

A New Exploration of the Effects of Oil Price Uncertainty and Economic Policy on Inflation: Modeling with Quantile-on-Quantile

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ARTICLE INFO

Article type:
Research

Article history
Received: 2025.02.28
Revised: 2025.07.24
Accepted: 2025.08.19
Published: 2025.10.01

Keywords:
Uncertainty,
Quantile-on-Quantile
Regression,
Inflation,
Iranian Economy.

JEL Classification:
E5, H2, C21

Abstract:

Objective: This study investigates the asymmetric effects of Economic Policy Uncertainty (EPU) and Oil Price Uncertainty (OPU) on inflation in Iran, using the Quantile-on-Quantile (QQ) regression method. Given Iran's oil-dependent economy, the research aims to understand how global and domestic uncertainties impact inflation dynamics, particularly during economic turbulence. Traditional models often neglect the non-linear and heterogeneous effects of uncertainty on inflation, prompting the use of the QQ approach to capture the varying impacts across different quantiles.

Methods: The study employs the QQ regression method to analyze the asymmetric effects of EPU and OPU on inflation, using monthly data from 2008 to 2023. The QQ approach is chosen to address the heterogeneity and non-linearity in the relationship between uncertainty and inflation, particularly in the context of Iran's oil-driven economy.

Results: The findings reveal significant heterogeneity in inflation responses to uncertainty shocks. At lower quantiles, both EPU and OPU have minimal effects on inflation, indicating that minor changes in uncertainty do not significantly alter inflation rates. However, at higher quantiles—especially during periods of heightened uncertainty—both factors show a more pronounced and positive effect on inflation. Additionally, the QQ analysis indicates that EPU has a more consistent impact on inflation compared to OPU, suggesting that

Cite this article: A. Moridian, H. Heidari, S. M Hosseini and H. Asgari (2025). A New Exploration of the Effects of Oil Price Uncertainty and Economic Policy on Inflation: Modeling with Quantile-on-Quantile. *International Journal of Business and Development Studies*, 17 (2), 5-27.
DOI: 10.22111/ijbds.2025.52263.2241.



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Publisher: University of Sistan and Baluchestan

policy-induced uncertainty exerts greater pressure on price levels than oil price volatility. **Conclusions:** The study highlights the importance of accounting for asymmetric and quantile-dependent uncertainty effects when formulating inflation control policies, as this can help address inflationary challenges in the face of fluctuating global and domestic conditions.

1. Introduction

Understanding the dynamics of inflation has been a central theme in macroeconomic research, given its implications for monetary policy, financial stability, and overall economic growth. Traditional models have long focused on domestic demand and supply shocks, monetary policy interventions, and external factors such as commodity price movements (Lim and Sek, 2015; Deniz et al., 2016; Boschi and Girardi, 2007). However, in recent decades, heightened global uncertainty has introduced new dimensions into the discourse on inflation determinants, underscoring the necessity of incorporating economic policy uncertainty (EPU) and oil price uncertainty (OPU) into inflation analysis (Al-Thaqeb and Algharabali, 2019; Elder and Serletis, 2010; Jo, 2014).

Economic policy uncertainty (EPU) has been increasingly recognized as a key driver of inflationary dynamics. Policy shifts, regulatory changes, and geopolitical developments create uncertainty that influences investment decisions, consumption patterns, and pricing strategies. Studies have established that economic uncertainty can exert asymmetric effects on macroeconomic variables, with negative EPU shocks often yielding more pronounced inflationary consequences than positive ones (Istiak and Serletis, 2018; Wen et al., 2021; Long et al., 2022). These asymmetries necessitate a more granular approach to modeling inflation responses to uncertainty shocks.

Similarly, oil price uncertainty (OPU) presents a significant challenge to inflation stability. While the relationship between oil prices and inflation is well-documented (Choi et al., 2018; Köse and Ünal, 2021), the role of uncertainty in oil markets has received comparatively less attention. Fluctuations in oil prices, driven by geopolitical tensions, supply disruptions, and demand volatility, contribute to inflation unpredictability. Empirical evidence suggests that oil price volatility affects consumer prices, investment decisions, and monetary policy effectiveness in both developed and emerging markets (for instance, see works such as those by Lily et al., 2019; Lacheheb and Sirag, 2019; Ali, 2020). Despite this, there remains a gap in understanding how OPU and EPU interact in shaping inflation trends across economies.

This study seeks to bridge this gap by conducting a comprehensive analysis of the asymmetric impact of economic policy and oil price uncertainty on inflation in Iran. Employing a Quantile-on-Quantile approach, we capture the evolving nature of uncertainty shocks and their transmission to inflation. This methodology provides a more dynamic perspective compared to traditional econometric models, allowing us to assess how the relationship between

uncertainty and inflation varies in different periods. By utilizing monthly data from 2008 to 2023, we aim to provide robust empirical insights into inflation dynamics under uncertainty in the context of an oil-exporting economy.

Theoretical perspectives suggest that uncertainty shocks can influence inflation through multiple channels. The real options theory posits that firms delay investment and employment decisions in response to heightened uncertainty, leading to demand contractions and potential disinflationary pressures (Bernanke, 1983; Bloom, 2009). Conversely, uncertainty-induced risk premia and supply chain disruptions may elevate production costs, fueling inflationary spirals (Antonakakis et al., 2014; Caldara et al., 2022). Given these contrasting mechanisms, the net effect of uncertainty shocks on inflation is inherently complex and warrants empirical investigation, particularly in a country like Iran, where government intervention and subsidy programs further complicate inflationary trends.

This paper contributes to the literature in several key ways. First, it incorporates both economic policy and oil price uncertainty into inflation modeling, acknowledging their growing relevance in a volatile global landscape. Second, the Quantile-on-Quantile methodology is used to capture the temporal dynamics of these interplays, providing a nuanced understanding of the evolving relationships over time. Third, it provides a country-specific analysis for Iran, offering novel insights into how uncertainty interacts with inflation in an oil-dependent, sanction-prone economy.

