

Revisiting the Linkages between Oil Prices and Macroeconomy for the Euro Area: Does Energy Inflation Still Matter?

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Abstract

This study revisits the relationship between oil prices and the macroeconomy for the euro area while assessing the effects of recent energy inflation on the real economy. We particularly investigate the impact of energy inflation on the real sector (household consumption, firm investment, and economic growth), financial sector (inflation, financial market), and economic agents' confidence. Considering the monetary authority's recent actions, we review this oil price–macroeconomy relationship while taking into account the ongoing monetary policy to check the policy's efficiency and to assess whether the recent successive interventions of the European Central Bank (ECB) have attenuated the effects of energy inflation. We test these hypotheses in linear and nonlinear frameworks using threshold models that offer a flexible econometric modeling. Our results reveal two interesting findings. First, an oil price shift exerts a significant and nonlinear effect on the real and financial sectors. This impact is asymmetrical and varies by regime, depending on the economic situation (geopolitical tension, inflation, war in Ukraine, etc.). Additionally, we empirically and endogenously estimate the threshold level at which the impact of oil price changes is significant. Second, the reaction of economic growth and inflation rate to oil price shifts remains highly significant, even when considering the ongoing monetary policy of the ECB.

Keywords: Oil Price Shock, Energy Inflation, geopolitical tensions, Real Economy, Financial Sector, Nonlinearity, Threshold Models.
***JEL*:** Q40, Q43, C22, G15.

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1. Introduction

This paper aims to revisit the relationship between oil price and macroeconomy for the euro area and to investigate whether oil price shifts have impacted the real economy of the euro area. Obviously, this question is not new but it merits reconsideration given the importance of energy inflation in the area, at least since the post-COVID-19 and geopolitical tensions (war in Ukraine and restrictions on Russia)[1]and the high level of inflation. Why should we focus on this research question? The investigation of the oil price–real economy relationship has always been challenging, even fueling debates among economists and analysts for which we can cite at least three examples.

First, a perpetual debate persists regarding the analysis of oil price volatility and the explanation of its drivers (e.g., demand versus supply shocks) and their effects. For example, the 2003–2008 period was characterized by a solid connection between oil price variations and changes in the global business cycle. During this period, the increase in oil demand—stimulated by the increase in oil consumption in China and emerging Asian countries—was faster than that of the global oil production, yielding a rapid increase in oil prices. Between 2010 and 2014, the West Texas Intermediate (WTI)[2] price increased from US$80 to US$110, before falling to US$26, presenting a serious decline of approximately 60% in the beginning of 2016 and stabilizing at around US$50 by the end of 2016; however, this oil price decline was not followed by a significant increase in household consumption, as consumers seemed to prefer saving their money rather than spending it. This suggests that the transmission of oil price shocks into the real economy is not straightforward, and remains challenging and time-varying. For example, Baumeister (2022) found that between October 2020 and October 2021, oil price shocks implied a global inflation of 2% for the US (0.3% due to oil supply shock and 1.7% due to oil demand shock), while the oil price shock over the same period accounts for 2.4% of global inflation for the euro area (0.3% due to oil supply shock and 2.1% due to oil demand shock).

Second, a key factor related to oil price fluctuations associated with the oil futures market's financialization has also divided energy economists. While Kilian and

[1] See Izzeldin et al. (2023) for a concise analysis on the effects of this war on financial markets among others.
[2] Abbreviations: West Texas Intermediate (WTI), European Central Bank (ECB), coronavirus disease 2019 (COVID-19), Threshold Autoregressive (TAR) model, Vector Autoregressive (VAR) model.

Murphy (2014) found no evidence that financial speculation drives real oil prices, Juvenal and Petrella (2015) reached the opposite conclusion and recommended reconsidering the derivative market's regulation. This recommendation was criticized by Kilian and Murphy (2014), who suggested that hybrid speculative shocks account for only 15% of the rush in the real oil price between 2003 and 2008, while oil supply disruption was responsible for 9%, and that approximately 58% of oil price fluctuations are associated with an oil demand shock and, therefore, with the global business cycle. In the same context, Baumeister (2020, 2022) found evidence of an oil price increase but demonstrated that the driver depends on the period under consideration. She found that the oil price increased by 88% between April and August 2020, of which 53% was attributable to supply, while the price increased by 67% between October 2020 and October 2021, of which 84% was attributable to demand.

Third, in a *Wall Street Journal* newspaper article[3], Christiane Baumeister and Stephen Moore[4] responded differently to this question with opposing analyses. For Stephen Moore, a low oil price might provide consumers additional money and cut manufacturing costs, whereas according to Christiane Baumeister, this positive effect is weak, as consumers might decide to increase their savings. For example, a low oil price can slightly damage the oil sector, neutralizing this low price's benefit and even hurting the US oil industry.

These three examples can point to the challenge and complexity related to the oil price–macroeconomy relationship. To reconsider and analyze this relationship over the last period, we focus on a classical channel related to energy inflation in the context of geopolitical tensions and the war in Ukraine and Russia (an important oil producer) and its effects. The COVID-19 outbreak disturbed the supply of oil and commodities and the post-COVID-19 recovery exhibited high demand, which dramatically increased the prices of most commodities, yielding an impressive energy inflation phenomenon. The latter has aggravated the general price levels, inducing a serious inflation problem for several developed and emerging countries—with a dramatic consequence on the purchasing power of households, investment in companies, and economic growth in the

[3] "*Are low oil prices good for the economy?*", The WSJ, November 14, 2016.

[4] Christiane Baumeister is a Professor of Economics at the University of Notre Dame, while Stephen Moore is an Economist at Freedom Works and an Economic Adviser to the former US President, Donald Trump.

US and Europe. To attenuate the effects of inflation, numerous central banks, including the European Central Bank (ECB) and Fed, have decided to increase interest rates several times.

Interestingly, this study aims to revisit the oil–macroeconomy relationship while assessing the effects of energy inflation on both the real and financial sectors in the euro area, as well as on householders' confidence and psychology. Indeed, for the two last decades the relationship between oil and the macroeconomy has been more challenging given that oil price, which has a key impact on both demand and supply, has been extremely volatile, motivating thus our interest in this relationship. Further, the focus on the real sector enables us to capture this double effect (the demand through the consumption component and the supply through the investment component). Otherwise, our focus on householder's confidence and psychology enables us to test whether this oil price volatility excess may produce a change in householder's behavior.

Additionally, we investigate this question by considering the ECB's ongoing monetary policy, which enables us to indirectly test its efficiency. Indeed, during the sample period, the ECB Monetary policy as well as that of most Central Banks has switched from conventional monetary policy to unconventional monetary policy to limit the effects of the global financial crisis in 2008 and this unconventional monetary policy has lasted for a while. Then, in the aftermath of the post-COVID-19 periods, several central banks including the ECB have started limiting their programs of purchasing of financial asset (Quantitative easing instrument) and have increased their interest rates to try to fight against the inflation caused directly or indirectly by the coronavirus pandemic, moving therefore toward their classical conventional policies. That is, this change in conducting monetary policy may impact the oil-macroeconomy relationship. To this end, we propose an on–off threshold modeling that enables us to investigate this research question in a flexible framework, allowing energy inflation's effect to enter asymmetrically and nonlinearly. To better explain this time-variation, we will hereafter compare the results of the nonlinear model to those of the linear benchmark model.

Our findings provide two stimulating results. First, an oil price shift exerts a significant and nonlinear effect on the real and financial sectors, and this impact is asymmetrical, varying by regime. Interestingly, we empirically estimated the threshold level at which oil price changes' impact is significant. Capturing this nonlinearity and identifying these regimes are relevant in particular to forecast more accurately the reaction of the economy (real sector, financial sector, etc) to an oil price shift with regard to the phase or the regime of the business cycle. This finding is also in line with the eminent works of Hamilton (1983a, 2009). However, to our knowledge, this finding in a particular and challenging context of high inflation, geopolitical tensions and post-COVID-19 period is a new result in the related literature. Second, the reaction of economic growth and inflation rate to oil price shifts remains highly significant, even when considering the ECB's ongoing rate policy. This finding is relevant as it helps evaluate a more appropriate economic policy to attenuate the effects of energy inflation. Indeed, our specification characterizes and quantifies the impact of oil price shift on the economy per regime and per state. Given that the energy inflation is an important driver for the global inflation, this result would enable policymakers to adapt their instruments and the conduct of monetary or fiscal policy to attenuate the effect of oil price shift according to the economic state under consideration.

The remainder of this paper is organized into four sections. Section 2 briefly debates related literature. Section 3 presents the data and discusses the main results. Section 4 concludes.

2. Literature Review

This challenge regarding the link between the real economy and oil price is not new and has persisted since the 1970s oil shock. Following Hamilton's (1983a) seminal work, the presence of an active and dynamic connection between economic cycles and oil prices has been acknowledged. Hamilton (1983a, 1983b) found evidence of a causal relationship between U.S. economic growth and oil price shocks, suggesting that an oil price shock significantly affects the real economy. Furthermore, this causal relationship means that a shift in oil price impacts the economic cycle and can even help forecast the future dynamics of economic growth in the US. While this conclusion has posed challenges, the origins and consequences of oil price shifts or shocks (demand shocks; supply shocks; political shocks, such as geopolitical tensions; and exogenous shocks, such as shortages and strikes) have also been debated, and oil price shocks' origins depend on the period of the conducted study.

