ORIGINAL ARTICLE

OPEN ACCESS

Impact of Oil Price Uncertainty on Selected Sectoral Returns in the Pakistani Stock Market: A Quantile-on-Quantile Approach

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Article History:

Submitted: July 11, 2024
Revised: September 22, 2024
Accepted: September 27, 2024
Published online: September 30, 2024

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A B S T R A C T

Purpose - This study investigates the impact of Oil Price Uncertainty (OPU) on the return of five energy-dependent sectors in the Pakistani market (Automobile and Assemblers, Cement, Oil and Gas, Power and Distribution, and Chemicals). More specifically, we examine how these selected sectors respond under OPU in different market conditions (that is, bearish, normal, and bullish market conditions).

Study Design/methodology/approach - The study employs the Quantile-on-Quantile Regression (QQR) approach to assess non-linear and quantile-dependent association between sectoral returns and OPU, as QQR considers the heterogeneous relationship between the series. Monthly data is used to perform the examination, ranging from February 2010 to July 2024. Before performing QQR estimation, we check for the applicability of this approach by testing normality, linearity, and stationarity of the selected series.

Findings- Our study confirms a non-linear, sector-dependent, and quantile-dependent relationship between returns and OPU. Where the Power and Distribution and Chemicals sectors' returns show a consistent and statistically significant negative association with OPU in bearish, normal, and bullish markets, the results of other sectors display more complexity in terms of the direction of association between OPU and sectoral returns. The Cement sector displays a positive relationship with OPU in bearish market conditions but a negative association in normal market conditions. Similarly, the Automobile and Assembly and Oil and Gas sectors show a negative association with OPU in bearish and normal market conditions, which turns into a positive association in bullish market conditions.

Research Practical Implications- From a practical perspective, our findings have implications for investors, policymakers, and practitioners. Our findings show that sectoral risk exposure should be managed differently across different market conditions, also considering the nature of the industry. Additionally, our findings recommend government intervention to stabilize the Power and Distribution sector of Pakistan under high OPU, as this sector demonstrates low resilience and adaptability under OPU.

Originality/value- Although literature documents the direct impact of OPU on commodities, tokens, and other macroeconomic uncertainties, the transmission of OPU through sectoral linkages remains underexamined, especially for frontier and less efficient markets like Pakistan. Additionally, examining this association from a non-linear perspective is also missing in literature. Our study addresses these identified gaps.

Keywords: Quantile-on-Quantile Regression, Sectoral Interdependencies, Oil price uncertainty, Market efficiency, Risk transmission

JEL Classification Codes: C32, G10, G11, E44

1 | INTRODUCTION

The interconnectedness of financial markets has long been an area of interest among scholars, practitioners, policymakers, and investors. This holds, both from a global perspective and within an economy, where different sectors influence one another. More precisely, within an economy, the degree of interconnectedness between different sectors influences asset prices, risk dynamics, and portfolio preferences (Syed et al., 2022). Understanding such sectoral dynamics holds special significance when considering frontier markets like Pakistan, which suffer from limited diversification and investment opportunities (Fan et al., 2011).

Among different macroeconomic factors that influence the performance of various sectors, oil price uncertainty (OPU) can be seen as one of the most critical factors. Literature shows that this uncertainty is especially relevant to energy-dependent sectors like oil, power, and manufacturing (Shao et al., 2021; Xiao et al., 2022). Furthermore, fluctuations in global oil prices also impact other macroeconomic factors like inflation, exchange rates, and industrial production (Alao & Payaslioglu, 2021; Śmiech et al., 2021). As such, the impact of OPU on different sectors may differ.

Although, literature documents the direct impact of OPU on commodities, tokens, and other macroeconomic uncertainties (Alao & Payaslioglu, 2021; Fan et al., 2021; Shao et al., 2021; Śmiech et al., 2021), the transmission of OPU through sectoral linkages remain underexamined, especially for frontier and less efficient markets like Pakistan. Additionally, examining this association from a non-linear perspective is also missing in literature. The current study addresses these identified gaps by employing the Quantile-on-Quantile Regression (QQR) approach to examine the non-linear relationship between OPU and the five energy-dependent sectors of Pakistan. QQR approach is used to examine non-linear and asymmetric effects of OPU on sectoral returns in Pakistan, providing a frontier market perspective, moving beyond aggregate market responses, and considering sector-specific vulnerabilities. Bridging these gaps is crucial for multiple stakeholders, including policymakers, investors, and practitioners. Additionally, employing QQR helps provide a granular and richer understanding of sectoral interdependence and reactions to OPU. Further, the Pakistani stock market is highly segmented and is characterized by low liquidity and weak market efficiency (Khan & Khan, 2016). Additionally, the Pakistani economy is highly dependent on oil, most of which is imported to fulfill the Country's needs (Kanwal et al., 2022). As such, this unique sectoral setup and oil dependency make the sector-specific responses to oil shocks extremely relevant for market stability.

Our findings show that the sectoral responses against OPU vary across market conditions as well as the nature of the sectors. Where the Automobile and Assembly sector returns show a shift from a negative to a mixed relationship with OPU across bearish to bullish market conditions, the Cement sector shows a reversal of positive to negative association across the same conditions. Similarly, the Oil sector returns show a shift from negative to positive association with OPU in the bullish market. Both the Power and Distribution and Chemicals sectors show a consistent negative association in their returns with the OPU across all three market conductions (that is, bearish, normal, and bullish conditions). These findings have significant theoretical and practical implications, which are discussed in detail in Section 5 of the study.

The rest of the study is organized as follows: Section 2 performs a detailed literature review, Section 3 lists the methodology employed, Section 4 shows the findings and discusses the results, and Section 5 concludes the study, identifying theoretical and practical implications of the findings and commenting on possible future research directions.

