



A NEW EMPIRICAL INVESTIGATION OF THE PLATINUM SPOT RETURNS

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Abstract: *The global platinum market has been in downturn and unstable for five consecutive years, and thus market participants are demanding effective quantitative risk management tools. Since platinum is so widely used and serves as an important investment vehicle, the importance of risk management of platinum spot returns cannot be understated. In this paper, we take advantage of a very popular econometric model, the generalized autoregressive conditional heteroscedasticity (GARCH) model, for platinum returns. We received two important findings by using the conventional GARCH models in explain daily platinum spot returns. First, it is crucial to introduce heavy-tailed distribution to explain conditional heavy tails; and second, the NRIG distribution performs better than the most widely-used heavy-tailed distribution, the Student's t distribution.*

Key words: GARCH model; fat tails; platinum spot returns

JEL classifications: C22; C52; G17

1. Introduction

Compared with gold and silver, which have been used by the human society since ancient time, platinum has a much shorter history in our financial sector. It has been estimated that platinum is about 15-20 times scarcer than gold, and thus platinum has been more expensive for a long time until 2014. In 2014, the platinum spot price fell below the gold spot price. Similar as palladium, the largest platinum supplier in the world is South Africa, in which more than 75% of global platinum is mined, followed by Russia and Zimbabwe. Platinum is widely-used in catalytic converters, laboratory equipment, electrical contacts and electrodes, and jewelry. Recently most of the increased demand comes from the Chinese market. In the past five year, the Chinese

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jewelry demand had a sharp contraction, which had led a weak global platinum market for five consecutive years.

With an unstable investment market for five years, the global platinum market demands effective quantitative risk management tools. Here, we search from the existing literature and aim to provide an effective risk management approach. We choose the approach in Guo (2017a) and utilize the generalized autoregressive conditional heteroscedasticity (GARCH) model to discuss several statistical distributions in empirical performance of fitting the platinum spot returns. Our focus is on the two types of heavy-tailed distributions, the Student's t distribution and the normal reciprocal inverse Gaussian (NRIG) distribution, which are the most popular heavy-tailed distribution and a newly-developed emerging heavy-tailed distribution respectively.

Literature Review

As one of the most important alternative investment vehicles, platinum has drawn significant attentions from the academia. Many researchers have applied the GARCH model to investigate the platinum returns dynamics. Klein (2017) modified the DCC-GARCH model and applied the model on precious metals prices of the developed countries. Klein identified gold and silver can only marginally served as safe haven but platinum shows signs of surrogate safe haven. Arouri, et al. (2012) investigate the potential of structural changes and long memory (LM) properties in returns and volatility of the four major precious metal commodities traded on the COMEX markets. By using an an ARFIMA–FIGARCH model, Arouri, et al. found conditional volatility of precious metals is better explained by long memory than by structural breaks, especially for platinum. McCown and Shaw (2017) examined the investment potential and risk-hedging characteristics of platinum by analyzing returns on the spot prices and comparing them with gold, crude oil, and stocks, using GARCH based models. McCown and Shaw found platinum is useful as a hedge for factors of the correlation with inflation, the correlation with foreign exchange rates, and the systematic risk of the investments. They also found platinum is also useful as a safe haven in periods of extreme stock market declines. A similar analysis can also be found in Chinhamu and Chikobvu (2014), Maree (2017), Maree, Card, Murphy and Kidman (2017), and Oden, Hurt and Gentry (2017).



Most of the above studies focus on markets inter-connections and ignore the conditional heavy tails effect. In this paper, we consider the conditional heavy tails under the GARCH framework for the platinum spot returns. There are extensive studies incorporating heavy-tailed distributions into the GARCH framework to account for conditional heavy tails, but focusing on other asset classes. For instance, the Student's t distribution is introduced into the GARCH model by Bollerslev (1987), so that the Student's t distribution could capture conditional heavy tails of a variety of foreign exchange rates and stock price indices returns. Tavares, et al. (2007) incorporated the heavy tails and asymmetric effect on stocks returns volatility into the GARCH framework, and showed the Student's t and the stable Paretian distribution clearly outperform the Gaussian distribution in fitting FTSE returns. Su and Hung (2011) considered a range of stock indices across international stock markets during the period of the U.S. Subprime mortgage crisis, and show that the GARCH model with normal, generalized error distribution and skewed normal distributions provide accurate risk estimates. Some other studies can be found in Guo (2017b) and Guo and Luo (2017).

In this paper, we take advantage of the model framework in Guo (2017a) and are interested in the NRIG distribution, a newly-developed heavy-tailed distribution. The remainder of the paper is organized as follows. In Section 2, we discuss GARCH models and the heavy-tailed distributions. Section 3 summarizes the data. The results are in Section 4. Section 5 covers conclusions.

2. The Models

A simple GARCH(1,1) process is given as:

$$\varepsilon_t = \mu + \sigma_t e_t \quad (2.1)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad (2.2)$$

where the three positive numbers α_0 , α_1 and β_1 are the parameters of the process and $\alpha_1 + \beta_1 < 1$.

