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# Relationship between Oil Price and White Precious Metals Return: New Evidence from Quantile-on-Quantile Regression

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**Abstract**

The present study examines the effects of oil price on white precious metal returns by using quantile-on-quantile regression proposed by Sim and Zhou (2015). In this study, we mainly focus on the returns of three white precious metals, which include palladium, silver, and platinum. The study is conducted on the monthly data of crude oil price and white precious metals from the period of January 2000 to December 2016. We use QQR approach to capture the complete picture of the studied relationship. Unlike conventional techniques, QQR provides the comprehensive results of the variables at distinct quantiles.

Similarly, the ARDL technique has also been used. Results reveal that the change in global oil price increases the returns of platinum and palladium. Whereas, an insignificant relationship has been found between the oil prices and silver returns. Results indicate that palladium and platinum both precious metals act as a safe haven for investors. In contrast, change in oil prices will not lead to high silver returns. Therefore, investors need to be prudent while investing in silver. These results have important policy implications for policymakers and investors.

**Keywords:** platinum, silver, palladium, quantile on quantile approach, oil price.

## 1. Introduction

Since the global financial crisis of 2007-2008, commodity markets have become more volatile due to the increased financialization. Political turmoil, global inflationary pressure, new financial innovations, and extreme weather conditions are some factors that affect commodity markets in recent years. Due to the financialization, the awareness of commodities, especially precious metals as an investment tool, has been increased vastly. This rapid increase is due to the following reasons; first, precious metals like silver, palladium, and platinum play a key role in the management and portfolio selection.

Investors have more faith in commodity markets as compared to the derivative markets because metals act as a best hedging tool against inflation (Nissanke, 2012). It is observed that precious metals are liquid, and the prices are more volatile. After the rapid increase in financial activities, precious metals such as palladium, platinum, and silver are perceived as a safe investment opportunity for investors (Lucey & Li 2015). Other than investment, these metals are also used in the production of industrial commodities; for instance, they are used to manufacture jewelry and industrial products, such as automotive parts and chemical-related products.

In recent times, the utilization of these white precious metals has also been observed in the financial sector. An investor uses precious metals as a hedging tool to mitigate risk as well as for commodity diversification. Increasing pressure of inflation and inflationary expectations compel investors to invest in white precious metals and avoid risks. According to the historical data, investors prefer to allocate 20% to 30%, specifically in white precious metals. It is also noticed that the majority of the investors prefer to allocate high investment in silver as compare to the palladium and platinum. Most importantly, platinum and palladium both precious metals are more considered as an inflation hedging tool for a long period. It is because platinum and palladium are less volatile and liquid precious metals, among others (Caporin et al., 2015).

Due to the growing importance of commodity markets, several researchers have gained interest in the fluctuations of commodity prices and their relationship with the macroeconomic factors. Recently, numerous studies have been conducted that investigated the dynamic role of white precious metals and its volatility. Many studies have also found that examined the association of oil prices shocks, and white precious metals with the macroeconomic factors, such as inflation, exchange rate, etc. (Lau, Vigne, Wang & Yarvoya 2017; Behmiri and Manera 2015; Jain & Ghosh 2013; among others). In addition, the academic literature has also revealed that precious metal returns significantly affect the oil prices fluctuations. However, scarce literature found that explored the reverse relationship of oil price and white precious metals. This study fills the gap by examining the effects of oil price on the returns of precious metals, such as platinum, palladium, and silver.

White metals have traditionally been considered as a precious metal that was generally used for production purpose in different industries and not used as an investment vehicle. However recently, white precious metals have increased the attention of investors and they are diversifying their investment towards platinum, silver, and palladium than investing in stocks, bond, real estate, etc. The white precious metal has been considered as a store of wealth and in the times of instability in oil prices, they have been seen as a safe haven. In addition, these white precious metals will have instinctive value due to their finite and tangible resources. This gives white precious metals exclusive leverage as well as great benefits for investors. It seems that white precious metal has an exclusive or unique feature of investment, but few research explored the association of oil price with white precious metal. Therefore, this research is motivated to explore the linkage between oil price and precious metal returns. The findings of the present paper will be useful for investors who prefer to invest in commodity markets because it will provide useful and comprehensive information related to oil price and precious metal returns.