2 | LITERATURE REVIEW

Fama (1970) states that available information is reflected in asset prices. Following this notion, it can be argued that macroeconomic uncertainties would also be reflected in the expected returns of various asset classes by investors. In the Global Financial Crises (GRC) of 2007-2008, scholars have rigorously examined the impact of macroeconomic uncertainties on economic activity (Baker et al., 2016; Bekaert et al., 2013; Bloom, 2009; Lahiri & Sheng, 2010). Additionally, literature shows ample evidence to support Fama (1970) Efficient Market Hypothesis (EMH), this hypothesis, for example, Aslam et al. (2023) and (Li et al., 2023) show that economic policy uncertainty is reflected in stock prices. Similarly, Hoque et al. (2023) show that trade policy uncertainties also have an impact on stock prices. Numerous other forms of risks and uncertainties have been examined in literature (like climate policy uncertainty, energy uncertainty, and geopolitical risk (Hoque & Zaidi, 2020; Ren et al., 2023).

Of these different variants of risks and uncertainties tested, one major uncertainty showing popularity in recent times is Oil Price Uncertainty (or OPU). Literature advocates for a critical role this uncertainty plays in impacting the prices of different asset classes. For example, Shao et al. (2021) show that OPU has a causal relationship with the return and risk of Chinese clean energy metal stocks. Similarly, Xiao et al. (2022) show that OPU is associated with stock price crash risk in China as well. Further, Alao and Payaslioglu (2021) show oil price volatility has an impact on the industrial production of countries. Oil price shocks are also transmitted to asset prices through such indirect means. These findings are corroborated by Ren et al. (2023) who show that OPU is associated with enterprise total productivity as well. Similarly, Śmiech et al. (2021) document that these shocks are more severe for oil-exporting countries, as such economies suffer from the impact of OPU on exchange prices as well. Nonetheless, even if not as severe as oil exporting economies, the impact of OPU on the stock market of other nations is also documented in the literature. For example, Fan et al. (2021) argue that the impact of OPU is much more direct on stock prices, as OPU impacts the leverage of companies, at least in the Chinese economy. These findings are corroborated by Hasan et al. (2022)who show that OPU also impacts debt maturity structure in an economy.

From the perspective of frontier markets, the literature marginally examines the impact of macroeconomic uncertainties in the Pakistani stock market. For example, Rehman and Ahmad (2024) confirm a non-linear relationship between OPU and manufacturing production in Pakistan. The authors show that with rising OPU, initially the manufacturing production increases, however, beyond a threshold the manufacturing production starts demonstrating an inverse relationship. Similarly, (Ghani et al., 2022) show a causal relationship between economic policy uncertainty with Pakistani stock market performance. The authors also confirm that among various macroeconomic factors tested for predictive power, oil prices show the most powerful predictions for the stock market in Pakistan. These findings corroborate the earlier work of Aziz and Hussain (2021). Further, Khan et al. (2023) argue that stock return series usually demonstrate non-linearity

and instability. These features warrant robust estimation approaches like quantile causality. The findings of their study also confirm the understanding developed from prior literature. Additionally, the studies focusing on global markets, specifically on developed markets, overall agree with the results received from the Pakistani market, where a non-linear and asymmetric relationship between macroeconomic uncertainties and market returns are confirmed (Ghani et al., 2022; Rehman & Ahmad, 2024). Nonetheless, literature strongly advocates the use of modern estimation approaches like QQR to examine the impact of macroeconomic uncertainties (for example, economic policy uncertainty, monetary policy uncertainty, OPU, etc.) on market (or sectoral) returns (Abiad & Qureshi, 2023; Arshad et al., 2024; Shahbaz et al., 2018; Sim & Zhou, 2015).

Frontier markets like Pakistan show unique characteristics, including low liquidity and higher volatility (Fan et al., 2011). This makes Pakistan an interesting study ground to examine the impact of OPU on sectoral returns, assessing how different sectors respond to this uncertainty in different market conditions (like bearish, normal, and bullish). Traditional econometric models, for example, Vector Autoregression (VAR), Autoregressive Distributed Lag (ARDL), and Ordinary Least Squares (OLS) fail to properly capture non-linear and asymmetric effects of OPU on market returns (Arshad et al., 2024; Saeed Meo et al., 2023; Shahbaz et al., 2018). Therefore, we apply the QQR approach as it captures a non-linear relationship while dividing dependent and independent variables into quantiles, giving deeper insights into the relationship in different market conditions (Arshad et al., 2024).

Generally speaking, focusing on the notions of Fan et al. (2021); Fan et al. (2021); Siddiqui, Khan, et al. (2024); Siddiqui, Sohail, et al. (2024), institutional settings and market conditions play a vital role in determining how asset prices react to different macroeconomic uncertainties. As such, the responses documented from studies examining developed economies, like Ren et al. (2023); Sim and Zhou (2015); and Syed et al. (2022), may significantly differ from the findings of other economies, for example, the work of Hung et al. (2022); Khan et al. (2023). Considering that the available literature marginally examines the impact of OPU on frontier markets like Pakistan, based on the suggestions of Siddiqui, Khan, et al. (2024), it is important to broaden the scope of literature to cover less developed markets as well.

To summarize, although literature examines OPU from different perspectives in prominent markets, examination focusing on relatively smaller markets like Pakistan remains quite marginal. More specifically, sectoral dependencies and OPU in Pakistan remain to be tested, as literature shows a preference for testing these relations considering aggregate market responses. Additionally, most literature examines the impact of these uncertainties using traditional econometric models. As such, there is a limited application of relatively modern and robust techniques like QQR, specifically in the context of smaller markets like Pakistan.

3 | METHODOLOGY & DESIGN

To examine the relationship between OPU and sectorial prices, we take sectoral returns from Business Recorder[1] which provides historical returns for thirteen sectors of the Pakistani market. Of these thirteen, three sectors are financial and the remaining ten sectors are non-financial. For focused insights, we limit the scope of the study to five non-financial energy-relevant sectors: (1) Automobile and Assemblers (Auto, for short);

[1] https://markets.brecorder.com/indices/index-archives.html

(2) Cement; (3) Oil and Gas (Oil, for short); (4) Power and Distribution (Power, for short); and (5) Chemicals. Further, the pharmaceutical sector was dropped from the sample for having a significantly lower number of observations when compared with the other sectors. The fertilizer sector was dropped from the sample due to its high sensitivity to government subsidies, seasonal demands, and high pricing regulations. Technology and Telecom sector was dropped from the sample due to being low oil-reliant when compared with other sectors included in the sample. Finally, the Food and Personal Care sector was dropped from the sample due to its high consumer demand elasticity and high reliance on supply-chain factors, which may reduce the impact of oil price volatility on the returns of this sector. Furthermore, the OPU index value is downloaded from credible and popular online sources[2] (used by numerous recent studies like (Arshad et al., 2024; Asafo-Adjei et al., 2020; Zhu et al., 2020), this index is credited to Abiad and Qureshi (2023)[3], which is created using the approach of Baker et al. (2016). We collect monthly time series data for sectoral returns and the OPU index from February 2010 to July 2024.