That is, the analysis of the historical origins of oil price shocks reveals different explanations and evaluations. For example, the 1947–1948 oil shock was related to the increased petroleum demand in the aftermath of the Second World War, which was associated with the reconstruction of Europe; the 1952–1953 oil price shift was caused by the Iranian nationalization and strikes by commodities' workers; the oil price variation in 1956–1957 was due to the Suez crisis; the 1973–1974 oil price shock was associated with a stagnation of the U.S. economy and the Arab–Israeli war; the 1978–1979 shock was caused by the Iranian revolution; the 1980–1981 oil price shock resulted from the Iran–Iraq war; the 2008–2009 oil price shift was triggered by the global financial crisis; the 2014–2015 oil price change was prompted by the shale revolution; and the 2020 oil price volatility was caused by the coronavirus disease 2019 (COVID-19) pandemic.

These oil price shocks have caused serious economic problems for businesses, industries, and transportation services in the US and Europe, often precipitating serious downturns and economic recessions. According to Hamilton (1986), most oil price shocks implied the collapse of U.S. output. For example, in 1979–1981, the second oil price shock, which was caused by the Iranian revolution in October 1978 due to a fall in Iranian oil production (from 6 Million barrels of oil a day to 0.4 million barrels per day) and a decrease of 9.1% of the total oil production, sparked an economic recession in the US as dated in the National Bureau of Economic Research in the first quarter of 1980. Thus, from this perspective, oil price increases are considered a systematic endogenous element related to the phases of the business cycle, complying with several forces and factors.

Regarding the evolution of oil prices over the last two decades, oil prices have become increasingly central to different actors and media attention, and their dynamics have been cyclical depending on different rules and factors. For example, the WTI oil price was stable at around US$22–28, adhering to the rules of the Organization of the Petroleum Exporting Countries (OPEC) after falling to US$10 in 1998. However, the WTI increased between 2004 and 2008, as we mentioned earlier, surpassing the level of US$100; this increase was driven particularly by the explosion of international oil demand and the high level of economic growth in the US and several emerging countries. During the 2008–2009 period, oil price experienced three different phases: It hovered around US$145 between January and July; fell to US$36 between July and

December; and reached US$90 by the end of 2009, remaining around this level before changing in the 2014–2015 period with the shale revolution. The WTI even turned negative for the first time in its history in April 2020, demonstrating the excessive volatility caused by the COVID-19 pandemic and its related uncertainty and restriction measures.

Excess volatility over the last decade and this abnormal oil price can be associated with the high level of financialization of the oil market, commodity markets, and physical oil market. Financial trading related to commodity derivatives—though still challenging—has demonstrated an impressive trading volume that exceeds more than forty times that of the physical market, which involves different actors and investors with diverse strategies (e.g., hedging, speculation, arbitrage, and diversification). Consequently, commodity price dynamics exhibited a greater complexity and interaction with the real economy than they did in the 1970s.

In the literature, Hamilton (1983a) is the first study to find a positive and significant linkage between oil price shocks and the growth of the U.S. gross national product (GNP) in the 1970s, viewing the oil price shocks as the cause of the economic downturn in the US. In the same context, but over a period with decreasing oil price, Mork (1989) found a negative and persistent correlation between oil price increase and the growth of the U.S. GNP. By contrast, Barsky and Kilian (2004) analyzed the period of oil price increases and economic recessions in the US and concluded that oil price shocks might have contributed to the economic recessions, however they found that their contribution is not central to this study. Jiménez-Rodríguez and Sánchez (2005) analyzed the reaction of real economy to oil price shocks in developed countries and pointed to a nonlinear effect of oil prices on real gross domestic product (GDP), which is in line with Nasir et al. (2019, 2020). Indeed, an oil price increase seems to have a more important effect on real GDP than an oil price decrease. Additionally, Lescaroux and Mignon (2008) found a significant relationship between oil prices and real GDP, particularly in the long run. Abbritti et al. (2020) studied the impact of oil prices on four main macro-financial variables in the US over the 1974–2016 period and found that oil price shocks significantly impacted production, unemployment, interest rates, and credit spread.

Further, Baumeister et al. (2018) suggested that oil price shocks can shift domestic aggregate demand and domestic aggregate supply, and identified two channels. The first channel, which is considered weak for the US, passes through a reduction in the production costs of goods and services. The second channel is illustrated by an increase in demand for goods and services. They examined the effects of oil price shocks with reference to the economic stimuli principle. They defined a demand stimulus as a trade shock when income is moved from oil-exporting economies to oil-importing economies. For example, while the consumption stimulus between 2014 and 2016 was approximately 0.51%, the authors also identified an investment stimulus that characterized a situation in which most non-oil firms could benefit from an oil price decrease. However, the authors suggested further evidence of asymmetry in the spread of oil price shocks, which can be justified by the uncertainty regarding future oil prices. Baumeister and Kilian (2016a), in a media note "*Expecting the unexpected: why oil price keeps surprising us*," published in VOX EU on 08th February 2016, recommended allowing for heterogeneous expectations in modeling the effects of oil price shocks.

Oil price shocks seem to affect emerging economies (either oil-exporting or oil-importing countries) and other macro and financial variables in addition to real GDP. Tiawon and Miar (2023) found evidence of a significant and asymmetrical oil price shock on real GDP and the real exchange rate for Indonesia, as the effect of a negative shock is higher than that of a positive shock. For Nigeria, an oil producer similar to Indonesia, Adeniyi et al. (2011) did not find a significant impact on the real economy. Considering Saudi Arabia, which is an important oil producer, Almutairi (2020) and Abboud et al. (2021) found a positive and significant correlation between oil price shocks and GDP in the long run, suggesting a strong dependence of the Saudi Arabian economy on the oil sector, and recommended the necessity of diversifying the economy.

As for the impact of oil price shocks on other macroeconomic and financial variables, Zhang et al. (2014) found that oil price shocks significantly impact household consumption in China, particularly in the transportation, food, and clothing sectors. This finding aligns with that of Sun et al. (2022), who found that oil price fluctuations exert the strongest impact on Chinese consumption and production in the oil and nuclear sectors[5].

[5] Nasir et al. (2019) also found that an oil price shift has a significant effect on the real economies of GCC (Gulf Cooperation Council) countries. In the same context, Nasir et al. (2018) showed a significant reaction of BRICS (Brazil, Russia, India, China and South Africa) countries to oil price shocks.

Sek (2019) showed a significant and asymmetrical effect of oil price fluctuations on the consumer price index (CPI), suggesting further evidence of inflation driven by oil price volatility. Further, Chen (2021) found that oil price shocks cause inflation in Taiwan and negatively impact real GDP. Renou-Maissant (2019) analyzed the effect of oil price variations on the inflation level over the 1991–2016 period in the US, Canada, Japan, Australia, France, Germany, Italy, and the UK. They found that even during periods of weak and stable inflation, oil price volatility drove the inflation rate. Choi et al. (2018) studied the impact of oil price on the inflation level for 72 developed and developing countries over the 1970–2015 period, which revealed that an increase in oil price of 10% implies an inflation increase of 0.4%. Furthermore, oil price shocks enter asymmetrically, as a positive oil price shock's effect is higher than that of a negative oil price shock. Elsayed et al. (2021) investigated the interconnectedness between oil prices and inflation for China as well as the G7 countries during the period 1987–2020 using both time-series models and time- and frequency-domain methods. The authors found a significant integration between oil price inflation and general inflation. Interestingly, the link between oil and general inflation is time-varying, increasing in particular during oil and financial crises. Oil price acts as an important transmitter in price increases, particularly in the US, while the influence of energy inflation is more relevant in the short term than in the long term. Adekoya et al. (2022) found that while oil prices were assimilated into the receptor of volatility from financial assets before the war in Ukraine, they became a volatility transmitter during the ongoing war.

Overall, we note that related studies highlight an active and challenging relationship between oil price shocks and provide economies with different conclusions and findings that vary from the sample under consideration. Furthermore, the oil price–real economy relationship seems to exhibit asymmetry and nonlinearity as indicated by Nasir et al. (2020). This relationship appears to be investigated less in the euro area, which we attempt to tackle here using a robust nonlinear modeling related to the threshold model that possesses the advantage of reproducing this asymmetry as well as further shifts and structural breaks in this relationship. In particular, we apply the class

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Interestingly, these reaction functions exhibit asymmetry and time-variation, which the authors explained in terms of difference in the structure of the economy of the country under consideration as well as depending on whether the country is an oil importer or exporter. Nasir et al. (2017) also found a negative relationship between oil price and the financial sector in the UK.

of threshold autoregressive (TAR) models of Tong and Lim (1980) and Tong (1990), which are relevant to capturing further asymmetry between oil price and the macro-financial variables through the identification of distinct regimes that are activated when an endogenous threshold is exceeded. This on–off and time-varying specification is particularly suitable for reproducing the impact of oil price inflation over different states and regimes (low-energy versus high-energy inflation).