The remainder of this paper is structured as follows: Section 2 reviews the existing literature on uncertainty and inflation dynamics in Iran and other oil-exporting economies. Section 3 outlines the econometric methodology and data sources. Section 4 presents empirical findings and policy implications. Finally, Section 5 concludes with recommendations for future research.

2. Literature review

The study of economic policy uncertainty (EPU) and oil price uncertainty (OPU) in relation to inflation is deeply rooted in economic theory, particularly in the fields of monetary economics and energy economics. Uncertainty plays a crucial role in shaping financial and economic decisions by households, investors, and policymakers, thereby impacting macroeconomic fluctuations (Bernanke, 1983; Bloom, 2009, 2014; Pastor & Veronesi, 2012; Sims, 2012). From a theoretical standpoint, EPU and OPU influence inflation through multiple transmission mechanisms, including real options, cost of financing, precautionary savings, and investment transmission channels (Bloom, 2014; Antonakakis et al., 2014; Leduc & Liu, 2020).

One of the key theoretical underpinnings of uncertainty transmission to inflation is the real options theory, which posits that firms delay investment and hiring

decisions due to heightened uncertainty (Bernanke, 1983). When uncertainty increases, businesses opt for a wait-and-see approach, delaying capital investments and reducing employment, which can dampen aggregate demand and economic activity (Bloom, 2014). In this way, economic uncertainty influences inflation through both demand- and supply-side effects (Charnavoki & Dolado, 2014; Ha et al., 2019).

A crucial factor in this relationship is economic policy uncertainty, as explored by Baker et al. (2016). Policy uncertainty is defined as a nonzero probability of unexpected changes in monetary, fiscal, or regulatory policies, which influence investment and consumption behavior (Baker et al., 2016). EPU is transmitted through multiple channels, including real options, financing costs, and precautionary savings mechanisms (Bernanke, 1983; Bloom, 2014; Al-Thaqeb & Algharabali, 2019). Increased uncertainty leads firms to reduce investments and delay hiring decisions (Bloom, 2009; Antonakakis et al., 2014). Similarly, uncertainty increases risk premiums, which in turn leads to higher borrowing costs and reduced economic activity (Antonakakis et al., 2014). From a demand perspective, households facing uncertainty cut back on spending and increase savings, leading to demand-driven disinflation (Kimbell, 1989).

Theoretical and empirical studies highlight that oil price uncertainty (OPU) can also influence macroeconomic variables through supply-side effects (Elder & Serletis, 2010; Jo, 2014). Rising oil prices directly affect consumer price inflation by increasing production costs, particularly in energy-intensive sectors (Choi et al., 2018; Köse & Ünal, 2021). This cost-push inflation is accompanied by indirect effects, where rising oil prices increase production costs for firms and are transmitted along the supply chain, influencing broader price levels in the economy (Choi et al., 2018; Lacheheb & Sirag, 2019). Uncertainty regarding oil prices adds another layer of complexity, affecting investment decisions and production costs in both oil-exporting and oil-importing countries (Elder & Serletis, 2010; Jo, 2014; Wang et al., 2017).

2-1 Research Background

The existing literature on the determinants of inflation has primarily focused on factors such as demand and supply shocks, monetary policy, and exchange rate fluctuations (for instance, see works such as those by Lim & Sek, 2015; Deniz et al., 2016; Boschi & Girardi, 2007; Lagoa, 2017; Dhakal et al., 1994; Baldini & Poplawski-Ribeiro, 2011; Greenidge & DaCosta, 2009; Eftekhari-Mahabadi & Kiaee, 2015). However, the role of economic uncertainty in shaping inflation expectations has only recently gained attention in macroeconomic analysis (Grier & Perry, 1998; Neanidis & Savva, 2013). More recent studies suggest that economic uncertainty shocks exhibit asymmetric transmission effects on inflation (Istiak & Serletis, 2018; Wen et al., 2021; Long et al., 2022).

Oil price uncertainty (OPU) has similarly been identified as a crucial determinant of inflationary dynamics. Empirical studies highlight that oil price volatility

exerts a negative influence on economic activity, but its direct impact on inflation has often been overlooked (Elder & Serletis, 2010; Jo, 2014). Further research suggests that oil price fluctuations have varying effects across different time horizons, with long-term consequences being more persistent due to indirect effects on supply chains and production costs (Choi et al., 2018; Köse & Ünal, 2021). For instance, Choi et al. (2018) estimated that a 10% increase in global oil prices can raise consumer price inflation by 0.4 percentage points across both developed and developing countries. However, the effect diminishes over time due to increasing central bank credibility. However, studies have found significant asymmetries in the pass-through effect of oil price changes on inflation for various economies, highlighting a differential response in oil-exporting and importing countries (Salisu et al., 2017; Long & Liang, 2018; Li & Guo, 2022).

In the Iranian context, the impact of economic policy uncertainty and oil price fluctuations on inflation has not been sufficiently explored in the literature. Iran, as a major oil-exporting country, faces unique macroeconomic challenges due to its high dependence on oil revenues and economic policy fluctuations. While studies have demonstrated that oil price changes influence inflation in both short and long-term horizons (Choi et al., 2018; Köse & Ünal, 2021), the simultaneous effect of economic policy and oil price uncertainty on inflation remains underexplored, especially for oil-rich emerging economies like Iran.

In this section, previous studies related to the research topic are briefly reviewed. First, international studies are discussed, followed by domestic studies.

Economic policy uncertainty refers to situations where government and central bank policy decisions are unpredictable, leading to economic fluctuations. Numerous studies have shown that increased economic policy uncertainty can raise inflation through changes in inflation expectations and reduced investment. Athari et al. (2021) examined the temporal and frequency co-movement between economic policy uncertainty and inflation in Japan, finding that economic policy uncertainty is a critical predictor of inflation and leads to inflation at different periods and frequencies.

Ashiru and Oladele (2022) studied the impact of economic policy uncertainty on inflation in Nigeria using the Autoregressive Distributed Lag (ARDL) model. The results indicated that EPU has a positive and significant effect on inflation, and this effect persists in the long run. Additionally, a study conducted by Adeosun et al. (2022) using the wavelet method revealed that economic uncertainty has different impacts on inflation in developed and developing countries. In developing countries, the effects are short-term and more intense, whereas in developed countries, the impacts are longer-term.