*1.1 Contribution*

More precisely, the purpose of the present study is to examine the effects of oil price on the returns of platinum, silver, and palladium. Our paper contributes to the existing body of literature in several ways. First, this study examines the reverse relationship between oil prices and white precious metals. Second, this paper provides useful and comprehensive insights to investors by running a novel QQR approach to quantify the complex relationship of oil price and white precious metal returns. Finally, an ARDL approach is also used to obtain long and short-run effects of oil price on precious metals.

The remaining paper is organized as follows. In section 1, we introduce the variables, discuss the background and problem, and state the objectives. In section 2, the existing studies on oil prices and white precious metals are reviewed. In section 3, the methodology and the method to attain the objective are discussed. In section 4, the estimation of QQR regression and ARDL approaches are reported, and finally, in the last section, we conclude the study by giving some policy implications and directions to future researchers.

## 2. Related Literature

Over the past few years, a debate regarding the white precious metals as an investment tool has gained increasing interest among investors and policymakers. Traditionally, precious metals, particularly platinum, silver, and palladium were viewed as a metal used for production. However, recently, it has been evolved as an important investment vehicle for investors. The current empirical literature is mainly categorized into two broad streams; the first stream focuses on the co-movement of oil price and precious metals, such as gold. The second stream reviews the literature focuses on the oil price shocks and precious metal volatility.

A plethora of studies explained the linkage of precious metals and oil price. The time-varying and persistent co-movement of precious metal prices with the oil prices are of great interest to investors. Changes in global oil price and metal prices are the crucial issues in econometric literature. Similarly, Jain and Biswal (2016) contend that gold has now emerged as an investment tool for investors. However, the returns of gold have an asymmetric effect of oil price shocks (Tiwari & Sahadudheen, 2015). It is also noticed that the co-movement of gold and oil prices is positive specifically in the crisis period (Baruník et al., 2016).

Other than gold, silver, platinum, and palladium have also gained the attention of the investors in recent times. Silver, which is the oldest financial asset sometimes used as a currency, whereas, palladium and platinum both are metals used for production purpose and nowadays for portfolio management. In previous studies, it is observed that oil price shock has a positive or negative relationship with the palladium, which means that negative or positive oil price shock increased the palladium volatility. The study of Plourde and Watkins (1998) noted that the silver price is less volatile than the price of oil. Oil and silver both have a bidirectional relationship, whereas the link between platinum returns and oil price is weak (Sari et al., 2010).

Similarly, the oil price has an outsize effect on industries, global geopolitics, and growth of the economies. However, Hammoudeh and Yuan (2008) noted that oil price shocks have the effect of calming on precious metals volatility; it is considered as a good diversifier in commodity markets. So white metals are classified as precious and would be used in portfolio construction. Balcilar et al. (2015) examine the transmission mechanisms between the spot price of oil and the precious metal (i.e. silver, platinum, palladium and gold) and also investigating their interaction with the exchange rate (US dollars/ euro) by using time series data. By using Hetroscedasity (ARCH) test, a result indicating the highest standard deviation between oil and palladium because oil is a primary energy source and massively used in the production whereas palladium has a low volatility due to the lower industrial use.

