGREA is a trustworthy measure of changes in the demand for energy (Baumeister et al., 2022; Fezzi and Fanghella, 2020, He et al., 2010). In this regard, the NFCI offers an in-depth analysis of a country's financial health, which has significant impacts on capital flows and investment decisions in the energy sector (Zhang and Wang, 2019). The goal of the research is to investigate the complex link that exists between the energy market cycle and the state of the economy and finances. By employing such indicators, it aims to shed light on how economic patterns in general affect energy costs.

Overall, one anticipates a favourable result for IGREA and maybe a poor result for NFCI. A positive association exists between rising global economic activity and rising energy consumption and pricing. In the meanwhile, a tightening of financial regulations at the federal level would indicate economic difficulties, which might lower the demand for and cost of energy.

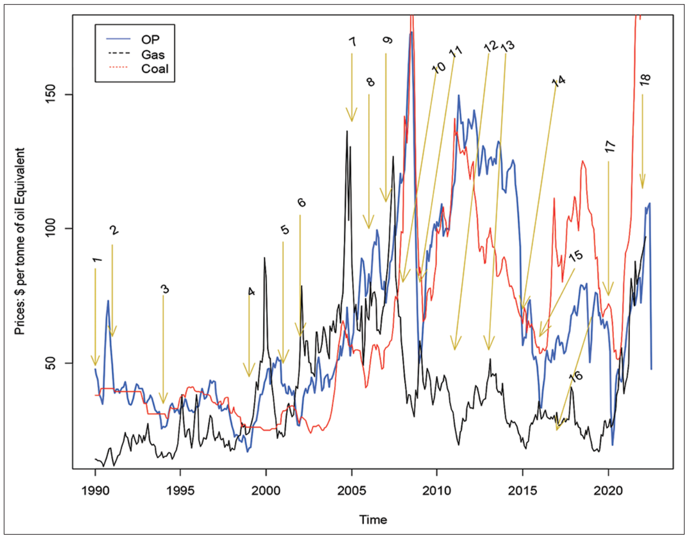
3.2. Data

In this investigation, monthly data is used over the period 1990:01–2022:07. We consider three energy indexes. The first index is the oil price, which is the dominant contributor, about 36%, to energy resources used. The second index is the Coal index, which roughly corresponds to about 28% of the energy resources used in the world. The final index is Gas index , which roughly corresponds to about 23% of the energy resources used in the world.

Figure 1 shows real prices of energy indexes over 1990:01–2022:07. The figure indicates the timing of significant historical events. It is evident that every time there is a significant event, there is a subsequent decrease in energy prices. Put differently, it seems that there is a correlation between major historical events and subsequent crashes in energy prices on the graph you are analyzing.

It can be also seen from the figure that major historical events often have a profound impact on the global economy. Wars, financial crises, and other significant events can disrupt economic stability, disrupting the supply chain and lead to a reduction in energy supply, driving prices higher. On the other hand, economic downturns associated with historical events can lead to a decline in energy demand, contributing to price crashes. Moreover, such events global crises, can create uncertainty and fear in financial markets. Investors may respond by selling off energy investments as a precautionary measure, leading to a decline in energy prices. Speculative trading and market sentiment plays crucial roles in the energy market, and major events can trigger significant price movements. Finally, governments often respond to major events with policy measures that can affect energy markets. For instance, decisions related to subsidies, tariffs, or regulations can impact the cost and availability of energy. Sudden policy changes

Figure 1: Real prices of energy indexes along with the timing of the outbreak of major historical events. 1: Gulf War, 2: SPR released oil, 3: NAFTA allowed cheap oil from Mexico, 4: Price Doubled, 5: Recession and 11/9, 6: Afghanistan War, 7: Hurricane Katrina, 8: Bernanke becomes Fed chair, 9: Banking Crisis, 10: Financial Crisis, 11: Great Recession, 12: Iran Threatened Straits of Hormuz, 13: The dollar rose 15%, 14: U.S. shale oil increased, 15: Dollar Fell, 16: OPEC cut oil supply to keep price stable, 17: Pandemic Reduced demand, 18: Russia invasion of Ukraine



or interventions in response to historical events may influence energy prices.