3. Empirical Analysis

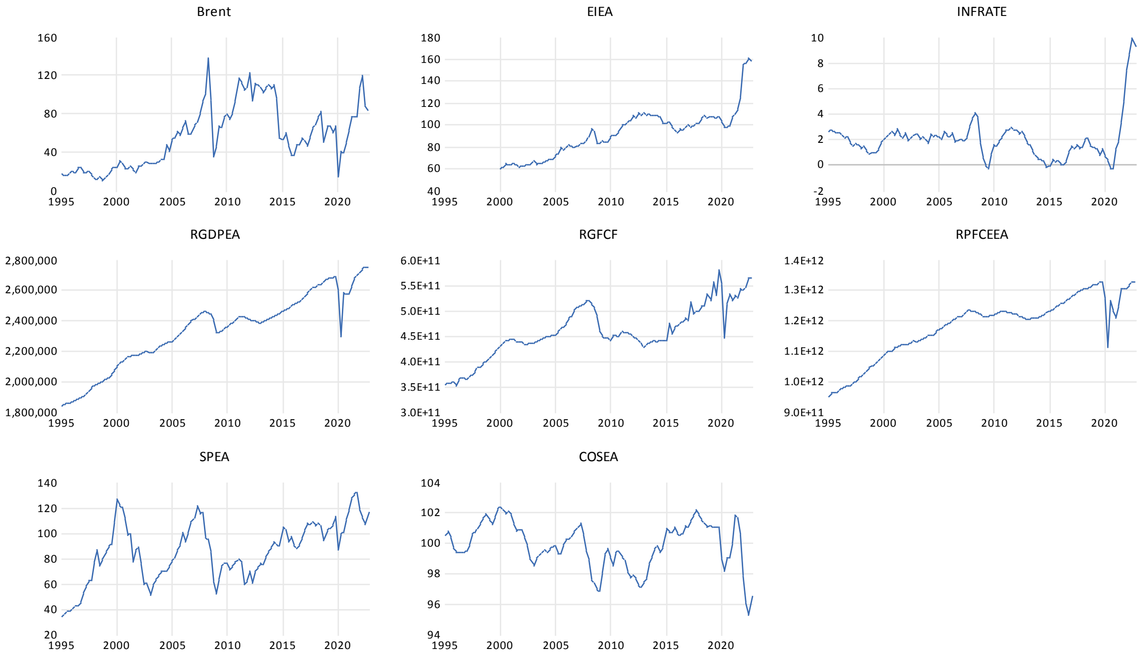
3.1 Data

Our sample includes quarterly data over the 1995Q1–2022Q3 period for the oil market and the real and financial sectors. This sample is relevant because it covers different oil price shifts as well as calm periods. The data were obtained from the Fed St. Louis. For oil prices, we use Brent, which is the benchmark oil price for Europe. Regarding the real sector, we use real GDP (RGDP) as a proxy for economic activity, real private final consumption expenditure (RPFCE) as a proxy for consumption, and real gross fixed capital formation (RGFCF) as a proxy for investment. For the financial sector, we consider the total share prices for the euro area (SPEA). We assess the inflation rate using the CPI and capture Central Bank Monetary Policy using the 3-month interbank rate (IREA). Finally, we capture the consumer opinion survey (COSEA) index using a confidence indicator (COSEA). For robustness, we also collected the Harmonized Index of Consumer Price category Energy (EIEA), which tracks the prices of non-durable goods and energy, including electricity, liquid fuels, solid fuels, heat energy, fuels, and lubricants for personal transport equipment. This index can be considered an energy inflation index.

3.2 Preliminary Analysis

In Figure 1, we report the dynamics of our main series: oil price (Brent), EIEA, inflation rate (INFRATE), RGDP, RPFCE, RGFCF, SPEA, and the COSEA index. Thus, from Figure 1, we can draw different conclusions.

Figure 1. Oil price and macro-financial variable dynamics[6]



First, we note that Brent has been more volatile, particularly after the global financial crisis with several up and down shifts, while the EIEA has been increasing exponentially, particularly after 2020 (COVID-19 and post-COVID-19 period), which seems *a priori* to drive the general inflation rate as illustrated by the graph of the inflation rate. However, this energy inflation and general inflation news seemed to cause a downturn in economic growth as well as a decline in the general level of consumption and investment. Unlike the real sector, the financial sector's reaction, as illustrated by the dynamics of the total share prices for the euro area (SPEA), seems to be lower. Finally, energy inflation seems to negatively affect householders' psychology and confidence levels.

Next, we test the stationarity using both Augmented Dickey Fuller and Philipps-Perron tests[7]. Accordingly, we find that the COSEA index and inflation rate are stationary, while all other series are not stationary in level but stationary in first difference, meaning that they are integrated in one order (I(1)). We then computed the

[6] All the data that is used is available from the first quarter of 1995 except that of EIEA, which is available from the first quarter of 2000.

[7] The results of the Unit Root tests are available upon request.

unconditional correlation between oil prices, inflation, energy, and other macroeconomic and financial variables (Table 1).

Table 1. Unconditional correlation matrix

	DLBRENT	DLEIEA	INFRATE	DLRGDPEA	DLRGFCFEA	DRPFCFEA	DLSPEA	DLCOSEA
DLBRENT	1	0.4609	0.0105	-0.1162	-0.1601	-0.1372	0.4654	0.1298
DLEIEA		1	0.3645	0.1986	0.1564	0.1202	0.1119	-0.2951
INFRATE			1	0.0234	0.0501	0.0400	-0.1521	-0.3959
DLRGDPEA				1	0.7936	0.9573	0.0488	0.2598
DLRGFCFEA					1	0.7253	0.0351	0.1582
DRPFCFEA						1	-0.0087	0.2586
DLSPEA							1	0.5319
DLCOSEA								1

Note: DLBRENT denotes oil return. DLEIEA is the variation in energy inflation. INFRATE refers to the inflation rate. DLRGDPEA is the economic growth rate in the euro area. DLRGFCFEA denotes the investment variation. DRPFCFEA denotes changes in private consumption. DLSPEA measures the variation in total shares. DLCOSEA denotes changes in consumer confidence.

Table 1 presents several interesting results. First, an oil shock of 1% implies an increase in the EIEA by 46%, and overall, 1% of global inflation, while energy inflation measured by the EIEA index represents 36.5% of global inflation, suggesting that energy inflation shocks are responsible for an important share of total inflation. Second, a 1% oil shock implies a decrease in economic growth of 11.62%, a decline in consumption of 13.72%, and an investment correction of 16.2%. Third, an oil price shock seems to have a positive effect on the financial sector, as a 1% oil price shock yields an increase of 46.54% in the total share, which can be explained by the high financialization of the oil futures market. In addition, a positive correlation was observed between oil prices and the confidence index. This result, although unexpected, can be due to the fact that this survey index is more of a composite index and not restricted to the survey about the energy sector. To better assess the impact of an oil shock on the real economy, we carry out different regressions and estimate the effect of an oil shock on macro-financial variables.

3.3 Linear Modeling the Effect of Oil Price Shifts

3.3.1 On the Real Sector

First, we run the typical linear autoregressive (AR) models to estimate the influence of oil price shifts on three main macroeconomic variables: economic growth, investment, and consumption. To this end, we set up the following ARX process:

$$Y_t = \alpha_0 + \sum_{i=1}^{p1} \alpha_i Y_{t-i} + \sum_{j=0}^{p2} \beta_j OR_{t-j} + \varepsilon_t \quad (1)$$

where Y_t denotes the endogenous variable of interest (economic growth, consumption, or investment); OR_t denotes the oil price change; ε_t is an error term; and, α and β are the AR coefficients.

Table 2. Estimation results of linear ARX models for the real sector[8]

Coefficients	Consumption Equation	Investment Equation	Economic Growth Equation
α_0	$0.004^{(**)}$ (0.03)	$0.005^{(*)}$ (0.06)	$0.004^{(*)}$ (0.06)
α_1	$-0.314^{(***)}$ (0.00)	$-0.315^{(***)}$ (0.00)	$-0.232^{(***)}$ (0.01)
β_0	-0.010 (0.13)	$-0.023^{(**)}$ (0.40)	-0.007 (0.26)
R^2	0.11	0.12	0.06
LL	282.09	225.45	292.31
Prob. F-Test	0.00	0.00	0.02

Note**:** R^2 denotes the adjusted R-squared, where LL is the logarithm of the likelihood function. Prob. F-test denotes the probability of the Fisher test, while values in () denote the probability of ratio tests. (***), (**), and (*) denote the statistical significance at the 1%, 5%, and 10% levels, respectively.

We estimate model (1) for the three variables related to the real sector and report our results in Table 2. Accordingly, oil price change has a negative but insignificant effect on consumption, which is in line with the related works and analysis of Christiane Baumeister. Householder purchasing power is more sensitive to changes in the price of gasoline than to changes in the price of oil barrels. An oil price shock has a negative

[8] For all specifications, the optimal number of lags was used on the basis of information criteria (Akaike Information Criterion [AIC] and Bayesian Information Criterion [BIC]) and the analysis of autocorrelation functions.

impact on investment in the euro area as an oil price shift of 1% would reduce investment by 2.3%, probably as oil price increase may increase production costs. Finally, we find that an increase in price returns has a negative but insignificant effect on the economic growth rate in the euro area. Next, we assess the effect of the oil price shift on the financial sector (inflation and financial markets).

3.3.2 On the Financial Sector

In practice, we estimate model (1) for both the inflation rate and European financial markets[9] and report our results in Table 3. Accordingly, we observe two stimulating results. On the one hand, as illustrated in Figure 1, we find that energy inflation and, therefore, oil price shifts drive the general level of inflation in the euro area. The elasticity of inflation to oil price changes is positive and statistically significant at approximately 1%. On the other hand, we find that the oil price shift has a positive effect on the financial sector, as an oil price change increase of 1% might generate an increase of 14.2% in the total shares of financial assets in the euro area, which is in line with the increase in the dimension of financialization of the futures oil market. Interestingly, when considering the sub-period 2019–2022 characterized by the COVID-19 pandemic outbreak, the war in Ukraine, and the recent inflation episode, the effect of oil price on the financial sector is higher, at about 16.4%.

3.3.3 On the Level of Confidence and Consumers' Opinions

Here, we examine consumer reactions after an oil-price shift. To this end, we estimate model (1) for the COSEA index and report our results in Table 4. Accordingly, we find no evidence of a significant effect of oil price changes on the consumer opinion survey, which is in line with our analysis of the influence of oil price shift on consumption, as oil price shifts do not directly seem to impact the level of private consumption for households or their opinions.

[9] The financial market of the euro area is captured here through the analysis of data related to the SPEA.