The latter stream focuses on the body of literature related volatility and oil price shocks. Behmiri and Manera (2015) examine the outlier as well as oil prices shock on the volatility of different metal prices. By using the EGARCH models, results indicated that volatility of industrial metal that contain fruitful information for future price volatility. It is also indicated that all metals are in non-negative condition. Results showing that for all precious metals the effects of current and past volatility are greater than the effects of past oil price shock on current volatility. In a similar study, Reboredo and Ugolini (2016) examined the impact of oil price fluctuations metals prices volatility. Using Copulas model, the dependence of oil price on the returns of precious metals (platinum, aluminum, gold, and silver) has been quantified. It is revealed that in the period of crises low average dependence has been noticed. Results also show that the upwards oil prices and downwards oil prices movement had a spillover effect on the metals market, before as well as after the outbreak of crises.

In the same way, Charlot and Marimoutou (2014) investigated the relationship of prices of oil and precious metals using time series data prevailing from the year 2005 to 2012. By using Hidden Markov model, the relationship has been estimated. They found bidirectional causality between silver and oil and unidirectional causality between platinum and oil price. Moreover, Sari et al. (2009) investigating the dynamics of oil prices, precious metal prices and exchange rate. Daily time series data has been used five days (working) per week. It is concluded that the result that initial impact of prices of platinum, silver, and palladium on oil prices is significant as well as positive but the results of palladium and silver die out by the second day but after some horizon this result again significant and positive. Precious metal commodities and oil have distinct fundamentals in the country that hoards low silver trade and ill liquidity. However, silver markets are only temporally determined by a mutation in each other and global oil prices (Sayota et al., 2009).

## 3. Methodology

In this section, we briefly describe the main features of quantile-on-quantile approach by (Sim & Zhou, 2015) as well as the model specification used in the study to examine the relationship between oil price shocks and white precious metals. In addition, we also discuss about the data and its sources.

The QQR method can be viewed as an extension of the conditional quantile regression, which allows one to examine the quantile effect of a regressor on the quantile of a

response variable. This approach is based on the combination of nonparametric estimation and quantile regression. The nonparametric estimation (local linear regression) is proposed by Cleveland (1979) and Stone (1977), normally used to estimate the local effect of a specific quantile of the independent variable onto the dependent variable. Local linear regression is used to avoid the curse of dimensionality problem usually occurs in the nonparametric models. However, the conditional quantile regression perceived as a broader form of linear regression introduced by Koenker and Bassett (1978). Unlike the standard linear regression, QR is utilized to estimate the effect of the independent variable onto the different quantiles of the dependent variable. Therefore, the combination of these two approaches enables to model the relationship between the quantiles of the independent variable and the quantile of the dependent variable. This novel approach provides a greater amount of information about the complex relationship between variables compared to conventional techniques such as OLS and standard quantile regression. In recent times, the importance of QQ approach has been particularly observed in the field of economics and finance. This approach is mainly found effective and give consistent results when the relationship is complex. Numerous studies have conducted in the recent past that used this novel approach to estimate the asymptotic relationship between variables (for instance: Shahzad et al. , 2017; Shahzad et al., 2017b; Sim and Zhou, 2015). Following is the basic equation of non-parametric quantile-on-quantile regression approach;

$$WPM_t = \beta^{\theta}(OP_t) + u_t^{\theta} \text{ ---------- (1)}$$

Where the $WPM_t$ denotes as returns of white precious metals. In this study, we have used three different types of white precious metals for a specific time period *t*, such as, palladium, platinum, and silver. $OP_t$ signifies as the global crude oil price used for a specific time period *t*. $\beta^{\theta}$ denotes as an unknown parameter because we have no prior information related to the relationship of crude oil price and white precious metal returns. Whereas, $\theta$ is the $\theta th$ quantile of the conditional distribution of the white precious metals and $u_t^{\theta}$ is the quantile error term.