4. DURATION DEPENDENCES ON ENERGY MARKET CYCLE

The duration analysis is well-suited for studying the length of contractions and expansions. It focuses on the number of months that a series remains in a state of contraction or expansion, depending on the phase being analysed. In order to assess the impact of duration and analyse the policy's effectiveness in different phases of the energy prices cycle, we examine two potential scenarios across consecutive periods. The first scenario involves a turning point in the cycle, transitioning from expansion to contraction. The second scenario involves a turning point from contraction to expansion.

4.1. Dating Energy Market Cycle

In order to analyse the data, we utilise the business cycle methods of Burns and Mitchell (1946) to determine the beginning and end of recessions in the energy market. This allows us to divide the energy market series into periods of expansion and contraction. A full cycle typically requires a minimum of 15 months when considering monthly data. Furthermore, every contraction (expansion) phase must last at least 6 months. In addition, the chosen turning point is selected to ensure they alternate. Simply put, a peak (trough) needs to be higher (lower) than the one before it.

Following Bry and Boschan (1971), the turning point of the energy series $y_t=\Delta \log Y_t$ at time is defined as

$$\text{Peak at } t=\{y_{t-k} < y_t > y_{t+k}\} \quad (1)$$

$$\text{Trough at } t=\{y_{t-k} > y_t < y_{t+k}\}, \forall\, k=1,\ldots,5. \quad (2)$$

Once we establish the beginning and end dates of recessions, we can analyse two key aspects of the cyclical phases: their length and intensity. According to Harding and Pagan (2002), the duration of expansion or contraction is measured by the number of months between one peak or trough and the next in a completed cycle. The amplitude in the same procedure is determined by the change in the series of interest, going from a peak to the next trough.

Following the work by Engel et al. (2005) and Morley and Piger, (2012), suppose the dates of the turning point produce *M* expansions and contractions. The average duration of expansions (D^E) and contractions are (D^C) given by

$$D^E = \frac{1}{M}\sum_{i=1}^{M} D_i^E ; D^C = \frac{1}{M}\sum_{i=1}^{M} D_i^C \quad (3)$$

Furthermore, the overall increase or decrease in house prices throughout the period can be approximated by calculating the cumulative movement, as shown by

$$C.M = \sum_{j=1}^{D} (y_j - y_0) - \frac{A}{2} \quad (4)$$

where *D* and *A* refer to the duration and amplitude of expansion (contraction), respectively.

4.2. Duration Model

The next step in our analysis aims to describe the duration model, which is used to evaluate the policies that affect the energy market during the contraction and expansion phases in the energy market.

Several techniques have been devised to analyse the impact of duration on the business cycle. Some studies utilise a Markov-switching model (Lam, 2004; Kim and Nelson, 1999), while others solely employ nonparametric tests (Diebold and Rudebusch, 1994). Logit models are also of interest for identifying such dependences in cross-sectional data over a specific year. Relevant studies on this topic include those by Kolari et al. (2002) and Cole and White (2012). One major issue with these methods is that they are static models and do not account for changes over time. This becomes especially problematic when dealing with long sample periods, as dependencies can shift.

Broadly speaking, The regression parameters can potentially change over time, so understanding the impact of the covariates on the failure time is crucial. During a period of contraction, adjusting the interest rate policy and/or the exchange rate can be effective in the initial conduct period. Over time, its effectiveness may diminish as time passes. Understanding the timing and speed at which a policy loses its effectiveness is essential if we want to assess its potential drawbacks.

Based on the existing literature on duration dependency, we aim to explore the presence of duration dependencies through the application of the Cox hazard Model (HM) with time-varying covariates. The survival function is evaluated for both expansion and contraction phases. The Cox model has the advantage of not assuming any specific distribution or shape for the survival function. Additionally, it can account for multiple risk factors at the same time.

The hazard rate at any given time is the probability of an event occurring at that time, assuming the event has not already occurred. The rate of events per unit of time is subject to change over time.

Denote by T_i a non-negative and continuous failure event in the energy market cycle, say the exit to expansion phase given that the current state is contraction, and suppose we are interested in its association with $K\times 1$ vector of covariate $X_i(t)$ that includes the GPR, USDX, IR, IGREA, and NFCI the hazard can be written as

$$h(t|X_i) = h_0(t)\exp(X_i\beta_i) \tag{5}$$

The baseline hazard rate $h_0(t)$ is an unspecified nonnegative function of time. It is the time-dependent part of the hazard and corresponds to the hazard rate when all covariate values are equal to zero.