Table 3. Estimation results of linear ARX models for the financial sector

Coefficients	Inflation	Financial Indicator
α_0	-0.001 (0.61)	0.007 (0.41)
α_1	1.047$^{(***)}$ (0.00)	0.110 (0.22)
β_0	0.01$^{(***)}$ (0.00)	0.142$^{(***)}$ (0.00)
R^2	0.89	0.15
LL	422.87	106.18
Prob. F-Test	0.00	0.00

Note: R^2 denotes the adjusted R-squared. LL is the logarithm of the likelihood function. Prob. F-test is the probability of the Fisher test, while values in () denote the probability of ratio tests. (***), (**), and (*) denote the statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4. Estimation results of linear ARX models for consumer confidence

Coefficients	Consumer Opinion Survey
α_0	0.342$^{(*)}$ (0.61)
α_1	0.925$^{(***)}$ (0.00)
β_0	0.002 (0.23)
R^2	0.82
LL	404.33
Prob. F-Test	0.00

Note: R^2 denotes the adjusted R-squared. LL is the logarithm of the likelihood function. Prob. F-test is the probability of the Fisher test, while values in () denote the probability of ratio tests. (***), (**), and (*) denote the statistical significance at the 1%, 5%, and 10% levels, respectively.

However, these findings should be considered with caution, as the baseline modeling we used has at least two limitations. On the one hand, we analyzed the interaction between oil price changes, the real sector, financial sector, and market opinion separately, equation by equation, and also while looking only at the statistical or current effect of oil price on these sectors. The interaction with oil price might not only be dynamic, but there could also be cross-interactions between oil price and macro-financial variables. On the other hand, the baseline framework used is rather linear and does not capture further complexity or nonlinearity in the oil–economy relationship.

To this end, we extend hereafter our analysis in two ways. First, we propose to set up a multivariate model of the linkage between oil prices and macro-financial variables in a system, while relying on a vector autoregressive (VAR) model, and to estimate the impulse response functions, which should robustly help to measure the reactions of the real and financial sectors to a further shock impacting oil prices. Second, we allow the oil price shock to enter nonlinearly and, in line with the related works of James Hamilton, we test whether the oil price–economy relationship exhibits asymmetry and nonlinearity as indicated in Nasir et al. (2018, 2020).

3.4 A Multivariate Analysis of the Oil Price and Macro-Financial Variables Relationship

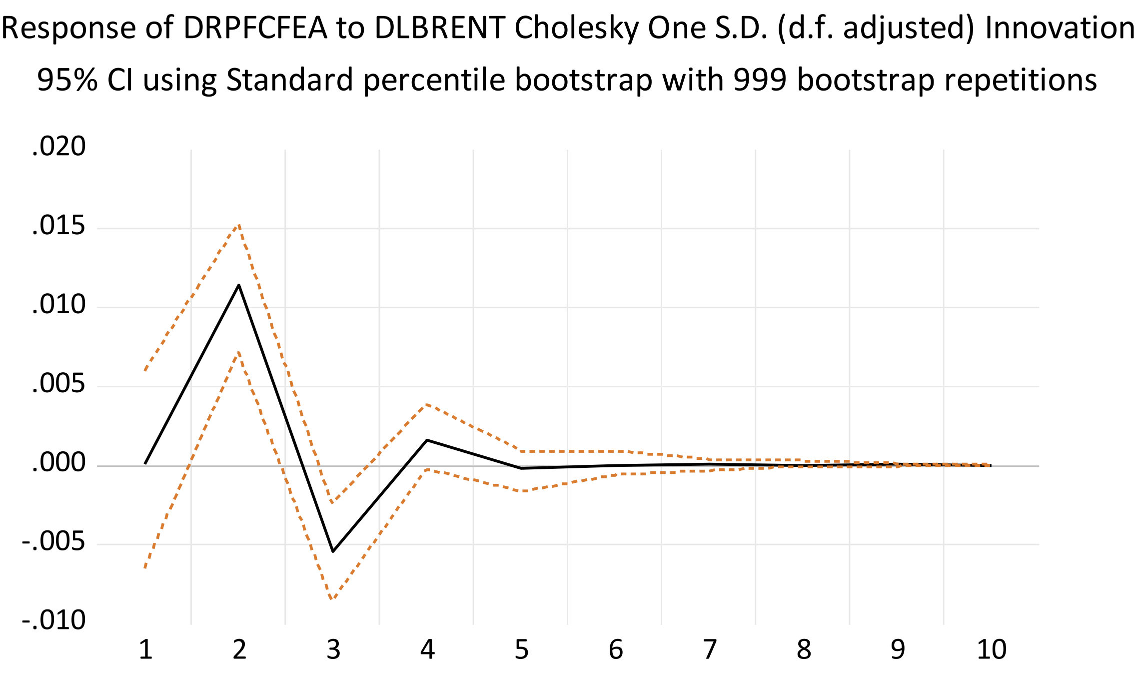
The advantage of setting up a VAR model is that it enables us to reproduce a further dynamic interdependence between the real/macro variables under consideration and changes in oil prices and to estimate the related reaction functions. In practice, to estimate these impulse response functions, we must orthogonalize the impulse responses for which the correlation between the errors is acquired from the (lower) Cholesky decomposition of the error covariance matrix. In other words, we must arrange the model variables in a suitable order, from the most exogenous to the least exogenous.

We specify and estimate the bilateral VAR model and related impulse response functions. Hereafter, we do not report the results of the VAR model estimation; however, these are available upon request. We focus only on the analysis of the impulse response functions. In practice, we use the well-known Cholesky decomposition to orthogonalize errors. Furthermore, the Bootstrap method is applied to estimate the confidence interval for the impulse response function, because this method does not require normality. The main results are shown in Figure 2. However, different results have been obtained. Regarding consumption, the reaction is delayed and asymmetrical, and disappears after six quarters. As for the variance decomposition, using Monte Carlo simulations (100 repetitions), we found that 59.72% of the variance in the forecasting error of DRPFCFEA is due to its own innovations, while 40.27% is due to the impact of a shock on DLBRENT.

For investment, the reaction function shows a profile similar to that of consumption, but for which the intensity is more pronounced and persistent, as the reaction to oil price shock disappears only after eight quarters. Furthermore, we find that 32.16% of the variance in the forecasting error of the investment variation (DLRGFCFEA) is due to the impact of a shock on DLBRENT. When considering the economic growth rate for the euro area, we also find that the reaction to an oil price shock is cyclical and asymmetrical. Further, a shock that impacts DLBRENT would be responsible for 47.94% of the variance in the forecasting error of DLRGDPEA, suggesting the vulnerability of the economic growth model and its sensitivity to the oil sector.

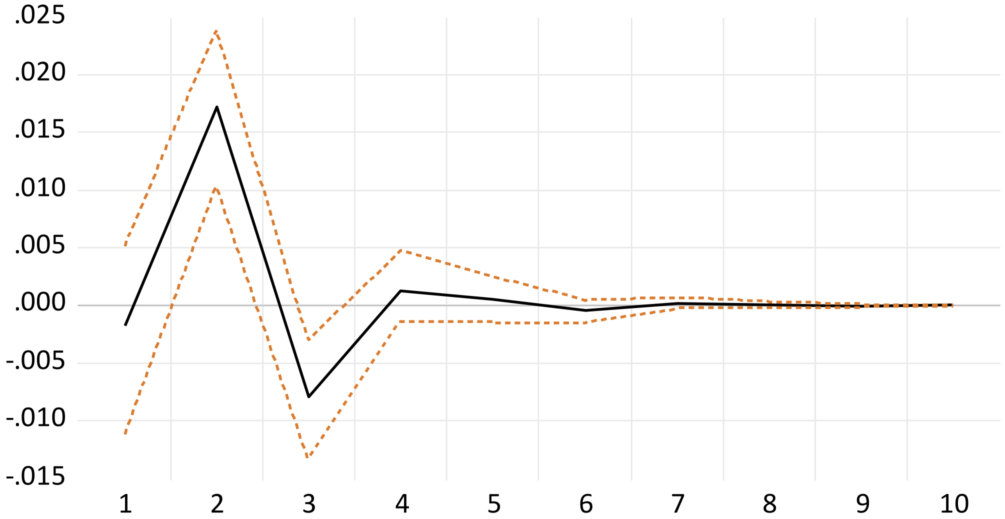
Figure 2. Estimation of impulse-response functions to oil shock

2.1 Response of the private consumption function



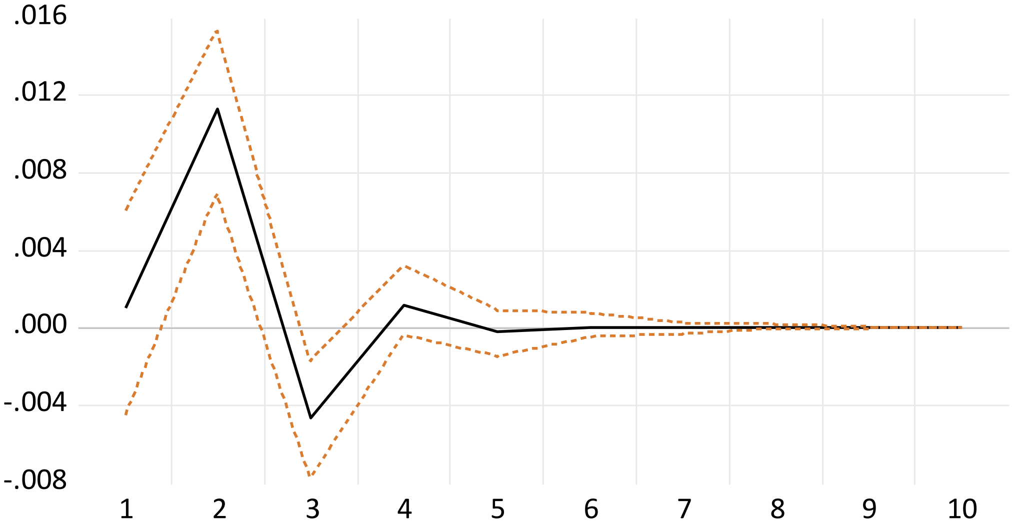
2.2 Response of investment

Response of DLRGFCFEA to DLBRENT Cholesky One S.D. (d.f. adjusted) Innovation
95% CI using Standard percentile bootstrap with 999 bootstrap repetitions