To assess the impact on the $\theta th$ quantile of global crude oil price on the $\tau th$ quantile of white precious metals return, expressed as, $WPM^{\tau}$, the equation-1 is further categorized in to three different equations as silver, palladium and platinum. So equation (1) can further be transformed as following:

$$\beta^{\theta}(Silv_t) \approx \beta^{\theta}(Silv^{\tau}) + \beta^{\theta'}(Silv^{\tau})(Silv_t - Silv^{\tau}) \text{ -------- (i)}$$

$$\beta^{\theta}(Plat_t) \approx \beta^{\theta}(Plat^{\tau}) + \beta^{\theta'}(Plat^{\tau})(Plat_t - Plat^{\tau}) \text{ ------- (ii)}$$

$$\beta^{\theta}(Pallad_t) \approx \beta^{\theta}(Pallad^{\tau}) + \beta^{\theta'}(Pallad^{\tau})(Pallad_t - Pallad^{\tau}) \text{ ------ (iii)}$$

Here, $\beta^{\theta'}$ is the partial derivative of $\beta^{\theta}(Silv_t)$, $\beta^{\theta}(Plat_t)$ , $\beta^{\theta}(Pallad_t)$ with respect to silver, platinum and palladium and can be viewed as marginal response. These can be interpreted as the slope of standard linear regression models.

The above equations (i, ii & iii) has the main advantage is that the slopes of $\beta^{\theta}(Silv^{\tau})$ and $\beta^{\theta'}(Silv^{\tau}), \beta^{\theta}(Plat^{\tau})$ and $\beta^{\theta'}(Plat^{\tau}), and\ \beta^{\theta}(Pallad^{\tau})$ and $\beta^{\theta'}(Pallad^{\tau})$ are the functions of $\theta\ and\ \tau. \theta\ is\ a$ function of crude oil price and $\tau$ is a function of silver,

platinum and palladium. Thus, the equations i, ii & iii can be changed as $\beta_0(\theta,\tau)$ and $\beta_1(\theta,\tau)$ and written as follows;

$$\beta^{\theta}(Silv_t) \approx \beta_0(\theta,\tau) + \beta_1(\theta,\tau)(Silv_t - Silv^{\tau}) \quad \text{-------- (iv)}$$

$$\beta^{\theta}(Plat_t) \approx \beta_0(\theta,\tau) + \beta_1(\theta,\tau)(Plat_t - Plat^{\tau}) \quad \text{------ (v)}$$

$$\beta^{\theta}(Pallad_t) \approx \beta_0(\theta,\tau) + \beta_1(\theta,\tau)(Pallad_t - Pallad^{\tau}) \quad \text{-------- (vi)}$$

*3.1 Data Sources*

The monthly data is used for all the variables starting from January 1st 2000 to December 31st 2016. The oil price data is obtained from Energy Information Administration (EIA), whereas, the prices of platinum and palladium are extracted from Johnson Matthey website. The monthly data of silver price is collected from Index Mundi. The unit of measures of oil price is dollars per barrel and white precious metals are in U.S. Dollars and Cents per troy ounce.

*3.2 Summary Statistics*

Table 1 reports the summary statistics of the related variables such as platinum, palladium, silver and oil price. It is shown from the given table that the platinum mean price from January 2000 to December 2016 was 1126.19 with a standard deviation of 417.3, with a highest price of 2066.4 and lowest of 432.9. The mean price of palladium for the given period was 491.08 with a standard deviation of 223.8, the maximum price of palladium was 1058.3 and lowest price was 166.3 US dollars per troy ounce. In the silver, the mean price was 14.68 with minimum price of 4.1 and maximum of 42.7, the standard deviation of silver was 9.22. The mean oil price was 62.49 US dollars per barrel with a standard deviation of 28.13, the lowest price of oil was 19.39 and the highest was 133.8 dollars per barrel.