We analyze the impact of OPU on sectoral returns, employing Quantile-on-Quantile regression (QQR), which is a non-parametric approach. This approach has the characteristics of combining Quantile Regression (QR) with non-parametric estimations. QQR has several advantages over Ordinary Least Squares (OLS) in overcoming limitations. First, this approach deals with the distribution of multivariate data, to generate unbiased outcomes. Second, many researchers widely employ this methodology because it provides more effective and generalizable results. Third, this approach is the modified form of QR, which examines the impact of different explanatory variables on exploratory variables at various levels of quantiles to overcome the limitation of the QR approach (Chang et al., 2022; Hung et al., 2022). Additionally, this approach provides the best insight into the surface relationship between explanatory and exploratory variables. Further, it focuses on the conditional quantile of explanatory variables, something that is missing in the traditional QR approach. More specifically, this approach examines the quantiles of the dependent variable against the quantiles of the independent variable, showing how the variables respond to one another in different market conditions (bearish, bullish, normal). Further, this method also considers the time-varying examination of exploratory variables across various quantiles (Sim & Zhou, 2015).

To summarize, QQR is specifically suitable for estimating series that show non-linearity and non-normality, unlike simple OLS (that is suited for linear series) and QR (that is suited for non-linear series but only considers quantiles for exploratory variables), as explained by Arshad et al. (2024). More specifically, QQR considers the heterogeneous relationship between the series, and as this approach considers how a specific quantile of explanatory variable effects a specific quantile of exploratory variable, this technique is more suited for a non-linear and non-normal estimation (Arshad et al., 2024). Additionally, techniques like Generalized Methods of Movements (GMM), and VAR do not capture asymmetric and quantile-dependent effects, that are effectively captured by QQR (Arshad et al., 2024).

[2] https://www.policyuncertainty.com/oil_uncertainty.html

[3] Abiad & Qureshi (2023) construct a new measure for OPU using textual analytics techniques, authors use data available in newspapers to construct their index.

The following estimations empirically demonstrate QQR's superiority over traditional estimation approaches like simple OLS and QR. Further, following the approach of earlier studies, the simplest form of the equations becomes:

$$Y_t = \beta^{\theta}(X_t) + \varepsilon_t^{\theta} \ldots \text{Equation (1)}$$

Where in **Equation (1),** θ shows the θth quantiles distribution of an explanatory variable. Where Y_t shows the dependent variable of the study. Where ε_t^{θ} shows the disturbance term of the respective quantile. Similarly, β^{θ} shows the unknown linkage between explanatory and exploratory variables because the relationship is not known. Therefore, considering these issues, Cleveland (1979) proposed the Taylor-expression of $\beta^{\theta}(.)$ around the X^{θ}. Hence, following this, the linear function is written as follows:

$$\beta^{\theta} \approx \beta^{\theta}(X^{\tau}) + \beta'^{\theta}(X^{\tau})(X_{\tau} - X^{\tau}) \ldots \text{Equation (2)}$$

Where in **Equation (2),** β'^{θ} shows the derivative (partial) of $\beta^{\theta}(X^{\tau})$. While $\beta^{\theta}(X^{\tau})$ shows the partial impact. Where $\beta^{\theta}(X^{\tau})$ and $\beta'^{\theta}(X^{\tau})$ exhibits the function of θ and τ respectively. Inspired by the approach of Shahbaz et al. (2018), this study employs QQR to investigate the impact of different quantiles of OPU on the conditional quantiles of selected sectoral returns.

The QQR is formulated as follows:

$$R_i = \beta^{\theta}(OPU) + \alpha^{\theta} r_{i-1} + \mu_i^{\theta} \ldots \text{Equation (3)}$$

Where, in **Equation (3),** Ri represents the sectoral returns at time 'i' and 'OPU' denotes a global measure of uncertainty related to oil price volatility. The β^{θ}coefficient measures the degree of change in the market's return with a change in OPU. The symbol θ indicates that this relationship can vary across different quantiles of the OPU distribution, meaning the impact of OPU on returns might differ at varying levels of uncertainty. The term $\alpha^{\theta} r_{i-1}$ is a lagged term, where r_{i-1} represents the market's return at the previous time (i-1). The inclusion of lagged terms is quite critical in the model, as it captures momentum effects and assesses how past market conditions influence sectoral returns. The α^{θ} show the relationship between the market's current return and its lag value, suggesting that this relationship can vary across different quantiles of return. The term μ_i^{θ} is the quantile error term where the conditional θth quantile is zero.

Additionally, before employing the QQR approach, which is suited for a non-linear and non-normal distribution of series, we test the sectoral returns and OPU index values for three features: (1) normality (tested through Jarque and Bera (1980)), (2) linearity (tested through Broock et al. (1996)), and (3) stationarity (tested through Dickey and Fuller (1981)). Once these tests show the suitability of the QQR approach, we proceed with performing the estimations explained in **Equations (1)** to **(3)** above.

4 | RESULTS and ANALYSIS

4.1 | Descriptive statistics, diagnostic tests, and correlations

Table 1 shows the summary of the descriptive statistics and diagnostic tests performed on the variables. The table shows that the mean value for OPU is 106.38, whereas the returns for the selected five sectors remain relatively stable when considering the dispersion in terms of standard deviation. Values of skewness and kurtosis show evidence of non-normality between the variables, which is further tested through the BDS Test. Considering the nature of the distributions, the Automobile and Assemblers and Power and Distribution

sectors show a positively skewed distribution, whereas oil and Gas and Chemicals sectors show a left-tailed distribution, implying a likelihood of large negative values in these sectoral returns.