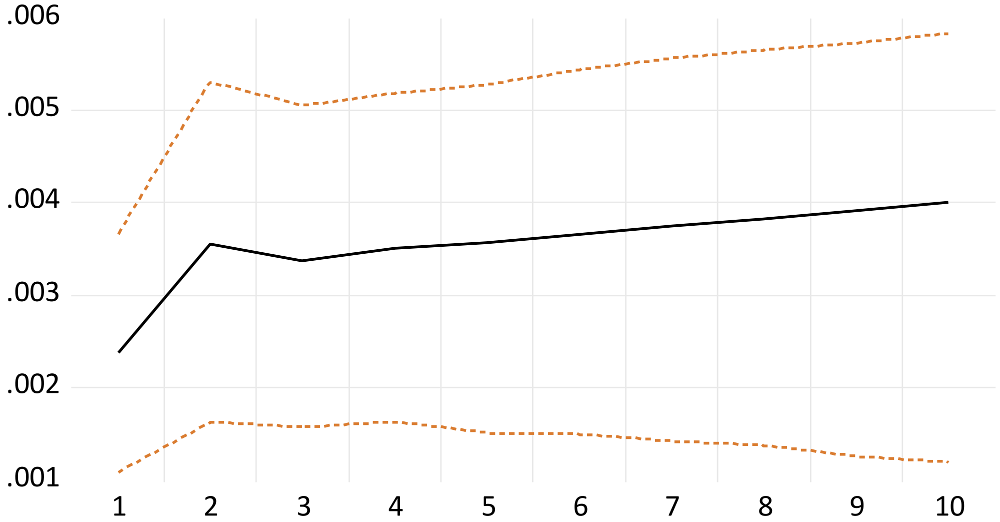
2.3 Response of economic growth

Response of DLRGDPEA to DLBRENT Cholesky One S.D. (d.f. adjusted) Innovation
95% CI using Standard percentile bootstrap with 999 bootstrap repetitions



2.4 Response of inflation

Response of INFRATEEA to DLBRENT Cholesky One S.D. (d.f. adjusted) Innovation
95% CI using Standard percentile bootstrap with 999 bootstrap repetitions

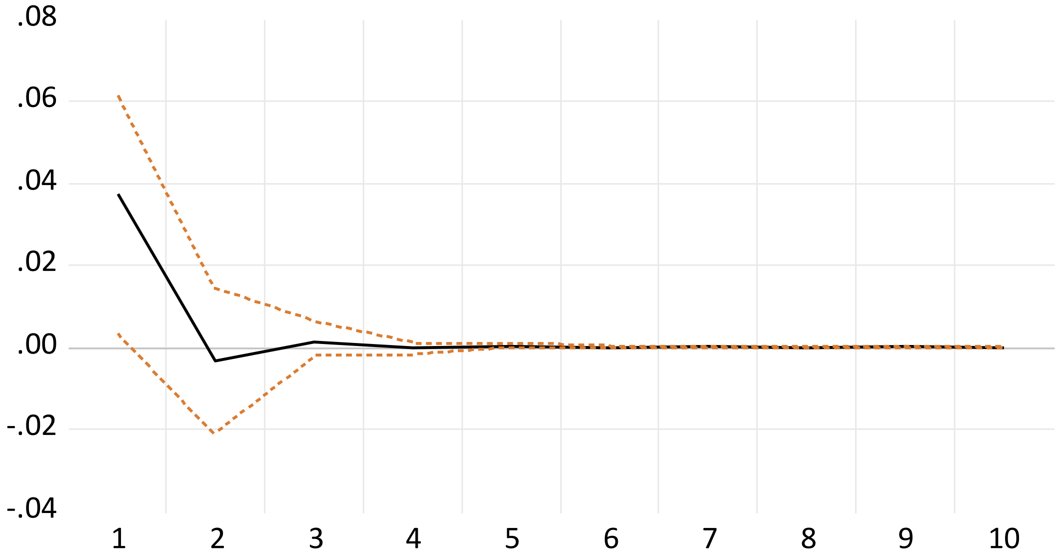


As for inflation, we found that its reaction to a shock impact on DLBRENT has been increasing and did not disappear even after 10 quarters, suggesting further evidence of a persistent contribution of oil price volatility to the general level of inflation. When analyzing the variance decomposition for the inflation rate, we found that, on average, 27.58% of the variance in the inflation rate forecasting error is due to the impact of a shock on DLBRENT. The financial sector's reaction to oil price shocks is less cyclical, and disappears in almost three quarters. In fact, we found that a shock that impacts DLBRENT would be responsible for only 13.75% of the variance in the forecasting error of DLSPEA, which suggests that the financial sector is less vulnerable than the real sector to oil price inflation.

Finally, we found that the response of the consumer opinion survey to the effect of an oil shock was not significant, as only 2.04% of the variance in the forecasting error of the confidence index was due to the impact of a shock on DLBRENT.

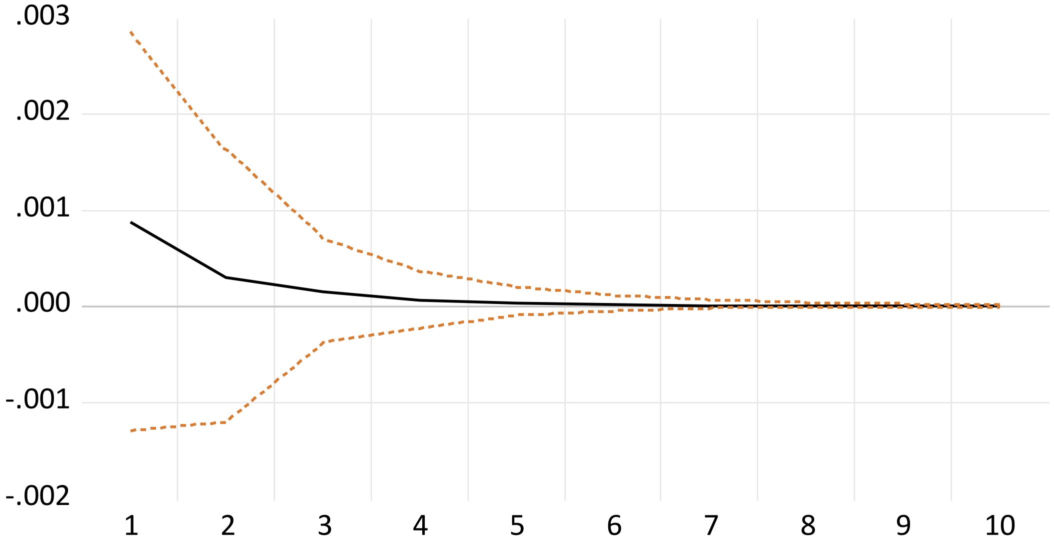
2.5 Response of financial index

Response of DLSPEA to DLBRENT Cholesky One S.D. (d.f. adjusted) Innovation
95% CI using Standard percentile bootstrap with 999 bootstrap repetitions



2.6 Response of consumer opinion survey

Response of DLCOSEA to DLBRENT Cholesky One S.D. (d.f. adjusted) Innovation
95% CI using Standard percentile bootstrap with 999 bootstrap repetitions



Overall, our findings provide further evidence of the statistical and significant reactions of key macroeconomic variables to a shock affecting oil prices. This reaction is cyclical for consumption, investment, and economic growth, but seems less pronounced when considering the financial index. For inflation, the reaction function indicates persistence and long memory. To better characterize these interdependencies, we run Granger causality tests and report the main results in Table 5.

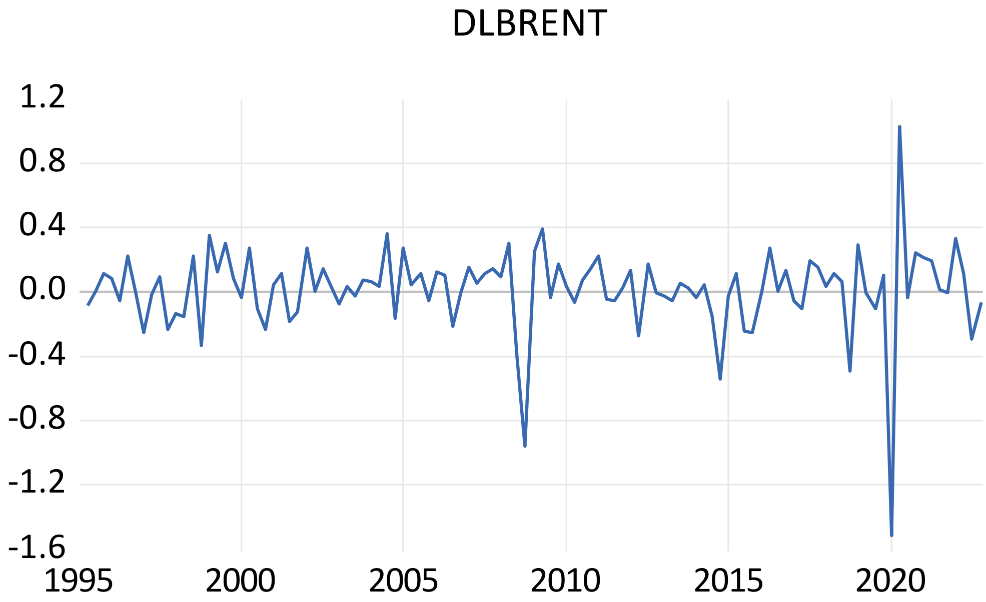
Table 5. Results of the Granger causality test