In equation (5), the hazard function *hj,o* (*t*) for each case can be specified as

$$h_{j,0}(t) = \lim_{\Delta t\to 0}\left(\frac{P(t < T \le t+\Delta t, T > t)}{\Delta t * P(T > t)}\right) = \frac{f(t)}{S(t)} \tag{6}$$

Where $f(t)$ is the probability density function, which can be formulated in terms of hazard rate as:

$$f(t) = h(t).\exp\left(-\int_0^t h(r)\,dr\right) \tag{7}$$

It is worth noting that the proportional hazards under consideration, $h(t\,|\,X_i)$ define the exit indicator as a binary variable. Therefore, the dependent variable in this context is a dummy variable with observations representing the possible phase changes between any two consecutive periods, namely

$$S^E = \begin{Bmatrix} 1; & S_t = 2\, and\, S_{t-1} = 1 \\ 0; & otherwise \end{Bmatrix} \tag{8}$$

$$S^C = \begin{Bmatrix} 1; & S_t = 1\, and\, S_{t-1} = 2 \\ 0; & otherwise \end{Bmatrix} \tag{9}$$

where S^E and S^C refer to the current state of expansion and contraction, respectively.

The duration (*d*) of the current phase up to time *t*–1 can also be defined as

$$d = \begin{Bmatrix} d_{t-1}+1; & S_t = S_{t-1} \\ 0; & S_t \ne S_{t-1} \end{Bmatrix}. \tag{10}$$

In this study, we take a step further to address the asymmetric response in such duration dependence by distinguishing between the impact of a positive shock in the interest rate and the US dollar from the impact of the negative shock.

To the latter end, we borrow from the seminal work of Shin et al. (2014) and decompose the targeted variable into their positive and negative sum as

$$IR_t = IR_0 + \sum_i^t \max(\Delta IR_i, 0) + \sum_i^t \min(\Delta IR_i, 0) \tag{11}$$

$$US_t = US_0 + \sum_i^t \max(\Delta US_i, 0) + \sum_i^t \min(\Delta US_i, 0) \tag{12}$$

where max (·) stand for the positive change, while min (·) represents the negative shock in the considered variables. The asymmetric impact can, then, be incorporated into the vector of covariates $X_i(t)$ explained in Eq. 5.

5. EMPIRICAL RESULTS

5.1. Energy Market Cycle Estimation

In this section, we compare the dates of the turning points along with the duration, frequency and amplitude of contractions and expansion cycles for each index. The first index is the oil price, which is the dominant contributor, about 36%, to energy resources used. The second index is the Coal index (Table 1), which roughly corresponds to about 28% of the energy resources used in the world. The final index is Gas index, which roughly corresponds to about 23% of the energy resources used in the world.

Over the course of more than three decades, Table 2 shows that there have been 10 contractions in the oil market, 11 contractions in the Coal market, and 12 contractions in the Gaz market. These contractions they lasting around 1.3, 1.1, and 1.2 years on average, respectively, implying that the oil market has been in a state of recession 41.3 per cent of the time, whereas the Coal market and Gaz market have been in a state of recession 38.4 and 41.3 per cent of the time, respectively. Furthermore, the average amplitude is around 69%, 37% and 43% for Oil, Coal and Gaz, respectively. In addition, the average output loss, from trough to peak, has been 60% for Oil, 24% for Coal and, 7% for Gas. However, this has been far from constant over time.

Coming to the expansion phase, the average expansion has lengthened 1.6 years for the oil index, 1.4 years for the Coal index, and 1.3 years for the Gas index. Moreover, the average amplitude is around 71%, 43% and 45% for Oil, Coal and Gaz, respectively. Further, the average output loss, from peak to trough, has been 25% for Oil, 25% for Coal and, 15% for Gas.