Additionally, **Table 2** shows the correlation coefficient of each of the selected five sectors with OPU. The table shows that none of the selected five sectors show a statistically significant correlation with the OPU index. However, as correlation is a linear measure that does not consider other factors that a regression analysis does (for example, regression assumes a stochastic process), we proceed with the estimation of our models under QQR for deeper (non-linear and asymmetric) insights.

Considering the three diagnostic tests performed, the variables do not show the problem of stationarity (tested through the Augmented Dicky Fuller (ADF) Test). However, all variables (except returns of the Chemicals sector, which shows linear distribution) show the problem of non-normality and non-linearity. The results of these three tests advocate for the use of the QQR approach, as it is designed to account for non-linear and dynamic relationships between two series (Arshad et al., 2024). **Figure 1** plots the price and return series of the five sectors on a line chart, as well as the OPU trend over the sample period.

Table 1

Descriptive statistics and diagnostic tests

	OPU	Auto	Cement	Oil	Power	Chemical
Obs	174	174	174	174	174	174
Mean	106.3809	0.0214	0.0172	0.0091	0.0165	0.0122
St.Dev.	61.0474	0.0827	0.0890	0.0727	0.0712	0.0747
Max	364.2255	0.3485	0.3523	0.2956	0.2482	0.1737
Min	18.2953	-0.2267	-0.1773	-0.3180	-0.2215	-0.4398
Skew.	1.4967	0.9187	0.4858	-0.3590	0.7633	-1.6571
Kurt.	3.0400	2.8376	0.7022	4.0498	1.8556	9.0490
Jarque-Bera	126.7413 (***)	78.2118 (***)	9.8867 (***)	114.0129 (***)	39.5666 (***)	635.5658 (***)
ADF	-5.3554 (***)	-6.0907 (***)	-3.7721 (***)	-14.2721 (***)	-12.5764 (***)	-12.3309 (***)
BDS	7.5304 (***)	1.9729 (**)	2.1300 (**)	4.04112 (***)	3.0568 (***)	0.6009

Note: This table displays the summary descriptive statistics of the sectoral returns and OPU index and results of the three diagnostic tests (normality (Jarque-Bera), linearity (BDS), and stationarity (ADF)). Here, 'Obs' means observations, 'St.Dev.' means standard deviation, 'Skew.' means skewness, and 'Kurt.' means excess kurtosis. Additionally, (***), (**), and (*) displays significance levels at 1%, 5%, and 10%, respectively.
Source: Author

Table 2

Correlation

Sector	Correlation	P-value
Automobile and Assembler	-0.08191	0.28262
Cement	-0.00272	0.9716
Oil and Gas	-0.07687	0.31337
Power and Distribution	0.0032	0.96657
Chemicals	-0.04782	0.5309

Note: This table shows the correlation of each of the five sectors with OPU.
Source: Author

4.2 | Findings

Here, we present the findings for each of the selected sectors one by one and provide a discussion on the results received from Figure 2 later in section-5. At this stage, it is also important to highlight that, as explained by Saeed Meo et al. (2023); Shahbaz et al. (2018); and Sim and Zhou (2015), the lower quantiles of both sectoral returns and OPU reflect the bearish market, the higher qualities of both sectoral returns and OPU reflect bullish market, and the median quantities of both sectoral returns and OPU reflect normal market conditions.

Focusing first on the Automobile and Assemblers (Auto, for short) (**Figure 2**, **Panel A**), in bearish market conditions, OPU shows an overall negative and statistically significant association with the Auto market returns. The same is true for normal conditions as well. However, in bullish market conditions, the association is not universally negative. Here, the association shifts from positive to negative as we enter higher quantiles of OPU. It is also important to highlight that the association of OPU at lower quantiles becomes insignificant on higher quantiles of the Auto sector return in Pakistan. Additionally, if we consider the higher quantiles of OPU with lower quantiles of the Auto sector returns, interestingly, the association is mostly positive. Indicating that in this section of quantiles, an increased OPU improves sectoral returns for the Auto sector. This dynamic and asymmetric relationship can be explained using economic, financial, and behavioral aspects (Section-5).

Moving to the second sector, Cement (**Figure 2**, **Panel B**), the results are quite different from the Auto sector. Here, in the bearish market, OPU overall shows a positive association with Cement sector returns. In normal market conditions, this association changes to a negative one. However, in a bullish market, the relationship mainly stays statistically insignificant. Interestingly, the association of OPU at higher quantiles remains positive with the Cement sector returns at lower quantiles, consistent with the behavior demonstrated by the Auto sector.

Shifting the focus on the third sector, Oil and Gas (Oil, for short) (**Figure 2**, **Panel C**), the results are, more or less, similar to the Auto sector. In the bearish market, the OPU and Oil sector show a negative association, consistent with the findings of Sim and Zhou (2015). This association stays negative in normal market conditions as well. However, partially aligned with the findings of the Auto sector, in a bullish market, the association turns positive. Additionally, inconsistent with the findings observed for the Cement sector, the association remains statistically significant. Additionally, at extremely higher quantiles of OPU but at lower quantiles of Oil sector returns, the association majorly remains positive. To summarize, the results of the Oil sector mainly align with the Auto sector but significantly differ from the findings of the Cement sector.

Moving on to the fourth sector, Power and Distribution (Power, for short) (**Figure 2**, **Panel D**), the impact of OPU on the Power sector returns remains relatively consistent in all three market conditions, bearish, normal, and bullish. The association between OPU and the Power sector remains negative in all these three market conditions. Although inconsistent with the findings of Sim and Zhou (2015), these findings align with the work presented by (Abiad & Qureshi, 2023).

Finally, focusing on the Chemicals sector (**Figure 2**, **Panel E**), the response shown by the Chemical sector is even more consistent than the Power sector. Here, all three market conditions again demonstrate a negative association with OPU. Additionally, unlike the Power sector, the association remains negative at both extremes of quantiles of one variable, with the lower quantiles of the other variable (that is, higher quantiles of OPU and lower quantiles of Chemical sector returns, and vice versa). Additionally, another interesting insight from this sector is that the association of OPU with the sector returns remains the same across all quantiles against the lower quantiles of OPU.