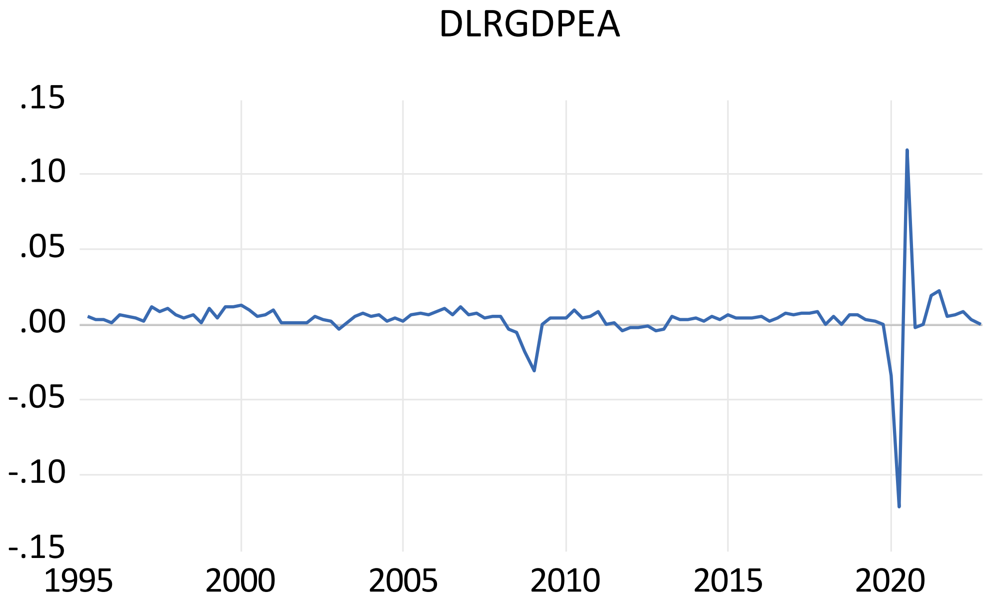
Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
DLCOSEA does not Granger cause DLBRENT	110	0.073	0.7869
DLBRENT does not Granger cause DLCOSEA		0.033	0.855
DLEIEA does not Granger cause DLBRENT	90	0.157	0.692
DLBRENT does not Granger cause DLEIEA		2.870	**0.093***
DLRGDPEA does not Granger cause DLBRENT	110	0.123	0.726
DLBRENT does not Granger cause DLRGDPEA		91.51	**5.E-16*****
DLRGFCFEA does not Granger cause DLBRENT	110	3.557	**0.062***
DLBRENT does not Granger cause DLRGFCFEA		44.22	**1.E-09*****
DLSPEA does not Granger cause DLBRENT	110	0.007	0.932
DLBRENT does not Granger cause DLSPEA		0.501	0.480
DRPFCFEA does not Granger cause DLBRENT	110	0.469	0.494
DLBRENT does not Granger cause DRPFCFEA		63.89	**2.E-12*****
INFRATEEA does not Granger cause DLBRENT	110	1.446	0.231
DLBRENT does not Granger cause INFRATEEA		4.351	**0.039****

Note: **Prob.** denotes the p-values of the causality tests. (***), (**) and (*) denote rejection of the null hypothesis of no causality at the statistical levels of 1%, 5% and 10% respectively.

Accordingly, these results are consistent with the conclusions of the VAR analysis. Indeed, Brent does Granger-cause consumption, investment, economic growth, harmonized energy inflation, and the level of global inflation in the euro area. This result is particularly interesting as it suggests that, while relying on the information provided by Brent, it would be possible to improve the forecasting of the above macro and financial variables. This finding is consistent with the main conclusions of Hamilton (1983a, 2009). Indeed, while this Granger causality relationship implies that it would be possible to improve the forecasting of future economic growth rate using information provided by the oil market, the analysis in Figure 3 shows that several economic growth rate downturns were preceded by an oil price shift: the downturn in 2009Q1 was preceded by an oil price increase in 2008Q2; the economic downturn in 2020Q3 was preceded by an oil price increase in 2020Q2; and the recent oil price increase in 2022Q1 provoked a GDP correction in 2022Q4. All these examples illustrate the main conclusion of Hamilton (1983a), suggesting that oil price shocks *a priori* still matter for the real economy of the euro area.

Figure 3. Dynamics of oil price return and economic growth rate





Note: DLBRENT and DLRGDPEA denote the oil price return and the real economic growth rate for the euro area, respectively.

Next, we extend our analysis to a nonlinear framework using a class of threshold models. This nonlinear modeling offers more flexibility in reproducing the effect of oil price shocks on macro-financial variables, while enabling the effect of oil prices to vary according to the regime under consideration. In addition, threshold modeling enables oil prices to enter the market nonlinearly and asymmetrically. A TAR model, for example, offers an on–off relationship between oil price and the macro-financial variable under consideration that might be activated differently when the threshold variable exceeds a given threshold. This multiple-regime modeling is particularly interesting, because our sample includes different episodes and states of oil price inflation.

3.5 A Nonlinear Analysis of Oil Price and Macro-Financial Variables' Relationship

First, we apply structural break and linearity tests to test the null hypothesis of linearity compared to the alternative hypothesis of nonlinearity. Second, if linearity is rejected, the threshold model is specified and estimated. Next, we present the main empirical results.

3.5.1 Results of Linearity Tests

In practice, we apply the Tsay and Hansen tests to check the linearity assumption against a TAR model. This nonlinear modeling helps us to enable the oil price-economy relationship to be time-varying and nonlinear, which is particularly relevant to the capturer's further asymmetry in the relationship. The reaction to an oil price shock may differ according to the sign, size, and phase of the business cycle. The main results are summarized in Table 6.

Accordingly, we find that regardless of the linearity tests, the null hypothesis of linearity is not accepted for all the macro-financial variables under consideration. This result suggests that the dynamics of these variables exhibit nonlinearity and threshold effects, and that a switching-regime model might fit their dynamics well.

Finally, we propose modeling the relationship between oil prices and these variables in a nonlinear framework while estimating a multiple-regime TAR model.

Table 6. Results of linearity tests

Series	Hansen (1996) threshold test	Tsay (1989) test
DLRGDPEA	0.01(***)	0.00(***)
DLRGFCFEA	0.00(***)	0.00(***)
DRPFCFEA	0.01(***)	0.00(***)
INFRATEEA	0.02(**)	0.04(**)
DLSPEA	0.00(***)	0.01(***)
DLCOSEA	0.06(*)	0.07(*)

Note: The values in the table denote the *p*-values of the linearity tests. (***), (**), and (*) denote the rejection of the null assumption of linearity at the statistical level of 1%, 5%, and 10%, respectively.

3.5.2. TAR Modeling

In line with the methodology of the TAR models described earlier, we set up the TAR process as follows: the linear benchmark model corresponds to Equation (2), while linearity tests help us specify the number of regimes as well as the threshold variable, and the value of the threshold.

Formally, for example, a two-regime TAR model corresponds to:

$$\begin{aligned} Y_t = &\ \alpha_{10} + \sum_{i=1}^{p11} \alpha_{1i} Y_{t-i} + \sum_{j=0}^{p21} \beta_{1j} OR_{t-j} + \varepsilon_{1t} \ if\ S_t < c \\ = &\ \alpha_{20} + \sum_{i=1}^{p12} \alpha_{2i} Y_{t-i} + \sum_{j=0}^{p22} \beta_{2j} OR_{t-j} + \varepsilon_{2t} \ if\ s_t \geq c \end{aligned} \quad (2)$$

where Y_t denotes the endogenous variable of interest, OR_t denotes oil price change, ε_{1t} and ε_{2t} are the error terms, and α_{1i} and β_{1j} are the AR coefficients of the first regime.

α_{2i} and β_{2j} are the AR coefficients in the second regime. S_t denotes the transition or threshold variable, and c refers to the threshold parameter.

We estimate the TAR model and discuss the main results for each macro and financial variable under consideration. First, we consider the results of the TAR model for the economic growth rate variables. Using the information criteria, we define the number of lags of the linear model under the null assumption of linearity. Both linearity tests show that the optimal threshold variable corresponds to DLBRENT, making it possible to identify three regimes. The main results of the estimation reported in Table 7 reveal different findings.

From Table 7, we note that the dynamics of the economic growth rate are characterized by three different regimes and that the relationship between oil price change and economic growth is nonlinear and significantly time-varying per regime. Indeed, in the first regime, when the oil price return is negative and less than -2.7% (which means that the oil price is slightly decreasing), this should boost economic growth by 2.8%, suggesting that the economy might benefit from a low or decreasing oil price. In the second regime, when oil price return is bounded between -2.7% and 19.1%, the effect of oil price change turns negative but seems insignificant. However, in the third regime, when the oil price shift strictly exceeds 19.1%, the reaction to the economic growth rate becomes negative and statistically significant. In this regime, an oil price shift exceeding 19.1% could cause an economic downturn of -15.3%. The reaction of the economic growth rate to an oil price shift is negative, at about -12.6%, suggesting a negative relationship between economic growth and oil price shock. This finding is relevant, and is in line with our analysis of the Granger causality test, as well as the main conclusion of Hamilton (1983a) and Jawadi (2019, 2023). Overall, our model seems well specified, as the related errors, even abnormal, are not auto-correlated or heteroscedastic.