Table 1: Cox hazard Model (HM) with time-varying covariates

	Contraction					
	Oil		Gas		Coal	
	Coef.	HR	Coef.	HR	Coef.	HR
GPR	0.161* (0.021)	1.175	0.037* (0.002)	1.038	0.120* (0.001)	1.127
IRP	−0.415* (0.128)	0.660	−0.018 (0.093)	0.982	−0.239** (0.108)	0.788
IRN	0.381** (0.142)	1.464	0.196 (0.835)	1.216	0.281 (0.565)	1.324
USDIN	0.078** (0.021)	1.081	0.081 (0.070)	1.084	0.076 (0.077)	1.079
USDIP	−0.053** (0.019)	0.949	−0.065** (0.025)	0.937	−0.122* (0.024)	0.885
IGREA	−0.218* (0.034)	0.804	−0.081*** (0.039)	0.922	−0.092** (0.031)	0.912
NFCI	−0.099 (0.149)	0.906	−0.213**** (0.139)	0.808	−0.110 (0.149)	0.896
	Expansion					
	Oil		Gas		Coal	
	Coef.	HR	Coef.	HR	Coef.	HR
GPR	−0.057* (0.002)	0.944	−0.024* (0.002)	0.976	−0.025* (0.002)	0.975
IRP	0.387* (0.010)	1.472	0.018 (0.093)	1.019	0.813** (0.397)	2.255
IRN	−0.455** (0.309)	0.635	−0.196 (0.835)	0.822	−0.906 (0.661)	0.404
USDIN	0.004 (0.072)	1.004	0.081 (0.070)	1.084	0.002 (0.068)	1.002
USDIP	−0.066 (0.037)	0.936	−0.065** (0.025)	0.937	−0.025** (0.017)	0.975
IGREA	0.105 (0.222)	1.111	0.008 (0.124)	1.008	0.390 (0.201)	1.477
NFCI	0.357 (0.260)	1.429	0.213*** (0.139)	1.237	0.660** (0.249)	1.433

The coefficient value=Ln (Haz. Ratio), S.E. in parentheses, *, **, *** indicate 1%, 5% and 10% significant code

Another remarkable outcome is that the recessions and expansion have become more frequent, occurring roughly every 1.5-2 years in the nineties, every year and a half (or less) since then.

These results provide evidence of asymmetry in the energy market cycle, where the upturn phases are longer than the decline phases. In terms of amplitude, a typical cycle features a more pronounced amplitude in expansion phases than in contraction. The latter is a well-known feature of most of the asymmetric cycles in economic activity.

Collectively, the data reveals longer energy market expansions, suggesting structural factors or policies at play. Policymakers are urged to prioritize understanding and reinforcing expansion factors, encouraging investment, innovation, and sustainability. The increased frequency of economic fluctuations may result from global energy shifts, technology, or policy changes, prompting policymakers to adopt flexible strategies and invest in research. With oil's dominance, policymakers should ensure stable and sustainable energy, diversify, and address output losses during contractions. Managing oil market volatility may require strategic reserves, regulations, or diversification strategies.

Of particular concern, is the shape of the cycle. In this vein, the following question arises: Does energy index activity fall and rise according to a short, sharp V-shape, a double-dip W-shape or a more permanent L-shape? Figure 2 plots the cyclical components of each variable against the turning point indices. It is interesting to see that the energy indexes in most of the cases peaked before the global financial crisis as well as before the COVID-19 pandemic. Moreover, one can note that recessions have been somewhat tick-shaped, with a short contraction and longer recovery.

5.2. Duration Dependences Estimation

The analysis of energy markets, focusing on oil, coal, and gas, reveals important economic trends and policy considerations. Notably, there is an asymmetry in the market cycle, with upturn phases (expansions) being longer than downturn phases (contractions). This suggests underlying factors or policies supporting sustained growth in the energy sector. Additionally, recessions and expansions have become more frequent in recent years, requiring agile and adaptable policy responses. The dominance of oil as an energy resource underscores its global significance, while coal and gas also play substantial roles. Policymakers should prioritize stable and sustainable energy supplies, considering strategies for diversification, efficiency, and transitioning to cleaner alternatives. Lastly, addressing the varying output losses and price volatility across energy sources calls for targeted policies to mitigate economic impacts, potentially through stimulus packages, workforce support, and market stabilization measures. In sum, understanding these dynamics and implementing flexible, forward-thinking policies will be crucial for managing the complexities of the global energy market.

Having confirmed the cyclicality in the energy market behaviour, the following important questions need to be answered (i) whether the cycle phase exhibits duration dependence, and (ii) to what extent these dependencies are driven by a shock to related factors such as interest rate, change in US dollar, Economic uncertainty, Geopolitical Risk Index, Index of Global Real Economic Activity, and National Financial Conditions Index (iii) how the role of these variables may change during the contraction compared to the expansion phases.