**Table 1: Summary Statistics**

| Variables | Unit | Obs | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|---|---|
| Platinum | per troy ounce | 204 | 1126.193 | 417.318 | 432.95 | 2066.41 |
| Palladium | per troy ounce | 204 | 491.0884 | 223.8894 | 166.35 | 1058.36 |
| Silver | per troy ounce | 204 | 14.68627 | 9.225161 | 4.12 | 42.7 |
| Oil Price | Per Barrel | 204 | 62.49172 | 28.13389 | 19.39 | 133.88 |

## 4. Empirical Results

*4.1 Zivot Andrews Unit Root test*

Prior analyzing the empirical relationship of oil and white precious returns by using autoregressive distributed lag model and QQ approach, we apply breakpoint unit root test developed by Zivot and Andrews (1992). This test is used to capture the structural breaks and the results are reported in table 2. From the given table, we conclude that all the variables are nonstationary at level I (0) and stationary at first difference I (1).

**Table 2: Zivot Andrews Structural Break Unit Root Test**

| Variables | At Level | | At 1st Difference | |
|---|---|---|---|---|
| | T-stats | Time Break | T-stats | Time Break |
| *Oil price* | -3.333 | 2004-05 | -10.402 | 2008-09 |
| *Platinum* | -3.011 | 2005-06 | -11.305 | 2007-08 |
| *Palladium* | -3.563 | 2009-10 | -10.874 | 2008-09 |
| *Silver* | -2.480 | 2009-09 | -12.356 | 2011-12 |

*4.2 Autoregressive Distributed Lag*

To analyze the effect of oil price on the returns of white precious metals, we apply autoregressive distributed lag (ARDL) to estimate the models. This method is justified over the other conventional methods based on the bivariate model. In ARDL, no control variables are required to control the effect of dependent variable because of the lagged variables (See for example; Asuamah, 2017 & Tursoy, 2017). The short-term results of ARDL for all the three models are reported in table 1, because according to the bound test results, there is no long-run relationship exists between oil price and white precious metal returns. From the given table, it is shown that oil price has a positive and significant impact on the returns of platinum, palladium and silver.

**Table 3: Autoregressive Distributed Lag (January 2000-December 2016)**

| **Panel-A: ARDL Bound Test** | | | | |
|---|---|---|---|---|
| **Regressors** | ***Platinum*** | ***Palladium*** | ***Silver*** | |
| Lag Length | 2,1 | 3,1 | 2,1 | |
| Bound Test | No Cointegration | No Cointegration | No Cointegration | |
| **Panel-B: Short-run Estimates** | | | | |
| D(Oil Price) | | 4.742*** | 1.718*** | 0.073*** |

Note: *,**,*** indicate 10%, 5% & 1% significance level

*4.3 Estimates of QQ Approach*

To have a complete understanding of the relationship between oil price and white precious returns, we also apply the quantile-on-quantile regression approach. According to Sim and Zhou (2015), QQ approach can be viewed as useful relative to other approaches because it uncovers all the complexities and gives a complete picture of the relationship. As in our case, the relationship of white precious metals and oil price is complex in nature; therefore, for the complete understanding of the relationship, we apply QQ approach. *Fig 1, 2,* and *three* display the slope coefficients $\beta 1$ $(\theta, \tau)$, which estimates the quantile ($\tau$th) effects of oil price on the quantile ($\theta$) of white precious metals, such as silver, palladium and platinum.

Using the QQ approach, we first investigate the relationship between oil price and platinum price. *Figure 1* displays the estimated slope coefficients on the Z-axis, where the quantiles ($\tau$) of oil price is on Y-axis and quantiles ($\theta$) of platinum price is on the X-axis. Interestingly, it is found that for most combinations of the quantiles, oil price and platinum price are positively related to each other. Examining the graph by quantiles, the

strong positive connection observed between both the variables at the lowest quantiles (0.1-0.2) of oil price and platinum price. Whereas, no negative correlation found between both the variables at any combination of quantiles, indicating that prthe ice of oil and platinum move in a same direction. However, no correlation has also been noticed between variables at the highest quantiles of both the variables (0.8-0.9).