5 | DISCUSSION

5.1 | OPU and Automobile and Assemblers Sector Returns

Considering the impact of OPU on the Auto sector, the results of bearish and normal market conditions are relatively easier to explain, as higher OPU negatively impacts the Auto sector returns, showing risk and uncertainty are reflected inversely in the asset prices by the market. This provides evidence of risk aversion, which is consistent with the findings of Ilyas et al. (2021). However, the relationship in a bullish market is not so simple. At relatively lower OPU quantiles, the Auto sector benefits, demonstrating relatively stronger economic conditions for the Auto sector, despite OPU. Furthermore, this association again turns negative at extremely high quantiles of OPU, consistent with our theoretical expectations and earlier literature (for example, the findings of Śmiech et al. (2021)). Additionally, the statistically insignificant association at lower quantiles of OPU and higher quantiles of the Auto sector shows that this sector remains strong regardless of market sentiments. In higher quantiles of the Auto sector returns and low OPU periods, the performance of the Auto sector is driven by other market- and industry-related factors. These findings partially align with the notions of Alao and Payaslioglu (2021). Finally, the positive association of higher quantiles of OPU and lower quantiles of Auto sector returns is most interesting. We link these findings to two possibilities, first, this relationship shows a defensive shift in investment portfolios from a behavioral perspective. Investors may be motivated to shift funds to perceived undervalued assets at times of high uncertainty due to oil prices. Second, government intervention may also help explain this arguably 'abnormal' behavior of the market, where subsidies and government intervention are used to help ease market conditions, something also argued by Song et al. (2022).

5.2 | OPU and Cement Sector Returns

Unlike the Auto sector, where in the bearish market OPU demonstrates a negative association with sectoral returns, in the Cement sector this association is positive. These findings are inconsistent with the earlier findings of Sim and Zhou (2015), who show that markets may perform under high OPU, but this holds if the market is performing well already, at least in the US economy. However, we link these contrasting findings with the market demand and sectoral needs. The cement industry is heavily reliant on public infrastructure projects. Considering the notions set forth by McCartney (2022), we identify the China-Pakistan Economic Corridor (CPEC) and similar infrastructure development projects as the key factors offsetting the negative impact of OPU in a bearish market. This shows that infrastructure development projects stabilize the negative impacts of OPU on the Cement sector, as it shows higher reliance on economic development projects than uncertainty in oil prices. However, moving on to the negative association of OPU and the Cement sector

returns in normal market conditions, we highlight that the negation impact of CPEC and similar projects gets dominated by the prevailing uncertainty due to oil prices at median quantiles (or normal market conditions).

Referring to the insignificant impact of OPU on the Cement sector returns in a bullish market, the primary reason highlighted for these inconsistent findings is market optimism. Our findings show that as the market shifts from normal (median quantities) to bullish (higher quantities), market sentiment and confidence start negating the negative impact of OPU on sectoral returns. As such, we document that for the Cement sector, the impact of OPU shifts from positive to negative from bearish to normal market conditions, where we identify the ability of development projects to negate the adverse impact of OPU become overshadowed by uncertainty as quantiles rise. However, when the market shifts from normal conditions to bullish, market confidence starts negating the adverse impact of OPU on sectoral returns.

5.3 | OPU and Oil and Gas Sector Returns

The association demonstrated by OPU and the Oil sector is consistent with the theoretical expectations and earlier literature, for example, our findings confirm the notions of Khan et al. (2023) in this sector's response as well. The bearish market usually concurs with an economic downturn, as highlighted by Abiad and Qureshi (2023), explaining the negative association of OPU and Oil sector returns. This association remains negative at normal market conditions, demonstrating a strong impact of OPU on the Oil sector in Pakistan, consistent with the findings of Ilyas et al. (2021) and Śmiech et al. (2021). The association of OPU and the Oil sector becomes positive a bullish market, demonstrating a strong reliance of the Pakistani economy on the oil and gas sector. Additionally, this also demonstrates that the higher OPU attracts speculative investments from a behavioral perspective, where the market anticipates that higher global oil prices will translate into higher returns from the Oil sector, as highlighted by Ilyas et al. (2021). Additionally, the Oil sector remains persistent as compared to the Cement sector, showing that the Oil sector primarily depends on oil as its main input and output, as such OPU remains its primary driver in terms of returns. However, as the Cement sector depends on infrastructure and development projects, it can better hedge OPU as compared to the Oil sector.

Finally, the positive association of OPU at higher quantiles with lower quantile Oil sector returns, suggests the possibility of market bottoming and rebound effects. That is, the investors may expect price recovery in the long term, with increased OPU and lower returns in the Oil sector, as highlighted by Abiad and Qureshi (2023). This relationship may also be explained from a speculative perspective. Investors may prefer taking long positions in such market conditions (or holding their investments despite uncertainty in the market), as these may indicate an underpricing of the Oil sector, where due to higher OPU, investors expect the prices to rise, increasing the value of their investment in the future.

5.4 | OPU and Power and Distribution Sector Returns

Our findings identify a unique role of the Power sector in the Pakistani economy. Unlike the Auto, Cement, and Oil sectors that display a rather complex association with OPU, the Power sector displays a relatively consistent impact across the three market conditions. These findings show a high reliance on the energy generation of Pakistan on oil, as highlighted by Kanwal et al. (2022). Additionally, strict regulations regarding power sector pricing can be seen as another reason why the Power sector results show no resilience and adaptation to OPU over all three market conditions. It is important to take note that external intervention

through market expectations and sectoral dependencies is possible (for example, in the case of the Cement and Oil sectors, which demonstrate flexibility to the negative impact of OPU across varying market conditions). However, in the case of the Power sector, a strict regulatory environment renders the sectoral response rather rigid, as discussed by Necoechea-Porras et al. (2021).