To answer these questions, it is necessary to examine separately the impact during expansion and that during contraction. Accordingly, each of the next tables presents the estimated hazard ratio of the parameters of the Cox hazard Model (HM) with time-varying covariates obtained for the energy cycle during contraction (expansion) periods, along with robust standard errors.

In the baseline specifications of both models, the vector X_{it} includes Geopolitical Risk Index (GPR) to control for the uncertainty condition, while other variables include a positive shock to US

Table 2: Dating of peaks (troughs) in real energy prices and classical energy prices cycle characteristics

Expansion				Recession			
Oil index							
Start	**End**	**Duration**	**Amplitude**	**Start**	**End**	**Duration**	**Amplitude**
February 1994	January 1997	35	0.9	August 1990	February 1994	42	1.9
November 1998	March 2000	16	0.6	January 1997	November 1998	22	0.6
March 2002	January 2003	10	0.1	March 2000	March 2002	24	0.7
October 2003	April 2006	30	0.7	January 2003	October 2003	9	0.1
March 2007	January 2008	10	0.4	April 2006	March 2007	11	0.4
May 2009	February 2014	57	1.1	January 2008	May 2009	16	1
March 2016	December 2016	9	0.1	February 2014	March 2016	25	0.9
June 2017	July 2018	13	0.3	December 2016	June 2017	6	0
June 2017	February 2019	7	0.1	February 2019	November 2019	9	0.2
November 2019	June 2020	7	0.2	June 2020	August 2021	14	2.1
Average		19.091	0.707	Average		16	-0.685
Excess area		0.249		excess area		0.598	
Coal index							
August 1990	June 1992	22	0.2	June 1992	October 1993	16	0.2
October 1993	November 1995	25	0.3	November 1995	November 1996	12	0.1
November 1996	August 1997	9	0	August 1997	December 1998	16	0.2
December 1998	June. 2001	30	0.3	June. 2001	April 2003	22	0.4
April 2003	September 2004	17	0.7	September 2004	November 2005	14	0.6
November 2005	May 2006	6	0	May 2006	March 2007	10	0.2
March 2007	May 2008	14	0.8	May 2008	July. 2009	14	0.9
July 2009	October 2011	27	0.6	October 2011	October 2012	12	0.6
October 2012	August 2013	11	0.2	August 2013	July 2014	11	0.2
July 2014	December 2014	5	0	December 2014	December 2015	12	0.3
December 2015	June 2018	30	0.7	June 2018	July 2020	25	0.9
Average		17.5	0.426	Average		13.539	-0.369
excess area		0.245		excess area		0.236	
Gas Index							
Nov. 1991	May 1993	18	0.3	July 1990	November 1991	16	0.4
Mar. 1995	April 1996	13	0.5	May 1993	March 1995	22	0.5
Jan. 1997	September 1997	8	0.2	April 1996	January 1997	9	0.1
Oct. 1998	November 2000	25	0.8	September 1997	October 1998	13	0.3
Jan. 2002	February 2003	13	0.5	November 2000	January 2002	14	1.1
May. 2004	September 2005	16	0.3	February 2003	May 2004	15	0.1
Feb. 2007	April 2008	14	0.5	September 2005	February 2007	17	0.3
Jun. 2009	April 2011	22	0.4	April. 2008	June 2009	14	0.7
May. 2012	May 2014	24	0.6	April 2011	May 2012	13	0.3
Nov. 2015	February 2017	15	0.4	May 2014	November 2015	18	0.6
Dec. 2017	October 2018	10	0.1	February 2017	December 2017	10	0.1
Feb. 2020	September 2021	19	1.1	October 2018	February 2020	16	0.3
Average		15.615	0.448	Average		14.077	-0.4265
excess area		0.156		excess area		0.068	