Aytaç and Saraç (2022) investigated the effect of economic policy uncertainty in Latin American countries and found that in the short term, economic policy

uncertainty positively affects inflation, but this effect diminishes in the long term. Moreover, Anderl and Caporale (2023), using the nonlinear NARDL model, demonstrated that economic policy uncertainty shocks have asymmetric effects on inflation, with negative EPU shocks having a stronger impact compared to positive shocks. Their findings also suggest that economic policy uncertainty can weaken the effects of monetary policies.

Alongside economic policy uncertainty, oil prices are also a significant factor in determining inflation rates, especially in countries heavily dependent on energy imports. An increase in oil prices affects the general price level through higher production and transportation costs. Kilian and Zhou (2022) examined the impact of the rise in oil prices from 2020 to 2023 on inflation expectations in the United States, concluding that while oil prices have a significant short-term impact on inflation, their long-term effect decreases. Zhao et al. (2025) employed network models to analyze the transmission paths of oil price shocks on inflation in various countries, revealing that oil shocks in China and the United States have a greater impact on inflation, transmitted through exchange rates and production costs.

In another study, Živkov et al. (2023) used the Markov-wavelet approach to investigate the effect of oil price changes on inflation in Central and Eastern European countries, finding that, in the long run, the increase in oil prices has a more substantial impact on inflation compared to the short run. Similarly, Ge and Sun (2024) demonstrated that positive and negative oil shocks have asymmetric effects on inflation, with rising oil prices leading to increased inflation, while falling oil prices have a lesser effect in reducing inflation.

Some studies have also examined the combined effects of economic policy uncertainty and oil prices on inflation. These studies have shown that the simultaneous increase in economic uncertainty and oil prices can have compounded effects on inflation. Anderl and Caporale (2023) found that economic policy uncertainty shocks have a more significant impact on inflation compared to oil price shocks. However, during periods when both variables fluctuate greatly, an interaction effect is observed, leading to greater inflation instability. Adeosun et al. (2022) also analyzed the combined impact of economic policy uncertainty and oil prices in five major economies. The results indicated that in countries such as the United States and Canada, economic policy uncertainty has a more significant effect on inflation. In contrast, in oil-importing countries, oil prices are the primary factor driving inflation.

Domestic studies have focused on the effects of oil prices, economic policy uncertainty, and other macroeconomic variables on inflation and economic growth in Iran. Their findings indicate that these variables have played a significant role in Iran's economic development.

Mehnatfar et al. (2018) conducted a study using quantile regression to examine the impact of oil price shocks on inflation in the Iranian economy from 1981 to

2014. The results showed that oil price fluctuations have a positive and significant effect on inflation. Additionally, GDP and trade openness negatively affect inflation, while liquidity has a positive impact, indicating the role of economic openness and GDP growth in reducing inflation.

Laleh Khazri and Ashna (2023) conducted a study using the Dynamic Conditional Correlation GARCH (DCC-GARCH) model to examine the relationship between global economic policy uncertainty, inflation, and inflation uncertainty in Iran from March 1997 to October 2022. The results demonstrated that global economic uncertainty significantly impacts inflation and inflation uncertainty in Iran. Furthermore, the correlation between these variables was positive in some periods and negative in others, which can be attributed to factors such as aggregate demand and supply channels, price stickiness, and monetary policy responses.

Fathi et al. (2023) conducted another study using the EGARCH approach and panel data from 1990 to 2018 to investigate the effects of oil price shocks and real exchange rate volatility on economic growth and inflation in selected OIC member countries. The results indicated that the response of economic growth and inflation to oil price shocks is asymmetric between oil-exporting and oil-importing countries. Additionally, real exchange rate volatility negatively impacts economic growth and positively affects inflation in oil-exporting countries, whereas for oil-importing countries, both effects are positive.

In another study, Kamijani and Hajihaydari (2023) used the NARDL model to analyze the asymmetric effects of oil price shocks, oil price uncertainty, and economic sanctions on economic growth and inflation in Iran during the period 1979 to 2020. The results revealed that positive oil price shocks positively affect economic growth, while negative shocks negatively impact it. Moreover, oil price uncertainty, economic sanctions, exchange rates, labor force, and government spending negatively impact economic growth, while capital stock has a positive effect. Furthermore, the second model results indicated that positive oil price shocks have a negative effect and negative shocks have a positive effect on inflation. Additionally, economic sanctions, trade liberalization, and government spending have positive and significant effects on inflation. The Wald test also indicated that the effects of oil price shocks on economic growth and inflation are asymmetric in both the short and long term.

The literature review indicates that both economic policy uncertainty and oil prices significantly influence inflation, but the intensity and nature of these effects depend on each country's economic conditions. Economic policy uncertainty primarily affects inflation through changes in expectations and monetary policies, whereas oil prices influence inflation through production costs and exchange rates. Moreover, combining these two factors can amplify

inflationary pressures, providing policymakers with insights for designing effective strategies to control inflation and manage economic volatility.

3. Data

Following the study by Kyriazis et al. (2024) and Anderl and Caporale (2023), the Quantile-on-Quantile (QQ) regression model is employed to examine the effect of oil price uncertainty and economic policy uncertainty on inflation. The dependent variable is Inflation, which is sourced from the Central Bank of Iran. The economic policy uncertainty (EPU) index is derived from the study by Ahir et al. (2022). Ahir et al. (2022) construct quarterly economic uncertainty indices for 143 countries by counting the frequency of the term 'uncertainty' (and its variations) in quarterly reports from the Economist Intelligence Unit (EIU). The EIU reports discuss major political and economic developments in each country and provide analysis and forecasts of political, policy, and economic conditions. The Oil Price Uncertainty (OPU) index, developed by Abdul Abiad and Irfan A. Qureshi, is constructed using the frequency of newspaper articles, following the methodology outlined in "Measuring Economic Policy Uncertainty" by Baker, Bloom, and Davis. This index, which covers the period from January 1969 to December 2019, is compiled on a monthly basis. To develop their index, Abiad and Qureshi focus on English-language articles containing at least 100 words, published in 50 newspapers worldwide. They deliberately exclude non-standard news items such as sports articles, editorials, abstracts, advertisements, sponsored content, blogs, opinion pieces, country profiles, transcripts, and press releases.