On the other hand, *figure 2* illustrates the slope coefficients on Z-axis against the quantiles ($\theta$) of palladium price on X-axis and quantiles ($\tau$) of oil price on Y-axis. The graph shows mixed results between the price of palladium and the price of oil. It is observed that oil price and palladium price have negative correlation at the highest quantiles (0.7-0.9). Similarly, few highest quantile combinations (0.9-0.9) have also showed no relationship between both the variables. Contrary to that, a positive and strong connection has also been noticed at the lowest quantiles of variables (0.1-0.3). Similar to this, most of the combination of quantiles particularly at the lowest side have strong and weak but positive correlation found between the studied variables. It is concluded, when the price of oil and palladium are low, both variables have a strong relationship, however, the moment prices increase, the positive relationship turns into negative.

In addition to the above, *figure 3* illustrates the relationship between the price of oil and the price of silver. The X-axis shows the quantiles ($\theta$) of silver price against the Y-axis shows the quantiles ($\tau$) of oil price and Z-axis is the slope coefficients. From the QQ graph, it is shown that the majority of the quantiles have a positive correlation between both the variables. Both variables have a positive connection at the highest quantiles (0.9-0.9). However, some lower combination of quantiles shows a weak and negative relation between oil price and silver price. Contrary to that, it is also noticed that lower quantile of silver and higher quantile of oil price have an inverse relationship. Therefore, it is indicated that oil price shocks might not affect silver investment due to the inverse relation, but it will only last for a shorter time period.