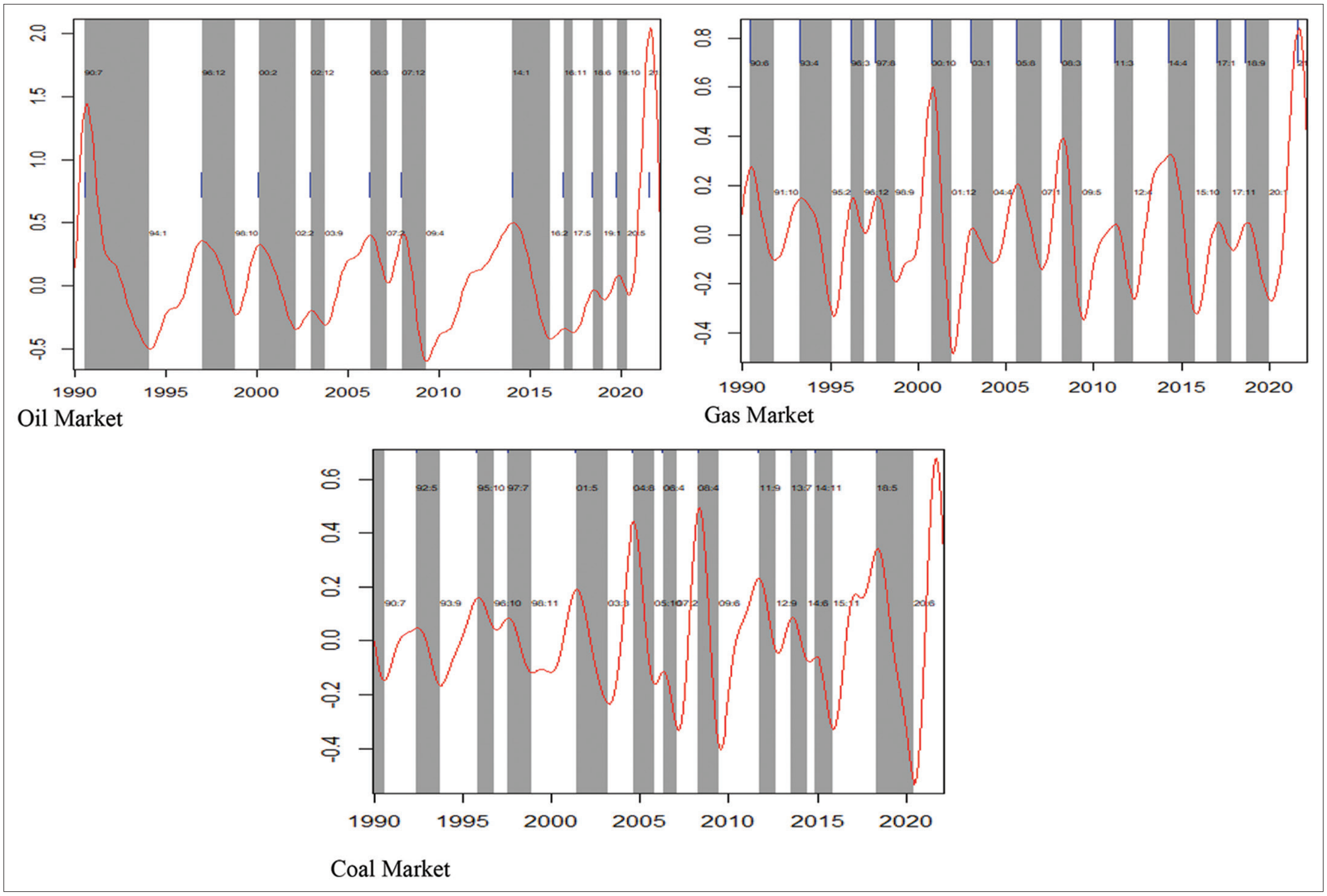
(1) Duration is expressed in months. (2) Duration and amplitude refer to the average of the duration and amplitude of the cyclical component by energy index. (3) Amplitude, cumulative and excess area are expressed in percentages

dollar index (USDXP), a negative shock to US dollar index (USDXN), a positive shock to interest rate (IRP), and negative shock to interest rate (IRN) to control the effect of such policy. Besides, two important global factors include Index of Global Real Economic Activity (IGREA) and National Financial Conditions Index (NFCI) to represent both financial and economic conditions.