4. Research Methodology

In this study, the QQ regression estimation developed by Sim and Zhou (2015) was used to examine the effects of oil price uncertainty and economic policy uncertainty on inflation. The section outlines the key aspects of the QQ regression technique and details the model specifications used throughout the analysis. The QQ approach builds upon the conventional quantile regression (QR) model by assessing how the quantile of one variable influences the conditional quantile of another variable.

Previous studies initially relied on the classical linear regression model to analyze relationships within time series data. Over time, this approach evolved into the more advanced quantile regression method, as pioneered by Koenker and Bassett (1978). The QQ approach merges the characteristics of nonparametric estimation with those of quantile regression (QR) estimation. In this framework, the QR method is initially applied to evaluate how explanatory variables influence the quantiles of the dependent variable. Unlike the conventional least squares estimation, QR estimation analyzes the effects of explanatory variables not only at the center but also at the tails of the dependent variable's distribution. This

enables a more comprehensive analysis of the relationship across various study periods (Koenker and Ng, 2005).

Additionally, local linear regression—originally introduced by Stone (1977) and Cleveland (1979)—is employed to examine the local relationship between variables and to reduce the dimensionality problem. This method helps in analyzing the local effect of a specific quantile of an independent variable on the dependent variable by assigning higher weights to nearby data points within the sample. Consequently, combining these two methods allows the QQ approach to deliver a more detailed assessment of the relationship between the quantiles of both dependent and independent variables, outperforming other techniques such as Ordinary Least Squares (OLS).

The QQ approach has been extensively applied in various energy and growth economy studies to investigate how the quantile of one variable impacts the conditional quantile of another variable (Kumah and Mensah, 2020). Owing to these advantages, this study adopts the QQ estimation technique to analyze the effects of the quantiles of economic policy uncertainty and oil price uncertainty on the quantiles of inflation. The following equation serves as the foundation of the QQ approach.

$$INF_t = \beta^\theta(OPU_t) + \mu_t^\theta \quad (1)$$

Where INF_t denotes inflation for period t and OPU_t denotes oil price uncertainty for period t , and θ represents the quantile distribution θ . Since we have no prior knowledge of the relationship between economic policy uncertainty, oil price uncertainty, and inflation, we assume $\beta^\theta(\cdot)$ to be an unknown function.

This approach is superior to previously reported results due to its flexible characteristics, as no functional form is assumed for the relationship between economic policy uncertainty, oil price uncertainty, and inflation. The ability to capture dependency is one of the limitations of the QR estimation technique. In the reference study, the QR model does not account for how the nature of oil price uncertainty shocks influences the relationship between oil price uncertainty and inflation.

To re-examine the relationship between oil price uncertainty (OPU), economic policy uncertainty (EPU), and the second quantile of inflation, Equation (1) was analyzed in the neighborhood of OPU_τ using local linear regression. Based on the unknown parameter $\beta^\theta(\cdot)$, the equation was expanded using a first-order Taylor expansion around the quantile OPU_τ .

$$\beta^\theta(OPU_t) \approx \beta^\theta(OPU_\tau) + \beta^{\theta'}(OPU_\tau)(OPU_t - OPU_\tau) \quad (2)$$

Here, $\beta^{\theta'}$ denotes the partial derivative of (OPU_t) , also referred to as the marginal response, which is equivalent to the slope coefficient in the linear regression model.

An important feature of Equation (2) is that the parameters $\beta^\theta(OPU_\tau)$ and $\beta^{\theta'}(OPU_\tau)$ are doubled in θ and τ . Consequently, $\beta^\theta(OPU_\tau)$ and $\beta^{\theta'}(OPU_\tau)$

are functions of θ and OPU^τ . Moreover, OPU^τ itself is a function of τ . Clearly, $\beta^\theta(OPU^\tau)$ and $\beta^{\theta'}(OPU^\tau)$ can be rewritten as $\beta_0(\theta, \tau)$ and $\beta_1(\theta, \tau)$, respectively. Subsequently, Equation (2) can be rewritten as:

$$\beta^\theta(OPU_t) \approx \beta_0(\theta, \tau) + \beta_1(\theta, \tau)(OPU_t - OPU^\tau) \quad (3)$$

Equation (4) is formed by substituting Equation (3) into Equation (1):

$$INF_t = \underbrace{\beta_0(\theta, \tau) + \beta_1(\theta, \tau)(OPU_t - OPU^\tau)}_{(*)} + \mu_t^\theta \quad (4)$$

Here, (*) represents the conditional value of inflation. Furthermore, Equation (4) highlights the relationship between the quantile of inflation (θ th), the quantile of oil price uncertainty (τ th), and economic policy uncertainty, emphasizing that the parameters β_0 and β_1 incorporate both θ and τ indices. We did not assume a linear relationship between the quantiles of the variables.

Similar to OLS, a simple minimization technique is used to extract Equation (4):

$$\min_{b_0, b_1} \sum_i^n \rho\theta [INF_t - b_0 - b_1(\widehat{OPU}_t - \widehat{OPU}^\tau)] K\left(\frac{F_n(\widehat{OPU}_t - \tau)}{h}\right) \quad (5)$$

In which $\rho\theta$ is the quantile loss function defined as $\theta, \tau(u) = u(\theta - 1(u < 0))$, where i denotes the indicator function. Additionally, $K(*)$ and h represent the kernel density function and the bandwidth parameters, respectively. $K(*)$ measures the observations of EPU, OPU^τ , where the minimum weights are negatively assigned to the distribution function \widehat{OPU}_t as $F_n(\widehat{OPU}_t - \tau) = \frac{1}{n} \sum_{k=1}^n I(\widehat{OPU}_k < \widehat{OPU}_t)$.