Table 7. Estimation results of TAR for the economic growth rate

Coefficients	Regime 1	Regime 2	Regime 3
α_0	$0.012^{(***)}$ (0.00)	$0.002^{(*)}$ (0.10)	$0.045^{(***)}$ (0.00)
α_1	$-0.818^{(***)}$ (0.00)	$0.545^{(***)}$ (0.00)	-0.027 (0.73)
β_0	$0.028^{(***)}$ (0.00)	-0.001 (0.93)	$-0.153^{(***)}$ (0.00)
Threshold	-0.027	0.191	-
R^2	0.84		
LL	391.06		
Prob. F-Test	0.00		
Prob. JB-Test	0.00		
Prob. ARCH Test	0.34		
Prob. LM Test	0.42		

Note: R^2 denotes the adjusted R-squared. LL denotes the logarithm of the likelihood function. Prob. F-test denotes the probability of the Fisher test, while values in () denote the probability of the ratio test for which the test statistics employ HAC covariances (Bartlett Kernl, Newey-West fixed bandwidth) while assuming a common data distribution. (***), (**), and (*) denote the statistical significance at the 1%, 5%, and 10% levels, respectively. Prob. F-test, Prob. JB-test, Prob. ARCH test, and Prob. LM test denote the probability of the Fisher global significance test, Jarque-Bera normality test, ARCH autoregressive conditional heteroscedasticity (ARCH) test, and serial correlation Lagrange multiplier test, respectively. β_0 measures the impact of an oil price shift.

For the consumption growth rate, we also find further evidence of nonlinearity and a three-dependent regime relationship. As for the economic growth rate, when oil prices are decreasing and oil price returns remain negative, this might boost consumption, while an important oil price shift, particularly when oil price returns exceed 21.5%, might negatively and significantly cause a correction of the consumption growth rate by 17.3%. Overall, the global nonlinear effect of oil price shocks on consumption is negative at approximately -15%. The nonlinear TAR model for consumption exhibited appropriate statistical properties.

When considering investments, we find that a two-regime TAR model fits the data well. A shift in oil prices does not seem to significantly impact investment growth in the first regime. However, when the oil price return exceeds 19.1%, the investment reaction becomes negative and significant, which can be justified by the fact that a high oil price causes an increase in investment and production costs and can provoke an investment crunch. The global nonlinear elasticity of investment growth toward oil price shift is negative at about -22%.

Overall, we find that oil price changes significantly impact the key variables of the real sector (consumption, investment, and GDP), and that this impact enters nonlinearly and asymmetrically and varies with the regime under consideration. Furthermore, although the assumption of nonlinear dependence is not rejected, we point to a global nonlinear effect of the oil price shift on the main drivers of the real sector. This finding is in line with that of Hamilton (1983a, 2003, 2015).

Table 8. Estimation results of TAR for the consumption growth rate

Coefficients	Regime 1	Regime 2	Regime 3
α_0	$0.009^{(***)}$ (0.00)	$0.003^{(*)}$ (0.09)	$0.049^{(***)}$ (0.00)
α_1	$-0.831^{(***)}$ (0.00)	$0.615^{(***)}$ (0.00)	-0.014 (0.94)
α_2	-0.119 (0.70)	$-0.657^{(**)}$ (0.02)	0.123 (0.42)
α_3	0.613 (0.02)	$0.166^{(***)}$ (0.00)	$0.346^{(***)}$ (0.00)
β_0	$0.024^{(***)}$ (0.00)	-0.001 (0.92)	$-0.173^{(***)}$ (0.00)
Threshold	-0.029	0.215	-
R^2	0.89		
LL	390.05		
Prob. F-Test	0.00		
Prob. JB-Test	0.10		
Prob. ARCH Test	0.71		
Prob. LM Test	0.14		

Note: R^2 denotes the adjusted R-squared. LL denotes the logarithm of the likelihood function. Prob. F-test denotes the probability of the Fisher test, while values in () denote the probability of the ratio test for which the test statistics employ HAC covariances (Bartlett Kernl, Newey-West fixed bandwidth) while assuming a common data distribution. (***), (**), and (*) denote the statistical significance at the 1%, 5%, and 10% levels, respectively. Prob. F-test, Prob. JB-test, Prob. ARCH test, and Prob. LM test denote the probability of the Fisher global significance test, Jarque-Bera normality test, autoregressive conditional heteroscedasticity (ARCH) test, and serial correlation Lagrange multiplier test, respectively. β_0 measures the impact of oil price shift.

Table 9. Estimation results of TAR for the investment

Coefficients	Regime 1	Regime 2
α_0	0.007(***) (0.00)	0.061(***) (0.00)
α_1	-0.566(***) (0.00)	0.223 (0.00)
α_2	0.318(***) (0.00)	-0.029 (0.71)
α_3	0.258(***) (0.00)	0.147(**) (0.03)
β_0	0.011 (0.33)	-0.231(***) (0.00)
Threshold	0.191	
R^2	0.70	
LL	279.42	
Prob. F-Test	0.00	
Prob. JB-Test	0.00	
Prob. ARCH Test	0.81	
Prob. LM Test	0.54	

Note: R^2 denotes the adjusted R-squared. LL denotes the logarithm of the likelihood function. Prob. F-test denotes the probability of the Fisher test, while values in () denote the probability of the ratio test for which the test statistics employ HAC covariances (Bartlett Kernl, Newey-West fixed bandwidth) while assuming a common data distribution. (***), (**), and (*) denote the statistical significance at the 1%, 5%, and 10% levels, respectively. Prob. F-test, Prob. JB-test, Prob. ARCH test, and Prob. LM test denote the probability of the Fisher global significance test, Jarque-Bera normality test, autoregressive conditional heteroscedasticity (ARCH) test, and serial correlation Lagrange multiplier test, respectively. β_0 measures the impact of oil price shift.

As for the financial sector, when considering the inflation dynamics rate, we estimate a three-regime TAR model and find that the oil price shift drives inflation in the euro area nonlinearly and significantly (Table 10). Indeed, in the first regime, when the oil price is increasing but the oil price return is less than 11.6%, an oil price shift increases inflation by 1%. However, in the second regime, when the oil price return is bounded between

11.6% and 21.7%, an oil price shift can cause an inflation increase of 6.5%, showing a global nonlinear effect of 7.48%. The reaction of inflation rate in the third regime does not seem to be significant. This finding is particularly relevant as it not only shows that oil price inflation is an important driver of general inflation but also enables us to quantify the threshold at which the reaction of the inflation rate to oil price shock will shift rapidly.

Table 10. Estimation results of TAR for the inflation rate

Coefficients	**Regime 1**	**Regime 2**	**Regime 3**
α_0	0.001$^{(*)}$ (0.07)	-0.001 (0.69)	0.001 (0.95)
α_1	1.432$^{(***)}$ (0.00)	0.669$^{(***)}$ (0.00)	1.731$^{(***)}$ (0.00)
α_2	-0.487$^{(***)}$ (0.00)	0.022 (0.81)	-0.641$^{(***)}$ (0.00)
β_0	0.010$^{(***)}$ (0.00)	0.065$^{(**)}$ (0.02)	-0.001 (0.83)
Threshold	0.116	0.217	-
R^2	0.94		
LL	449.72		
Prob. F-Test	0.00		
Prob. JB-Test	0.21		
Prob. ARCH Test	0.19		
Prob. LM Test	0.41		

Note: R^2 denotes the adjusted R-squared. LL denotes the logarithm of the likelihood function. Prob. F-test denotes the probability of the Fisher test, while values in () denote the probability of the ratio test for which the test statistics employ HAC covariances (Bartlett Kernl, Newey-West fixed bandwidth) while assuming a common data distribution. (***), (**), and (*) denote the statistical significance at the 1%, 5%, and 10% levels, respectively. Prob. F-test, Prob. JB-test, Prob. ARCH test, and Prob. LM test denote the probability of the Fisher global significance test, Jarque-Bera normality test, autoregressive conditional heteroscedasticity (ARCH) test, and serial correlation Lagrange multiplier test, respectively. β_0 measures the impact of oil price shift.

We then model the dynamics of the returns of total financial assets in the euro area with a three-regime TAR model (Table 11). Accordingly, the assumption of nonlinearity is not rejected, and oil price inflation has a positive and nonlinear effect on the dynamics of the financial sector in the euro area. Interestingly, the financial sector's reaction to price shocks varies according to the regime under consideration. In the first regime, when the oil price is decreasing and the oil price return is negative but less than -12.24%, investors appear to arbitrate, and this arbitrage or diversification strategy pushes them to invest more in the financial sector. Particularly, in this regime, the elasticity of the financial sector with regard to oil price changes is positive at approximately 19.18%, while when oil prices continue to increase in the second correction, the financial sector reacts significantly. However, when the oil price increases and oil price returns exceed 21.70%, this seems to increase investors' appetite and cause an increase in the returns of the total financial share of 38.34%, which could be supported notably by the contribution of investment in the energy sector, reflecting the high dimension of financialization of the oil futures market. Overall, it appears that oil price inflation has had a global nonlinear effect of 59.4% on the returns of the total share in the euro area, which is the highest reaction of the variable under consideration for an oil price shift. This is also in line with the high performance shown by the financial sector in the euro area over the last period. This finding is consistent with the conclusions of Jiménez-Rodríguez and Sánchez (2005).

Table 11. Estimation results of TAR for the financial index

Coefficients	Regime 1	Regime 2	Regime 3
α_0	0.010 (0.73)	0.020$^{(*)}$ (0.07)	-0.114$^{(***)}$ (0.00)
α_1	0.255$^{(**)}$ (0.02)	0.115 (0.20)	0.327$^{(*)}$ (0.10)
α_2	0.378 (0.12)	0.049 (0.61)	-0.364$^{(***)}$ (0.00)
α_3	0.652$^{(***)}$ (0.00)	-0.090 (0.31)	-0.577$^{(***)}$ (0.00)
β_0	0.191$^{(***)}$ (0.00)	0.020 (0.89)	0.383$^{(**)}$ (0.00)
Threshold	-0.122	0.217	-
R^2	0.39		
LL	121.45		
Prob. F-Test	0.00		
Prob. JB-Test	0.00		
Prob. ARCH Test	0.17		
Prob. LM Test	0.21		

Note: R^2 denotes the adjusted R-squared. LL denotes the logarithm of the likelihood function. Prob. F-test denotes the probability of the Fisher test, while values in () denote the probability of the ratio test for which the test statistics employ HAC covariances (Bartlett Kernl, Newey-West fixed bandwidth) while assuming a common data distribution. (***), (**), and (*) denote statistical significance at the 1%, 5%, and 10% levels, respectively. Prob. F-test, Prob. JB-test, Prob. ARCH test, and Prob. LM test denote the probability of the Fisher global significance test, Jarque-Bera normality test, autoregressive conditional heteroscedasticity (ARCH) test, and serial correlation Lagrange multiplier test, respectively. β_0 measures the impact of oil price shift.