The results of the hazard ratio during the contraction period are reported in Panel A of Table 2. This table is quite revealing in several ways. First, it is apparent that almost all the variables generally have the expected sign. Second, it seems that the energy market is more prone to any change in the interest rate policy (IR) than the other factors. In this context, a positive shock to the interest rate increases the likelihood of switching to expansion by 34%, 8% and 22% in the case of oil, Gas and coal markets, respectively. Similarly, a positive shock to USDX increases the likelihood of switching to expansion by around 6% in all cases. By contrast, the negative shock positively contributes to the contraction phase. In this vein, the observed decrease in the hazard ratio reveals a decline in the probability that expansion will be reached. To be specific, a negative shock to the interest rate contribute to the surviving of contraction period by around 46% for the oil prices. However, it seems that the positive shock to the interest rate has no direct impact in case of Coal and Gas. A possible explanation here is the fact that the high interest rate could results in appreciation (depreciation) in the US dollar, which would cause the U.S. dollar index (USDX) to fluctuate and thus affect the energy prices since they are denominated in U.S. dollars (e.g., Haberly and Wójcik, 2022; Waltz, 1999).

This impact can also be seen when considering the negative shocks to USDX, in which the likelihood of contraction increased by around 8% of their previous value in all cases. These results are

Figure 2: The cyclical components of each energy variable against the turning point indices. The dashed gray line shows the peak date while the white line shows the trough date



The dashed gray line shows the peak date while the white line shows the trough date

in agreement with the current literature that the depreciation of the U.S. dollar rises the OP in the considered oil exporting countries (e.g., Yousefi and Wirjanto, 2003; Reboredo et al., 2014; De Schryder and Peersman, 2016; Liu et al., 2020).

Turning to the economic and financial conditions, the results highlight that both economic growth and tend to promote the energy prices index. In this case, IGREA increases the probability of switching to expansion by 20% for the oil prices and by around 8% for the Coal and Gas indexes. This expected outcome is in line with the Conservation hypothesis, which supports the causality from the economic growth to energy prices (e.g., Ouedraogo, 2013; Jebli and Youssef, 2015). However, the financial conditions seem to have no direct impact to the contraction phase.

Considering the economic uncertainty, as expected, any change in GPR approximately increases the hazard of failure to 17% for the oil market, 4% for the Gas market, and only about 13% for the coal market of their previous value. These observed increase in the hazard ratio reveals a decline in the probability that contraction will continue.

Coming to the expansion phase, Panel B of Table 2 highlight that changing the policy plays a crucial role in affecting the energy market compared with the uncertainty. It simply (perhaps predictably) indicates that an uncertainty likelihood is more in a recessionary environment.

Be that as it may, a positive shock to interest rate policy actions has proved to be relevant to detecting the presence of negative dependence on the duration of the expansion. In this case, a one-unit change increased the hazard to 47% of its previous value in the case of oil index and about 25% for the coal index. By contrast, lowering interest rate during the expansion will decrease the hazard to 36 of its previous value for oil. However, this negative shock seems has no impact to the Gas, and coal. Similar results are obtained when we consider a shock to US dollar, though the impact is smaller and even insignificant in some case.

Regarding the economic and financial conditions, the results show no role for both IGREA and NFCI in increasing the likelihood of expansion to survive. By contrast, the economic uncertainty would increase the likelihood of switching to contraction by 6% for oil prices index and around 4% for both Coal and Gas.

Taken together, the considered factors underscore the nuanced interplay of various factors in shaping energy market dynamics, providing valuable insights for policymakers to navigate and promote stability in this crucial sector. Notably, positive shocks to interest rates and the US dollar emerge as catalysts for market expansion, while negative shocks contribute to contractions. Policymakers should carefully manage interest rate policies and monitor US dollar dynamics to foster market stability. Additionally, economic growth positively influences energy prices during contractions, supporting the need for policies that stimulate economic development. Geopolitical risks and economic uncertainty play pivotal roles, highlighting the importance of risk mitigation strategies and clear, consistent economic policies. In the expansion phase, policy changes significantly impact the energy market, emphasizing the need for adaptable and responsive policymaking.

5.3. The Cop Meetings Role in the Energy Cycle Dynamics

In expanding our analysis to capture additional dimensions of the energy market dynamics, we introduced a new variable related to Conferences of Parties (COP) meetings. An important question needs to be answered: to what extent are the dependencies in the energy market driven by COP climate policies, and how may the role of these variables change during the contraction compared to the expansion phases?