Research has shown that the use of nonparametric estimation significantly increases the importance of bandwidth selection (Shahzad et al., 2017). The smoothness of the results is influenced by calculating the neighborhood dimensions around the target point. A smaller bandwidth results in estimates with greater variance, while a larger bandwidth introduces bias into the estimates. Therefore, it is crucial to select an optimal bandwidth to strike a balance between variance and bias. Following the method proposed by Sim and Zhou (2015), the bandwidth parameter h was selected from the range [0.05, 0.95].

5. Model estimation and results

5.1. Descriptive statistics

Table 1. Descriptive statistics

	INF	OPU	EPU
Mean	2.067077	4.591255	0.334162
Maximum	10.56879	5.907353	1.433000
Minimum	-0.358423	2.928432	0.000000
Std. Dev.	1.673573	0.583081	0.262498
Skewness	1.461684	-0.157371	1.220921
Kurtosis	6.423008	3.039963	5.013106
Jarque-Bera	161.2602	0.801086	79.70420
Probability	0.000000	0.669956	0.000000

Table 1 examines the descriptive statistics of the variables inflation (INF), oil price uncertainty (OPU), and economic policy uncertainty (EPU). The mean inflation rate is 2.067, which differs from the median of 1.626, indicating data asymmetry. The positive skewness (1.46) and high kurtosis (6.42) suggest a right-skewed distribution with long tails. The oil price variable has a mean of 4.59 and a median of 4.61, with a slight negative skewness (-0.15) and kurtosis close to the normal distribution (3.03), indicating an approximately symmetric distribution. Economic policy uncertainty has a mean of 0.334, with positive skewness (1.22) and high kurtosis (5.01), indicating a right-skewed distribution. The Jarque-Bera test for inflation and economic policy uncertainty shows high statistical significance (p-value of 0.000), indicating the non-normal distribution of these variables. In contrast, the oil price uncertainty variable, with a p-value of 0.67, follows a normal distribution.

4.2. Wavelet Quantile ADF unit root tests

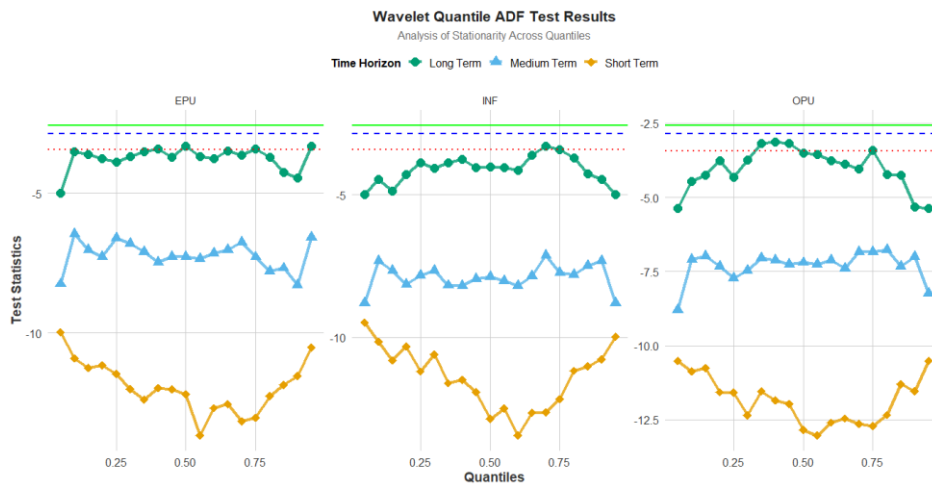


Fig. 1. Wavelet Quantile ADF

According to the results of the Wavelet Quantile Augmented Dickey-Fuller (QADF) test, all variables are stationary at various significance levels (5% and 10%) and across different time horizons (short-term, medium-term, and long-term). This indicates that shocks affecting these variables (inflation, economic policy uncertainty, and oil price uncertainty) do not have a permanent impact and tend to revert to their long-term mean over time. In particular, the EPU variable consistently exhibits t-values lower than the critical values across all horizons, indicating strong stationarity. The variables INF and OPU also show a tendency toward stationarity in the long term, although they may experience fluctuations in

the short and medium term. These findings suggest that policymakers can plan economic strategies with greater confidence, knowing that these variables will eventually return to their long-term trend.

4.3. BDS test

Table 2. BDS test outputs

Dimension	INF(inflation)		EPU(economic policy uncertainty)		OPU(oil price uncertainty)	
	z-Statistic	Prob.	z-Statistic	Prob.	z-Statistic	Prob.
2	13.11541	0.0000	13.83991	0.0000	10.37259	0.0000
3	13.47418	0.0000	15.23382	0.0000	10.40877	0.0000
4	14.12047	0.0000	16.27177	0.0000	10.12607	0.0000
5	14.53885	0.0000	17.02161	0.0000	10.29286	0.0000
6	15.51356	0.0000	17.75075	0.0000	10.43618	0.0000

The results of the BDS test for the variables inflation (INF), economic policy uncertainty (EPU), and oil price uncertainty (OPU) indicate that all-time series exhibit nonlinear structures across various dimensions (from 2 to 6), as the z-statistic is positive and significant in all cases. This finding leads to the rejection of the null hypothesis of no nonlinear dependence. Among the variables, economic policy uncertainty exhibits the highest degree of nonlinear dependence, while oil price uncertainty shows the lowest. Additionally, an increase in dimension generally corresponds to an increase in the z-statistic, indicating a stronger nonlinear structure at higher dimensions. Therefore, the use of nonlinear models appears necessary for analyzing these variables.

4.4. QQR

This study focuses on analyzing the relationship between oil price uncertainty, economic policy uncertainty, and inflation in the Iranian economy using the quantile-on-quantile approach. The three-dimensional plot illustrates the interaction between oil price uncertainty and inflation across multiple quantile levels, allowing for the investigation of different trends and patterns at various points in the data distribution.