5.5 | OPU and Chemicals Sector Returns

Although the Chemicals sector is, arguably, just as dependent on oil as the Auto sector and Cement sector, however, it shows less resilience to OPU as compared to these two markets. As such, the study refrains from using the explanation of higher input costs for this sector as the primary reason for the negative association of OPU with this sector's returns. However, our findings do indicate that this sector shows the problem of limited cost pass-through capability when compared with the Auto sector and Cement sector. Similarly, unlike the Oil sector which may benefit from underpricing and speculative aspects of investment, this sector does not demonstrate such prospects relating to the OPU. Finally, the Chemicals sector is also not as strictly regulated as the Power sector, as such, the reasons for the Power sector cannot be replicated here for the possible explanation for the consistent negative impact of OPU.

Nonetheless, the association remains consistently negative across all quantiles for OPU and the Chemicals sector return. We highlight structural characteristics and unique supply chain aspects associated with this sector as the reason for such a highly rigid response of this sector to the OPU. The OPU disrupts production for this sector, impacting the overall sector stability. As such, this sector displays the least potential for hedging in an uncertain environment regarding oil prices. More specifically, the Cement sector is inherently raw material-intensive, relying on crude oil, making this sector structurally dependent on oil-based inputs. Further, the relatively inelastic supply chain of the Chemicals sector (that is, having long production cycles), makes this sector relatively more rigid than other sectors like Auto.

5.6 | Summary of the Discussion

To summarize, our findings show drastic differences between the responses of the five sectors selected for the examination under the OPU. While some sectors show a non-linear and quantile-dependent relationship with OPU, others display a relatively consistent trend across the three market conditions (bearish, normal, and bullish). Where the Auto sector demonstrates a shift from a negative to mixed association between sectoral returns and OPU, the Cement sector reveals a gradual positive to negative impact across the three market conditions. Contrastingly, the Oil sector shows a shift from a negative to a positive association between OPU and sectoral returns in the bullish market. The Power sector and the Chemicals sector both show a consistent negative association between OPU and the respective sectoral returns. We highlight high regulations as the key reason for this in the Power sector, and supply chain disruptions caused by OPU in the Chemicals sector. Additionally, our findings advocate for the potential for the Auto and Cement sectors to hedge against the adverse impact of OPU. Similarly, the Oil sector shows the highest potential for speculative gains under different market conditions. The following table concisely displays this summary for clarity.