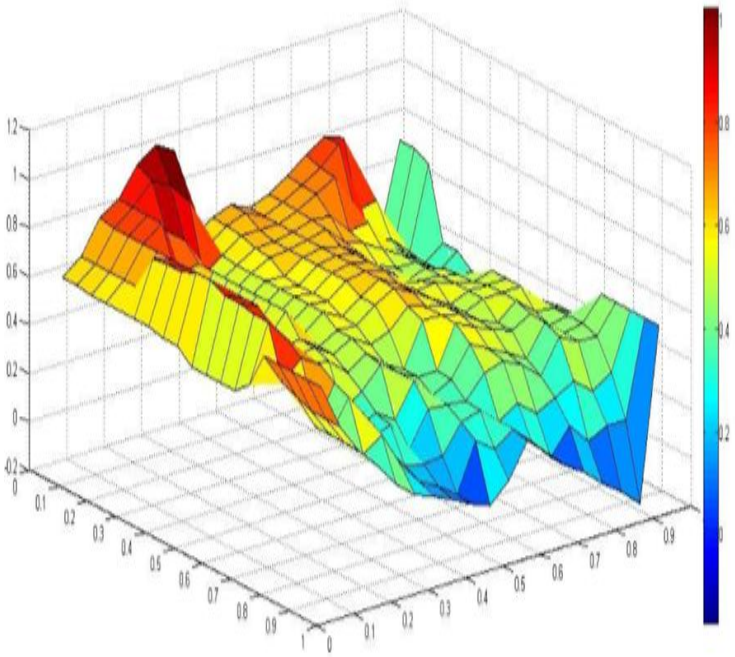

**Figure 1: QQ Estimates of Platinum and Oil Price**

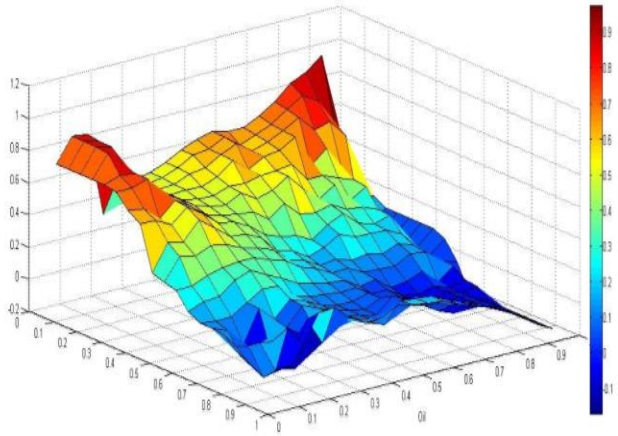

**Figure 2: QQ Estimates of Palladium and Oil Price**

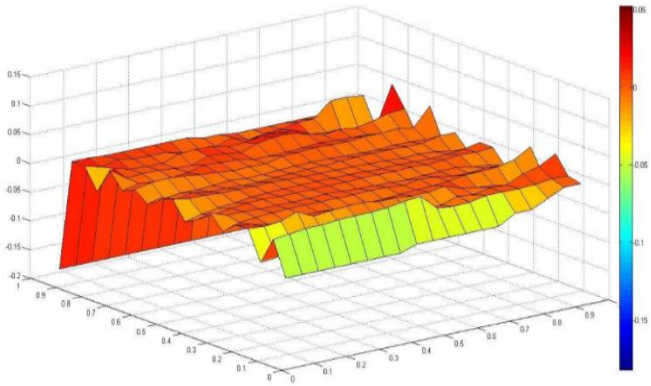

**Figure 3: QQ Estimates of Silver and Oil price**

Table 2 reports the results of QQ correlation coefficients for the three white precious metals across different quantiles. It is shown from the given table that the correlation between oil price and precious metal differs across quantiles. In case of platinum, the lower quantiles of oil price do not have a correlation with all the quantiles of the platinum, indicating when the oil price is low it has no real effect on platinum price and thus returns. However, the higher quantiles of both variables are showing a mixed relationship. The highest quantiles of oil price (0.9-0.95) are showing a positive relationship with platinum at the moderate quantiles, suggesting that high oil price will slightly increase the platinum price and subsequent returns, whereas at some highest quantiles of both the variables the relationship becomes negative.

In addition, table 2 also illustrates the results of palladium and oil price. It is observed from the given table that throughout oil price and palladium price are showing positive relationship across quantiles; however, in some middle quantiles (0.05-0.50) and (0.10-

0.50) the relationship becomes negative. Similar to the platinum and oil price, palladium and oil price are also not correlate the lowest quantiles. The findings from overall quantiles suggest that increase in oil price will have a slight impact on the price of palladium but the magnitude is weak. On the other side, it is noticed that the price of oil and silver will have a strong and mixed relationship with each other. Though in the mid quantile of oil (0.50), no relationship found in any of the quantiles of silver. The lowest quantiles of both the variables have positive correlation but it becomes negative the moment the price increases. It is suggesting that when the price of oil is low, it will benefit the investor who invested in silver.

**Table 4: The Quantile-On-Quantile Coefficients for White Precious Metals**

| **Platinum** | | | | | |
|---|---|---|---|---|---|
| Quantiles | *Q (0.05)* | *Q (0.10)* | *Q (0.50)* | *Q (0.90)* | *Q (0.95)* |
| *Q (0.05)* | 0.000 | 0.000 | 0.000 | 4.529 | 4.529 |
| *Q (0.10)* | 0.000 | 0.000 | 0.000 | 4.529 | 4.529 |
| *Q (0.50)* | 0.000 | 0.000 | 0.000 | 4.859 | 5.569 |
| *Q (0.90)* | 0.000 | 0.000 | 0.000 | -4.861 | -10.406 |
| *Q (0.95)* | 0.000 | 0.000 | 0.000 | -4.861 | -4.861 |
| ***Palladium*** | | | | | |
| *Quantiles* | *Q (0.05)* | *Q (0.10)* | *Q (0.50)* | *Q (0.90)* | *Q (0.95)* |
| *Q (0.05)* | 0.000 | 0.000 | -2.498 | 14.865 | 14.865 |
| *Q (0.10)* | 0.000 | 0.000 | -1.444 | 3.410 | 3.410 |
| *Q (0.50)* | 0.000 | 0.000 | 0.000 | 4.650 | 3.206 |
| *Q (0.90)* | 3.118 | 3.118 | 2.518 | 1.906 | 1.700 |
| *Q (0.95)* | 3.118 | 3.118 | 3.118 | 1.987 | 1.912 |
| ***Silver*** | | | | | |
| *Quantiles* | *Q (0.05)* | *Q (0.10)* | *Q (0.50)* | *Q (0.90)* | *Q (0.95)* |
| *Q (0.05)* | 0.000 | 0.000 | 0.000 | 4.529 | 4.529 |
| *Q (0.10)* | -42.651 | 0.000 | 0.000 | 4.529 | 4.529 |
| *Q (0.50)* | -39.891 | -0.368 | 0.000 | 3.687 | 5.569 |
| *Q (0.90)* | 109.505 | 63.281 | 0.000 | -4.861 | -10.406 |
| *Q (0.95)* | 109.505 | 63.281 | 0.000 | -4.861 | -4.861 |