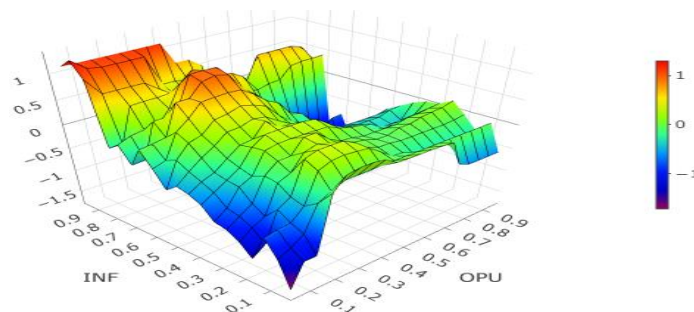


Fig 2. Quantile on Quantile OPU and INF

Initially, in areas where both oil price uncertainty and inflation are at low levels, the relationship intensity is relatively weak, indicating that minor changes in oil price uncertainty do not significantly affect inflation in these regions. This pattern is predominantly observed in areas marked by cool colors, such as blue and green, indicating lower elevations on the plot. This finding suggests that at lower quantile levels, oil price uncertainty is not substantial enough to significantly impact the inflation structure of the economy. As oil price uncertainty increases, in areas where inflation is also at higher levels, the relationship intensity becomes more pronounced. This is especially evident in sections marked by warm colors, such as yellow and red, indicating higher elevations on the plot. This pattern may suggest that in periods of oil market instability, characterized by high uncertainty, inflationary pressures intensify. The reason for this could be associated with rising costs, price volatility, and uncertainty in financial markets, which ultimately increase consumer costs and drive inflation. This finding aligns with Ren et al. (2024), who concluded that oil shocks amid high economic uncertainty can globally increase expected inflation, with stronger effects in oil-dependent economies. Similarly, Madanian (2018) confirmed that oil price shocks significantly impact both consumer and producer inflation rates in Iran, with these effects being more pronounced during periods of sharp oil price declines. Furthermore, examining the patterns in the plot reveals that the relationship between oil price uncertainty and inflation across different quantile levels is multifaceted, and a purely linear relationship cannot be established. In some cases, a decrease in uncertainty correlates with lower inflation rates, while in others, this relationship is highly fragile and dependent on specific economic conditions. Studies by Kyriazis et al. (2024) and Correa and Lopez (2023) also indicate that oil-dependent economies, due to their heavy reliance on oil revenues, are highly sensitive to long-term price shocks. These findings emphasize the importance of analyzing and understanding the complex role of oil price uncertainty in the Iranian economy. Consequently, the study's results indicate that economic policies should be formulated with caution, considering oil market instability, as fluctuations in uncertainty within this market can have both direct and indirect impacts on national inflation. Overall, employing the quantile approach in analyzing this relationship enables a better understanding of its dispersion and structure, helping policymakers develop economic resilience strategies to withstand oil price shocks.

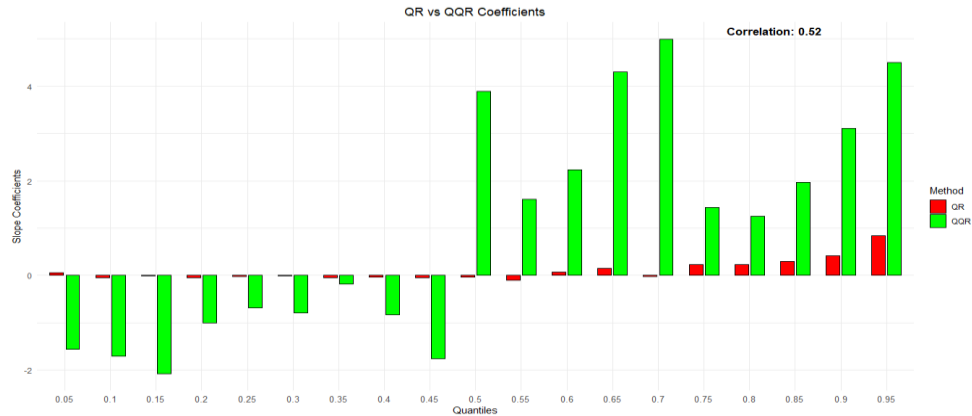


Fig.3. Average Quantile in Quantile and QR OPU and INF

This chart illustrates how the impact of oil price uncertainty on inflation in the Iranian economy varies across different parts of the distribution. In the lower segments of the distribution (low quantiles such as 0.05 to 0.25), the results indicate that the effect of uncertainty is relatively small or even negative. This means that in these areas, oil price uncertainty may not significantly influence inflation or may even slightly reduce it. However, in the middle segments, the effect of uncertainty gradually starts to increase, although it still remains relatively modest. As we move towards the upper parts of the distribution, particularly higher quantiles such as 0.75 to 0.95, a different pattern emerges. In these areas, both methods—particularly the Quantile-on-Quantile Regression (QQR)—indicate that the effect of oil price uncertainty on inflation becomes stronger and positive. In other words, when oil price uncertainty intensifies in these segments, inflation also rises. This finding suggests that during periods of crisis or heightened uncertainty, the fluctuations in oil prices have a more pronounced impact on inflation, playing a significant role.

Overall, this analysis demonstrates that the effect of oil price uncertainty on inflation in Iran varies across different parts of the distribution. In the lower segments, the impact is not clearly evident, whereas in the upper segments, oil price uncertainty can significantly contribute to rising inflation. Additionally, the QQR method better captures the sensitivity and variation of the effect across different segments, highlighting the importance of quantile-on-quantile analysis for a more nuanced understanding of these relationships.