Table 3

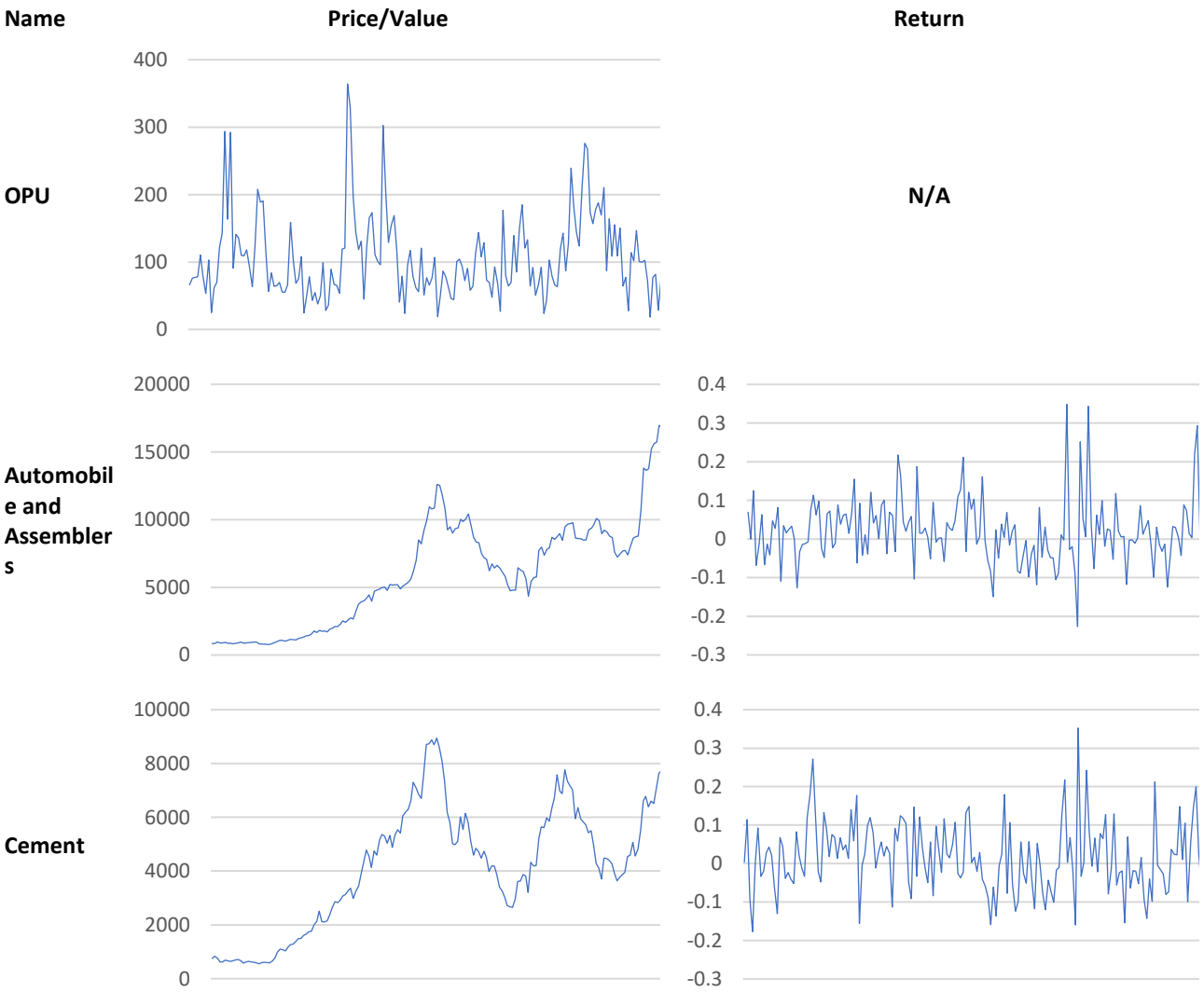
Summary of the findings

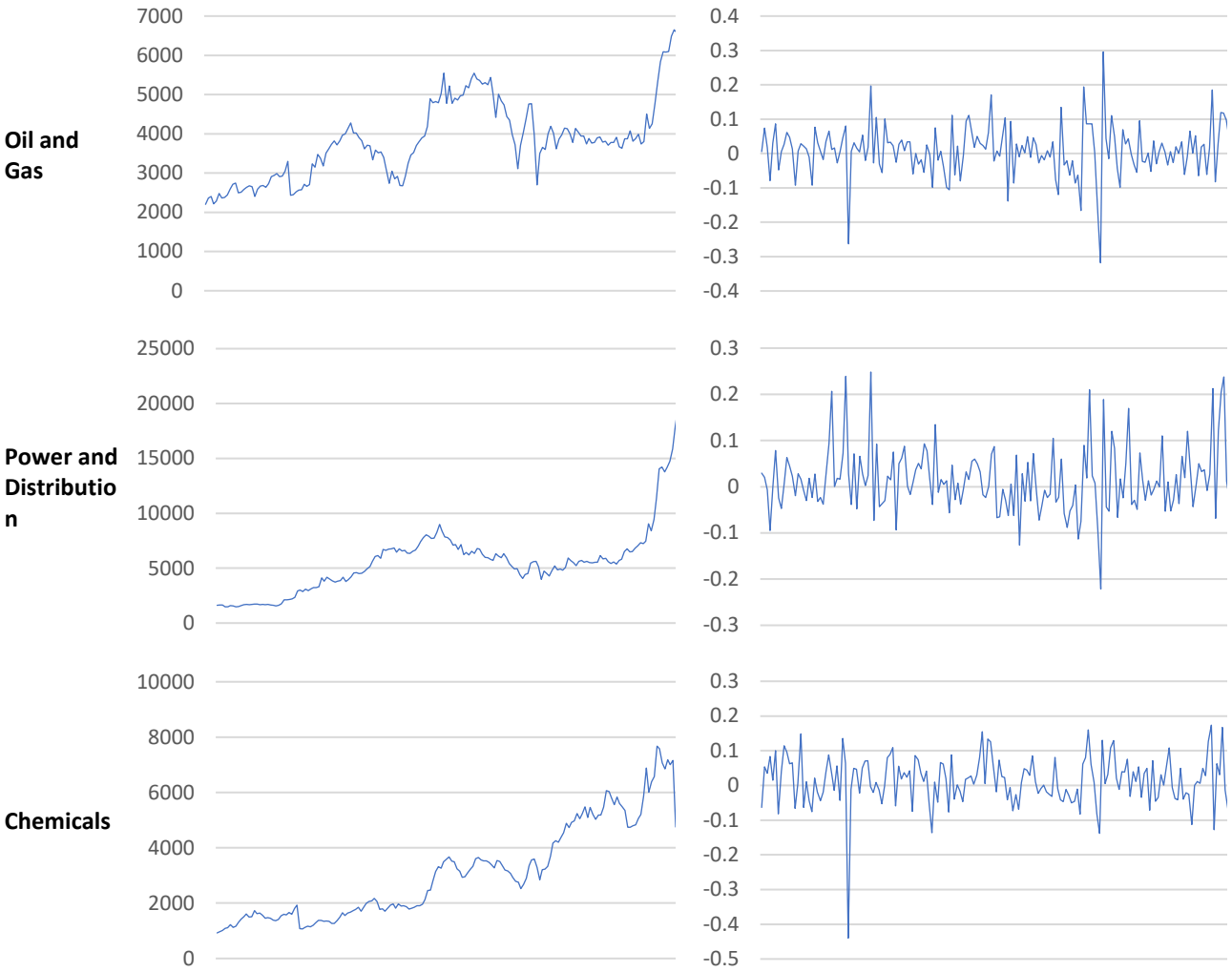
Sector	Bearish market	Normal conditions	Bullish market
Automobile and Assemblers	Negative	Negative	Mixed (shifts from positive to negative)
Cement	Positive	Negative	None (Insignificant)
Oil and Gas	Negative	Negative	Positive
Power and Distribution	Negative	Negative	Negative
Chemicals	Negative	Negative	Negative

Note: This table displays a summary of the findings across the five sectors and the three market conditions.
Source: Author