## 5. Conclusion

Due to the distinctive nature, platinum, palladium and silver are treated as precious metals. Some uses them for production purpose in industries whereas, some utilizes it as a hedge tool in financial asset investments. It is necessary to have a proper understanding

of white precious metals for risk and portfolio management decision as well as for the production decisions. As noted in prior studies, white precious metals may be profitable in the long-run due to the diversification (Sari, Hammoudeh, & Soytas, 2010). Thus, in the present study, we effort to examine the relationship of oil price and white precious metals, such as, silver, platinum and palladium. A monthly basis data spanning the period from January 2000 to December 2016 was used. In order to estimate the relationship between both the considered variables, we applied ARDL and quantile-on-quantile method developed by Sim and Zhou (2015). This method is preferred over the other conventional approaches, because QQ approach provides comprehensive insights of the complex relationship.

The estimations of QQ approach reflects that oil price has a strong positive relationship with platinum price, which shows that as an increase in the oil price results increase in platinum price. Results are also evident that investment in platinum is beneficial for investors. Because when the price of oil increases, the price of platinum will also increase, and later investors gain high returns. The above mentioned result is consistent with the finding of Jain and Ghosh (2013). It indicates that for investors platinum can make an efficient portfolio, which diversifies risk and provides a desirable risk adjusted return. However, this positive relation of oil and platinum is affecting manufacturing industries in term of purchasing costs of oil and platinum.

In addition to the above results, it is also found that oil price and palladium price are positively related to each other, indicating that oil price increases, which also increases the palladium price. However, for a short-term period, the relationship between both commodity (i.e. palladium and oil) is negative, which means that change in oil price decreases the palladium returns. To conclude this, most of the time investors have the benefit to investing in palladium but they have to keep eyes on the fluctuation of these commodities price trend. By investing, metal traders will receive a huge return. These result corroborates the analysis of Bildirici and Turkmen (2015) i.e. a positive change in oil prices of 1 percent, resulting in increase of 1.33 percent in the silver price. In addition, Results of Jain and Ghosh (2013) explained that silver price has a huge correlation with oil price; this is because they both have a major industrial use.

These findings can also draw some implication for commodity market investors. It is found that white metals have a significant relationship with oil prices, so investors should invest in white metals to save their capital from oil prices affects and to earn maximum returns. Furthermore, investors should prefer white metals investment over risky financial assets. They should invest in white precious metals such as silver, platinum, and palladium in order to gain a maximize profit. Besides that, it is strongly recommended that policymakers should have to raise the proportionate of white metals (especially platinum) as asset reserves to stop the currency from declining its value.

### *5.1 Limitations and Future Research Directions*

Though the purpose of this research is fulfilled, however, it has some limitations. First, the non-availability of palladium and platinum data, which was limited to the years 2000-2016. Second, the current research is limited to only three precious metals, such as silver, platinum, and palladium. It is recommended to the future researchers to use other white precious metals such as rhodium, aluminum, and titanium, etc.

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