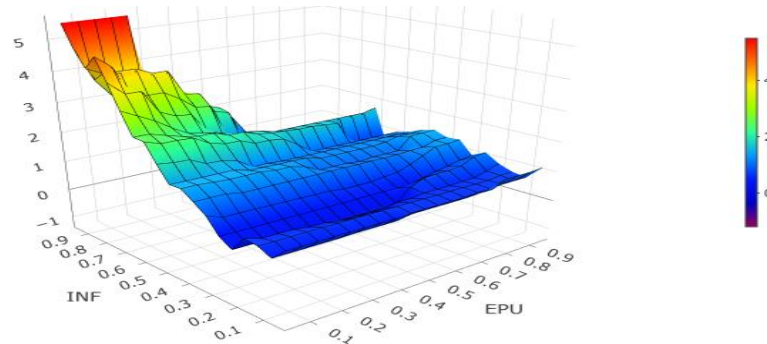


Fig.4. Quantile in Quantile EPU and INF

This three-dimensional graph illustrates the relationship between economic policy uncertainty (EPU) and inflation in Iran, analyzed using the quantile-on-quantile (QQ) approach. In this graph, the left horizontal axis represents the inflation level (INF), while the right horizontal axis shows the EPU index (economic policy uncertainty). The various colors in the graph, ranging from purple and blue in the lower quantiles to green and red in the higher quantiles, indicate the intensity of the relationship. The results reveal that as economic policy uncertainty increases, inflation at the national level rises significantly. In areas with low uncertainty, inflation remains relatively stable and low. However, as uncertainty increases, inflation rises nonlinearly and sensitively. These changes in the end regions of the graph, displayed in warm colors, signify a strong and tight relationship between uncertainty and inflation under critical conditions. Particularly in higher quantiles, even small changes in uncertainty can have a considerable impact on inflation. This finding is consistent with the study by Baker et al. (2016), who found that rising economic policy uncertainty in the United States leads to increased inflation expectations in the short term and heightened market volatility. Additionally, Bloom (2009) stated that uncertainty disrupts economic activities in the short term and, through expectation effects, causes more severe fluctuations in inflation and production. Using the quantile-on-quantile approach allows for the analysis of structural differences in the distribution of the relationship, demonstrating that the impact of uncertainty is more pronounced and limited in certain parts of the distribution. In lower quantiles, the effect is less significant, while in higher quantiles, the relationship becomes sharper and more intense. These findings indicate that policymakers should particularly focus on controlling economic policy uncertainty, as this factor plays a crucial role in inflation variations and economic instability. Overall, the results suggest that managing economic policy uncertainty can significantly contribute to controlling inflation, especially during critical

situations. Understanding the nonlinear and sensitive nature of this relationship is vital for the community and the country's economy. This study could serve as guidance for policymakers aiming to maintain economic and price stability amid political fluctuations and uncertainties.

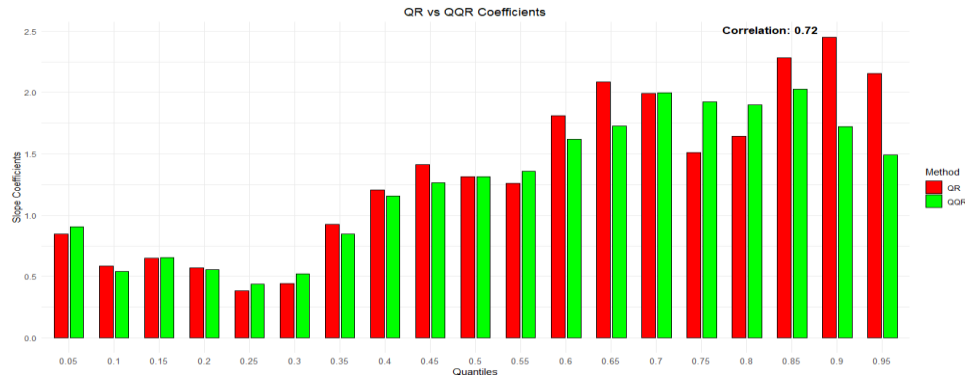


Fig 5. Average Quantile in Quantile and QR EPU and INF

This comparative chart illustrates the relationship between economic policy uncertainty and inflation in Iran based on the QR (Quantile Regression) and QQR (Quantile-on-Quantile Regression) methods. The horizontal axis displays the quantiles (ranging from 0.05 to 0.95), while the vertical axis represents the slope coefficients for each method at each quantile. The red colors correspond to the QR method, while the green colors indicate the QQR method. The analysis reveals that in all quantiles, the slope coefficients of the QR method are generally higher than those of the QQR method. The overall trend for both methods indicates an increase in slope as the quantile level rises, though differences in magnitude and sensitivity appear across various regions. Notably, in the middle and upper quantiles (e.g., 0.7, 0.8, 0.9), the QR slope coefficients are higher, indicating that the impact of uncertainty on inflation is stronger in these distribution segments. In contrast, in the lower quantiles (e.g., 0.05 to 0.3), the difference between the two methods is smaller, with both methods showing relatively low and similar effects. Moreover, the increasing trend of coefficients in both methods suggests that in the upper distribution segments, the effect of uncertainty on inflation becomes more intense and sensitive. However, the QQR method exhibits less variability, showing relatively more stable slopes, which can be attributed to QQR's ability to model nonlinear and structural relationships across different distribution domains. Overall, these results indicate that the effect of economic policy uncertainty on inflation in Iran is particularly strong and sensitive at higher quantile levels, while in the lower segments, this effect is weaker and more stable. Additionally, the difference between the two methods highlights the importance of conducting in-depth analyses, as QQR can better

capture the variable effects across different distribution levels, providing a more nuanced understanding of both direct and indirect impacts of uncertainty across various economic sectors. These findings underscore the need for policymakers to pay closer attention to fluctuations and structural uncertainties in economic policies to manage inflation and ensure economic stability.

6. Conclusion and Recommendations

This study provides a comprehensive analysis of the asymmetric impacts of economic policy uncertainty (EPU) and oil price uncertainty (OPU) on inflation in Iran, employing the Quantile-on-Quantile (QQ) regression method. By utilizing monthly data spanning from 2008 to 2023, the research aims to understand the heterogeneous effects of uncertainty across different quantiles of the inflation distribution. Iran's oil-dependent economy, coupled with high sensitivity to policy shifts, underscores the necessity of this analysis, especially given the complexities introduced by both domestic and global uncertainties.

The results of the QQ regression analysis reveal significant non-linear and asymmetric responses of inflation to both EPU and OPU. The findings indicate that the relationship between uncertainty and inflation is quantile-dependent, with lower quantiles demonstrating minimal impacts, while higher quantiles reflect a substantial and positive effect. This heterogeneity suggests that during periods of economic stability or lower uncertainty, inflation remains relatively unaffected by fluctuations in EPU and OPU. However, as uncertainty intensifies, particularly during economic crises or global oil market disruptions, inflation shows a marked increase. This pattern is particularly evident in the upper quantiles, emphasizing the disproportionate influence of uncertainty shocks when inflation is already elevated.