Figure 1

Return and price series of the sectors and OPU trend

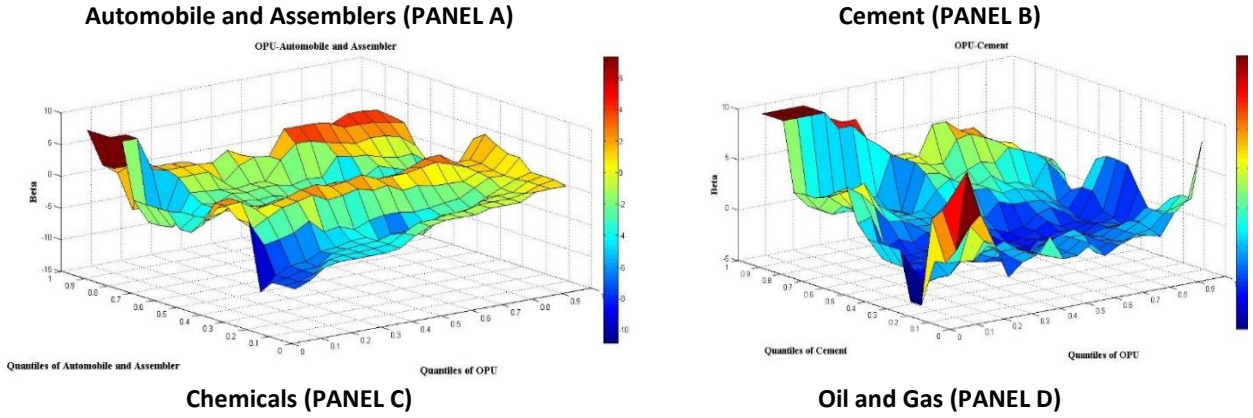


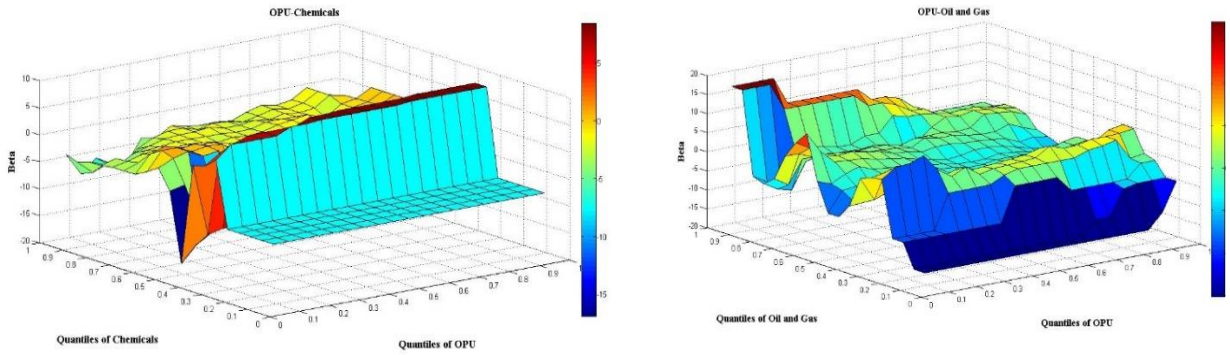


Note: This figure shows the price and return series of the five sectors and the OPU trend as a line chart. The x-axis for all the charts displays the sample period.
Source: Author

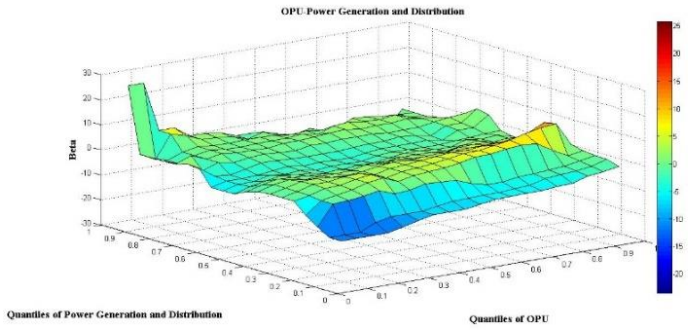
Figure 2

QQR charts





Power Generation and Distribution (PANEL E)



Note: This figure shows the QQR 3-D surface plots.
Source: Author

5 | CONCLUSION

The current study investigates the sectoral dependencies in Pakistan due to OPU. For this, we select five energy-dependent sectors in Pakistan (Automobile and Assemblers, Cement, Oil and Gas, Power and Distribution, and Chemicals) and use the QQR approach to examine the non-linear and quantile-dependent relationship between OPU and the selected sectoral returns. The QQR approach helps decipher the association between these variables in the bearish, normal, and bullish market conditions. Our findings reveal that the response of different sectors to OPU varies in terms of their nature and market conditions. Auto and Oil sectors display a negative association with OPU in both bearish and normal market conditions. However, in bullish market conditions, this relationship becomes positive. The Cement sector, on the other hand, displays a positive relationship with OPU in a bearish market but transitions to a negative association in normal conditions. These findings show hedging potential in the Cement and Auto sectors. The Power and Chemicals sectors both display a consistent negative association with OPU in all three market conditions. These findings show a speculative potential in the Oil sector. Overall, our findings show evidence that different sectors are affected by OPU differently, as different factors show a potential impacts on their association. For example, as the Cement sector shows reliance on other factors like development projects, it shows a hedging potential in times of higher OPU. Additionally, as the Oil sector's primary input is oil, in highly uncertain times, the market sees this as a potential investment opportunity, thus, high OPU at lower quantiles of Oil sector returns show a positive association.

From a theoretical perspective, our study extends the available literature on OPU effects across different market conditions by focusing on a frontier market (that is, Pakistan). Our findings also hint towards the relevance of behavioral aspects in sectoral returns. For example, a positive association of higher OPU at lower return quantiles of the Oil sector shows positive market sentiments despite higher uncertainty. From a practical perspective, our findings have implications for investors, policymakers, and practitioners. Our findings show that sectoral risk exposure should be managed differently across different market conditions, considering the nature of the industry. Additionally, diversification strategies need to account for non-linear and quantile-dependent relationships when considering OPU and sectoral returns. Similarly, hedging strategies for OPU need to be tailored based on the sectors and the market conditions. For policymakers, a focus on the Power sector warrants their attention in Pakistan. As this sector consistently displays a negative association with OPU across all market conditions, government inventions are needed to stabilize this sector under different OPU quantiles. Given Pakistan's reliance on fossil fuels for power generation, uncertainty induced by oil price volatility poses a significant risk to economic stability. Our findings show recommendations for dynamic pricing models for the Power sector, to help improve the flexibility of this sector.

Finally, as with all studies, despite providing newer insights, the current study suffers from certain limitations, which can provide avenues for future research. First, the study restricts the scope to five sectors for focus and clarity. Future research may examine other relevant sectors to assess their interdependencies due to OPU or other macroeconomic uncertainties (for example, the sectors excluded from the sample, as highlighted in Section 4.1.). Second, our study focuses on the market of Pakistan, therefore, there is a potential for lack of generalizability of the findings of the current study to other countries or markets with different economic conditions. As such, future studies may target other prominent emerging and frontier markets to further widen the available literature (for example, focus on BRISC markets may reveal interesting insights on how sectoral returns of emerging markets react under OPU). Finally, our study applies the QQR approach that remains silent on causal relationships, future studies may use other approaches that can examine the causality across sectoral returns and OPU for deeper insights.

Acknowledgment: The authors would like to express their sincere thanks to the editor and the anonymous reviewers for their helpful comments and suggestions.

Author Contributions: Conceptualization, O.S., N.K., and M.S; methodology, O.S., and M.S; software, N.K; validation, N.K., and O.S; investigation, O.S., and N.K.; data curation, M.S.; writing original draft preparation, O.S., N.K., and M.S.; writing—review and editing, N.K., and O.S. All authors have read and agreed to the published version of the manuscript.

Declaration of Conflicting Interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding: The author(s) received no financial support for the research, authorship, and/or publication of this article.

Data Availability Statement: Data that supports the findings of this study are available on request from the corresponding author.

Plagiarism Statement: This article was scanned by the plagiarism program. No plagiarism was detected.

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