The United Nations Conference on Environment and Development, also known as the Earth Summit, resulted from years of diplomatic negotiations. The Convention was ratified by 198 countries, collectively referred to as Parties to the Convention. Conferences of Parties (COPs) have been held worldwide to discuss progress on climate change, desertification, and biodiversity. Since COP1 in Berlin in 1995, the progress in tackling climate change has varied among the 198 signatories. In 2015, COP21 in Paris resulted in the unprecedented Paris Agreement among the world's nations to limit carbon emissions and combat climate change. The Paris Agreement came into effect in November 2016, with signatory countries committing to implementing low‒carbon strategies, marking the beginning of the process to reduce global emissions.

This requires changing how we conduct our businesses, from agriculture to manufacturing and the consumption of fossil energy, to make progress and ensure that global emissions remain below the two-degree limit. This demonstrates how the policies from COP meetings can play a vital role in energy prices.

We also strengthened the reliability of our study by integrating the COP meeting variable in our model. The results accord with our earlier findings. The possibility of market expansion in the oil, gas, and coal industries is positively affected by interest rate shocks even during contractions. Furthermore, the possibility of switching to an expansion phase remains influenced by the substantial impact on the US dollar index, yet the likelihood of contraction is increased by any negative consequences. Particularly, the latter tendencies were not affected by the inclusion of the COP meeting variable, signifying that it is not affected by the energy market's cyclical patterns. Beyond what the present model deliver, COP gatherings may affect the market in other ways. Policymakers may benefit from more in-depth information if researchers investigated the precise mechanisms by which COP meetings affect energy market dynamics.

6. CONCLUSION AND POLICY IMPLICATIONS

In conclusion, this paper undertakes a comprehensive exploration of the intricate dynamics within energy market cycles, set against the backdrop of financial deregulation and technological advancements. With a focus on energy commodities and their historical significance, the study sheds light on their pivotal role in global economic equilibrium. The investigation underscores the potential consequences of energy price shocks on economic growth and systematically analyzes the asymmetric behavior inherent in energy market cycles.

Employing the extended BBQ algorithm as well as the Cox hazard Model (HM) with time-varying covariates, the research identifies turning points in these cycles and investigates duration dependencies, incorporating factors such as geopolitical risks, the US dollar index, interest rates, and economic and financial conditions. The study contributes significantly by providing historical context for economic downturns and recoveries, unraveling non-linarities across booms and busts, and revealing durational dependencies between energy cycles and key influencing factors.

Covering a substantial timeframe from January 1990 to July 2022, including periods of economic stress such as the COVID-19 pandemic, this research offers a nuanced understanding of the complex interplay between energy markets, economic conditions, and policy responses. The findings provide valuable insights for policymakers navigating and mitigating the consequences of recessionary phases in the global energy market.

Our results, spanning three decades and three energy indices (oil, coal, and gas), reveal several facets, including comparisons of turning points, duration, frequency, and amplitude of contractions and expansions. Notably, expansion phases have lengthened, highlighting an asymmetry in the energy market cycle. Policymakers are urged to prioritize understanding the factors driving expansion, emphasizing investment, innovation, and sustainability. Given the dominant role of oil and increased economic fluctuations, flexible strategies and research investment are deemed essential, potentially involving strategic reserves, regulations, or diversification strategies to manage oil market volatility.

Examining various factors underscores the intricate patterns that govern energy markets, offering policymakers valuable insights to promote stability in this crucial sector. Positive changes in interest rates and the US dollar are recognised as factors that drive market growth, while negative changes contribute to market downturns. establishing market stability calls for careful management of interest rate policies and close monitoring of US dollar dynamics.

On top of that, the study points out the positive effect of economic growth on energy prices during recessions, demonstrating the significance of policies that promote economic development. Geopolitical risks and economic uncertainty have been viewed as crucial factors, underscoring the necessity of implementing effective risk mitigation strategies and maintaining consistent economic policies. throughout the expansion phase, the study shows the importance of policy changes in shaping the energy market, underscoring the need for flexible and proactive policymaking.

Incorporating a variable that involves COP meetings to the enlarged study offers insight on the way COP climate policies influence energy market interdependence. Interest rates and the US currency had significant impacts, yet the COP meeting variable had minimal impact on these patterns. It is urged that more research be done to identify particular pathways in order to gain more nuanced insights for policymakers, as this indicates that COP meetings might impact the market through processes that are not completely reflected by current variables.

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