The study also demonstrates that EPU generally exerts a more consistent and robust effect on inflation compared to OPU. This outcome aligns with the theoretical perspective that economic policy shifts—whether anticipated or unexpected—directly impact investment decisions, consumption patterns, and price stability. In contrast, OPU, while influential, shows a less uniform impact, particularly when oil price fluctuations do not coincide with significant economic policy changes. This difference highlights the centrality of policy stability in maintaining inflation control, especially in economies where government intervention and regulatory shifts frequently alter the economic landscape.

6.1 Implications for Policy and Practice

Understanding the asymmetric and non-linear nature of the relationship between uncertainty and inflation carries profound implications for policymakers. First, given the heightened sensitivity of inflation to EPU at higher quantiles, it is crucial for economic policymakers to minimize policy ambiguity, particularly during periods of financial or political instability. Clarity and consistency in

fiscal and monetary policy could mitigate inflationary pressures exacerbated by policy uncertainty. Moreover, the less pronounced but still significant effects of OPU suggest that Iranian policymakers should adopt energy price stabilization mechanisms to cushion the economy against oil market shocks. This approach could include strategic oil reserves and hedging strategies to reduce the transmission of oil price volatility into consumer prices. Additionally, diversifying the economy away from oil dependence would diminish the inflationary impact of global oil price uncertainties. The quantile-dependent nature of the effects also implies that inflation control measures should be flexible and adaptive. During lower quantile periods, traditional monetary tools may suffice, while higher quantile scenarios—characterized by crisis or heightened uncertainty—may require more aggressive interventions, such as interest rate adjustments or targeted subsidies.

6.2 Theoretical Contributions

From a theoretical perspective, this study contributes to the growing body of literature that challenges the linear assumptions often employed in conventional inflation models. By leveraging the QQ method, the research not only captures the heterogeneity of inflation responses but also provides a more nuanced understanding of the interaction between uncertainty shocks and inflation dynamics. This advancement helps bridge the gap between theoretical postulations and empirical realities, offering a robust framework for analyzing inflationary dynamics in oil-dependent and policy-volatile economies like Iran.

6.3 Limitations and Future Research Directions

Despite the robustness of the QQ approach, the study faces certain limitations. The reliance on monthly data, while offering detailed temporal insights, may not fully capture the long-term structural adjustments within the economy. Future research could extend the analysis by incorporating quarterly or annual data to assess the persistent effects of uncertainty over extended periods. Additionally, while the study emphasizes EPU and OPU as key uncertainty variables, other forms of uncertainty, such as geopolitical or financial market volatility, could also influence inflation dynamics. Integrating these additional variables into the QQ framework could yield a more holistic understanding of inflation determinants in Iran.

This study underscores the critical role that economic policy and oil price uncertainties play in shaping inflation trends within Iran. The asymmetric effects observed through the QQ analysis highlight the necessity for adaptive and context-specific policy interventions. By acknowledging the non-linear dynamics between uncertainty and inflation, Iranian policymakers can better prepare for economic disruptions, enhance resilience, and foster long-term stability. Future studies should continue exploring the nuanced interactions between various forms of uncertainty and macroeconomic variables to refine policy recommendations and theoretical models further.

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کاوشی جدید در مورد اثرات عدم قطعیت قیمت نفت و سیاست اقتصادی بر تورم: مدل‌سازی با استفاده از روش رگرسیون چندک روی چندک

چکیده:

هدف: این مطالعه با استفاده از روش رگرسیون چندک روی چندک (QQ)، اثرات نامتقارن عدم قطعیت سیاست اقتصادی (EPU) و عدم قطعیت قیمت نفت (OPU) را بر تورم در ایران بررسی می‌کند. با توجه به اقتصاد وابسته به نفت ایران، هدف این تحقیق درک چگونگی تأثیر عدم قطعیت‌های جهانی و داخلی بر پویایی تورم، به ویژه در طول آشفتگی اقتصادی است. مدل‌های سنتی اغلب اثرات غیرخطی و ناهمگن عدم قطعیت بر تورم را نادیده می‌گیرند و همین امر باعث می‌شود از رویکرد QQ برای ثبت تأثیرات متغیر در چندک‌های مختلف استفاده شود.

روش‌ها: این مطالعه از روش رگرسیون QQ برای تحلیل اثرات نامتقارن EPU و OPU بر تورم، با استفاده از داده‌های ماهانه از سال ۲۰۰۸ تا ۲۰۲۳ استفاده می‌کند. رویکرد QQ برای بررسی ناهمگونی و غیرخطی بودن رابطه بین عدم قطعیت و تورم، به ویژه در زمینه اقتصاد نفتی ایران، انتخاب شده است.

نتایج: یافته‌ها، ناهمگونی قابل توجهی را در پاسخ‌های تورم به شوک‌های عدم قطعیت نشان می‌دهد. در چندک‌های پایین‌تر، هم EPU و هم OPU اثرات حداقلی بر تورم دارند، که نشان می‌دهد تغییرات جزئی در عدم قطعیت، نرخ تورم را به طور قابل توجهی تغییر نمی‌دهد. با این حال، در چندک‌های بالاتر - به ویژه در دوره‌های افزایش عدم قطعیت - هر دو عامل تأثیر برجسته‌تر و مثبت‌تری بر تورم نشان می‌دهند. علاوه بر این، تحلیل QQ نشان می‌دهد که EPU در مقایسه با OPU تأثیر ثابت‌تری بر تورم دارد، که نشان می‌دهد عدم قطعیت ناشی از سیاست، فشار بیشتری بر سطوح قیمت نسبت به نوسانات قیمت نفت وارد می‌کند.

نتیجه‌گیری: این مطالعه بر اهمیت در نظر گرفتن اثرات عدم قطعیت نامتقارن و وابسته به چندک هنگام تدوین سیاست‌های کنترل تورم تأکید می‌کند، زیرا این امر می‌تواند به رفع چالش‌های تورمی در مواجهه با شرایط نوسانی جهانی و داخلی کمک کند.

کلمات کلیدی: نااطمینانی، رگرسیون چندک روی چندک، تورم، اقتصاد ایران.