Finally, when looking at the reactions to consumer opinion surveys (which can be seen as a proxy for consumer confidence), we find further evidence of nonlinearity and switching regimes. We also find an indication of asymmetry in consumer reactions to oil price shifts. Indeed, in the first regime, when oil prices are decreasing and oil price returns are below the threshold of -10.1%, this shift positively impacts consumers' opinions and seems to increase their confidence levels by 1.2%. Their opinions are not significantly impacted in the second regime, while an abrupt increase in oil price returns (when this exceeds the threshold of 19.2%), yields a correction of consumer confidence by 2.6%. Changes in consumer or investor confidence and behavior can be considered as a canal through which oil price shifts impact the real and financial sectors and the real economy as a whole.

Table 12. Estimation results of TAR for the consumer confidence index

Coefficients	**Regime 1**	**Regime 2**	**Regime 3**
α_0	0.212 (0.59)	0.563(***) (0.00)	0.895 (***) (0.01)
α_1	1.177(***) (0.00)	1.550(***) (0.00)	2.229(*..) (0.00)
α_2	-0.119 (0.77)	-1.129(***) (0.00)	-1.085(***) (0.00)
α_3	-0.102 (0.62)	0.455(***) (0.00)	-0.399(*) (0.07)
β_0	0.012(***) (0.00)	-0.003 (0.71)	-0.026(***) (0.00)
Threshold	-0.101	0.192	-
R^2	0.92		
LL	439.69		
Prob. F-Test	0.00		

Prob. JB-Test	0.40
Prob. ARCH Test	0.17
Prob. LM Test	0.21

Note: R^2 denotes the adjusted R-squared. LL denotes the logarithm of the likelihood function. Prob. F-test denotes the probability of the Fisher test, while values in () denote the probability of the ratio test for which the test statistics employ HAC covariances (Bartlett Kernl, Newey-West fixed bandwidth) while assuming a common data distribution. (***), (**), and (*) denote the statistical significance at the 1%, 5%, and 10% levels, respectively. Prob. F-test, Prob. JB-test, Prob. ARCH test, and Prob. LM test denote the probability of the Fisher global significance test, Jarque-Bera normality test, autoregressive conditional heteroscedasticity (ARCH) test, and serial correlation Lagrange multiplier test, respectively. β_0 measures the impact of oil price shift.

3.5.3 Robustness Analysis

Our empirical analysis shows that an oil price shift has a significant and time-varying effect on the real sector, financial sector, and consumer confidence. Furthermore, it appears that the oil–macroeconomic relationship exhibits asymmetry and nonlinearity. We also know that over the last period, the ECB, Fed, and several other central banks decided to fight the ongoing inflation episode by reducing their purchasing of financial assets and increasing their interest rates.

We check the robustness of our conclusion while testing whether the recent implementation of active monetary policies and, particularly, the increase in interest rates, has attenuated the effects of oil price inflation on the real and financial sectors. These robustness tests also allow us to indirectly test the efficiency of the ECB rate policy in reducing the effects of energy inflation. This is particularly relevant for evaluating the efficiency of the current monetary policy of the ECB. To this end, we propose re-estimating the multiple-regime TAR model while including interest rates among the explanatory variables. To save space, we analyze the results only for economic growth and inflation rate.

From Table 13, we find two interesting results. First, the ECB's rate policy does not seem to impact the dynamics of the economic growth rate in the euro area. Second, when comparing the reaction function of the growth rate with and without the ECB rate policy, we note that while the global impact of an oil price shift on real economic growth was about -12.6%, it is now only -12.3%, suggesting that the interest policy has provided a gain of only 0.3%, which is insignificant.

As for the inflation, we find that the interest rate has a negative and significant effect on the inflation rate dynamics only in the third regime. Further, the global effect of an oil price shift on the inflation rate is now about 9.3% when considering the ECB rate policy rather than a global effect of 7.4%, again suggesting a lower efficiency of the ECB's rate policy to attenuate the effects of energy inflation.

Table 13. Estimation results of augmented TAR for the economic growth rate under the assumption of active ECB rate policy

Coefficients	Regime 1	Regime 2	Regime 3
α_0	0.011$^{(***)}$ (0.00)	0.001 (0.20)	0.043$^{(***)}$ (0.00)
α_1	-0.822$^{(***)}$ (0.00)	0.541$^{(***)}$ (0.00)	-0.017 (0.82)
β_0	0.028$^{(***)}$ (0.00)	-0.001 (0.92)	-0.150$^{(***)}$ (0.00)
γ	0.020 (0.77)	0.02 (0.31)	0.065 (0.55)
Threshold	-0.027	0.191	-
R^2	0.85		
LL	39154.0		
Prob. F-Test	0.00		
Prob. JB-Test	0.00		
Prob. ARCH Test	0.27		
Prob. LM Test	0.34		

Note: R^2 denotes the adjusted R-squared. LL denotes the logarithm of the likelihood function. Prob. F-test denotes the probability of the Fisher test, while values in () denote the probability of the ratio test for which the test statistics employ HAC covariances (Bartlett Kernl, Newey-West fixed bandwidth) while assuming a common data distribution. (***), (**), and (*) denote the statistical significance at the 1%, 5%, and 10% levels, respectively. Prob. F-test, Prob. JB-test, Prob. ARCH test, and Prob. LM test denote the probability of the Fisher global significance test, Jarque-Bera normality test, autoregressive conditional heteroscedasticity (ARCH) test, and serial correlation Lagrange multiplier test, respectively. β_0 measures the impact of oil price shift. γ measures the impact of the interest rate.

These findings have several explanations. On the one hand, the oil price depends simultaneously on supply (supply shock) and demand (demand shock). Therefore, despite the influence of an interest rate change on the demand side, if on the other side, oil producers cut into their production, this action might cancel the effectiveness of the monetary policy. However, as shown in Hamilton's energy economics works (1983a, 2009), oil demand has become less elastic to interest rates. Therefore, if consumers' consumption remains constant at higher interest rates, the expected monetary policy objective cannot be achieved. In other words, an alternative policy to reduce the effects of energy inflation on the real economy would be to run a fiscal policy while cutting or revising, for example, the imposition on energy consumption. However, this is challenging because, while it might reduce the final oil price for consumers, it will also induce a reduction in the fiscal resources provided by the oil sector for the government.

Table 14. Estimation results of augmented TAR for the inflation rate under the assumption of active ECB rate policy

Coefficients	Regime 1	Regime 2	Regime 3
α_0	0.00 (0.58)	-0.005 (0.22)	-0.001 (0.58)
α_1	1.05(***) (0.00)	0.621(***) (0.00)	1.400(***) (0.00)
β_0	0.010(***) (0.00)	0.088(***) (0.02)	-0.005 (0.12)
γ	-0.044 (0.24)	0.083 (0.11)	-0.143(**) (0.04)
Threshold	0.116	0.217	-
R^2	0.93		
LL	444.32		
Prob. F-Test	0.11		
Prob. JB-Test	0.21		
Prob. ARCH Test	0.24		
Prob. LM Test	0.38		

Note: R^2 denotes the adjusted R-squared. LL denotes the logarithm of the likelihood function. Prob. F-test denotes the probability of the Fisher test, while values in () denote the probability of the ratio test for which the test statistics employ HAC covariances (Bartlett Kernl, Newey-West fixed bandwidth) while assuming a common data distribution. (***), (**), and (*) denote the statistical significance at the 1%, 5%, and 10% levels, respectively. Prob. F-test, Prob. JB-test, Prob. ARCH test, and Prob. LM test denote the probability of the Fisher global significance test, Jarque-Bera normality test, autoregressive conditional heteroscedasticity (ARCH) test, and serial correlation Lagrange multiplier test, respectively. β_0 measures the impact of oil price shift.

5. Conclusion

This study revisits the relationship between oil price and macroeconomy in the context of high uncertainty, important geopolitical tensions, and inflation levels. Particularly, we investigate the impact of oil price shifts and, therefore, energy inflation in the real and financial sectors, and consumer confidence. To this end, we set up a multiple-regime TAR specification and estimate the oil price shift's impact in a dynamic, nonlinear, and more flexible econometric framework. For example, the TAR model offers an on–off relationship between oil price and the macro-financial variable under consideration, which might be activated differently when the transition variable exceeds a given threshold. This multiple-regime modeling is particularly interesting as our sample includes different episodes and states of oil price inflation. In line with Jiménez-Rodríguez and Sánchez (2005), Nasir et al. (2018, 2020) and Jawadi (2019, 2023), our results indicate threshold effects in the links between oil price shifts and macro-financial variables. We empirically estimate the value of the threshold at which the influence of oil price changes on the macro or financial variables under consideration (consumption, investment, economic growth, inflation, and financial index) becomes effective. Finally, we reconsider the oil–economy relationship by considering the ongoing ECB rate policy and demonstrate that our conclusions remain unchanged. Moreover, these results highlight the monetary policy's low effectiveness. These findings are relevant and have different implications. First, they are important for policymakers when determining the GDP rate and investment requirement to identify different scenarios for the oil price level. Second, in a context of high inflation and volatile oil price, we suggest projecting further fiscal policies to attenuate the impact of energy inflation. A further extension of this work would to analyze the forecasting

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