The assumption of a constant mean return μ is purely for simplification and reflects that the focus of the paper is on dynamics of return volatility instead of dynamics of returns. The variable e_t is identically and independently distributed (*i.i.d.*). Two types of heavy-tailed distributions are

considered: the Student's t and the normal reciprocal inverse Gaussian (NRIG) distributions. The density function of the standard Student's t distribution with ν degrees of freedom is given by:

$$f(e_t | \psi_{t-1}) = \frac{\Gamma(\frac{\nu+1}{2})}{\Gamma(\frac{\nu}{2})[(\nu-2)\pi]^{1/2}} \left(1 + \frac{e_t^2}{(\nu-2)}\right)^{-\frac{\nu+1}{2}}, \nu > 4. \tag{2.3}$$

where ψ_{t-1} denotes the σ -field generated by all the available information up through time $t-1$.

The NRIG is a special class of the widely-used generalized hyperbolic distribution. The generalized hyperbolic distribution is specified as in Prause (1999):

$$f(e_t | \lambda, \mu, \alpha, \beta, \delta) = \frac{(\sqrt{\alpha^2 - \beta^2} / \delta)^\lambda K_{\lambda-1/2}(\alpha \sqrt{\delta^2 + (e_t - \mu)^2})}{\sqrt{2\pi} (\sqrt{\delta^2 + (e_t - \mu)^2} / \alpha)^{1/2-\lambda} K_\lambda(\delta \sqrt{\alpha^2 - \beta^2})} \exp(\beta(e_t - \mu)), \tag{2.4}$$

where $K_\lambda(\cdot)$ is the modified Bessel function of the third kind and index $\lambda \in \mathbb{R}$ and: $\delta > 0$,

$0 \leq \beta < \alpha$. When $\lambda = \frac{1}{2}$, we have the normalized NRIG distribution as:

$$f(\varepsilon_t | \psi_{t-1}) = \frac{\alpha K_0\left(\sqrt{(\alpha^2 - 1)^2 + \frac{\alpha^2 \varepsilon_t^2}{\sigma_t^2}}\right)}{\pi \sigma_t} \exp(\alpha^2 - 1). \tag{2.5}$$

3. Data and Summary Statistics



Figure 1: Daily platinum spot prices

Figure 1 illustrates the daily platinum spot prices in the New York Mercantile Exchange (NYME). NYME is currently owned by the CME Group of Chicago and also one of the largest commodity exchanges in the world. The data covers the period from June 21, 1991 to June 30, 2017 and has in total 7508 observations. Figure 2 illustrates the dynamics of the platinum spot returns. There are significant volatility clustering phenomenon and several huge spikes were observed in the sample.

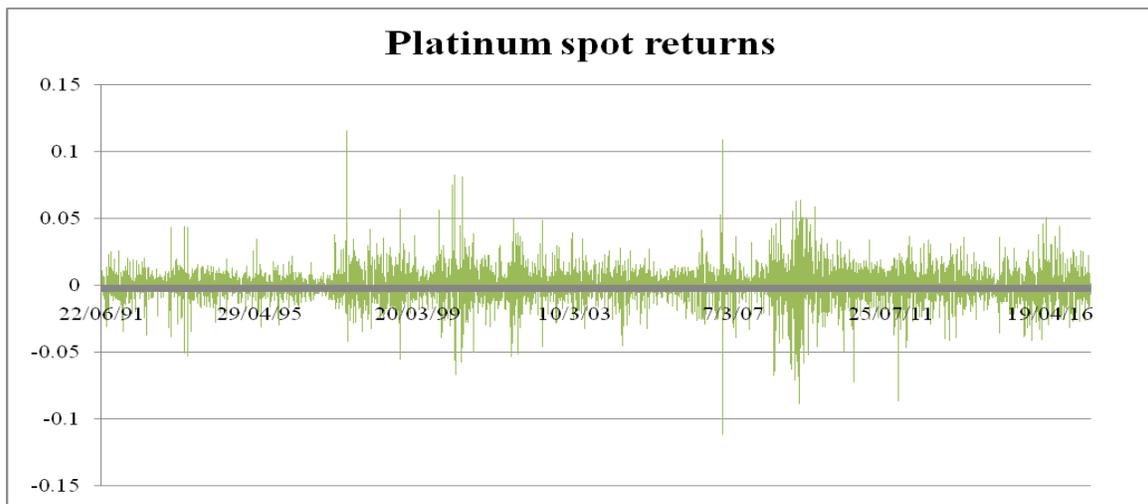


Figure 2: Daily platinum spot returns

Table 1 summarizes statistics of the data. Several well-known stylized facts of asset prices series are confirmed: non-normality, limited evidence of short-term predictability and strong evidence of predictability in volatility. All series are presented in daily percentage growth rates/returns. The Bera–Jarque test conclusively rejects normality of raw returns in all series, which confirms our assumption that the model selected should account for the heavy-tail phenomenon. The smallest test statistic is much higher than the 5% critical value of 5.99. The market index is negatively skewed and has fat tails. The asymptotic SE of the skewness statistic under the null of normality is $\sqrt{6/T}$, and the SE of the kurtosis statistic is $\sqrt{24/T}$, where T is the number of observations. The data exhibits statistically significant heavy tails.

Series	Obs.	Mean	Std.	Skewness	Kurtosis	BJ	Q(5)	Q ^{ARCH} (5)	Q ² (5)
Platinum spot returns	7507	0.02%	1.21%	-0.11*	7.95**	88.6**	10.24**	6.42*	55.12**



Table 1: Summary statistics. BJ is the Bera-Jarque statistic and is distributed as chi-squared with 2 degrees of freedom, $Q(5)$ is the Ljung-Box Portmanteau statistic, $Q^{\text{ARCH}}(5)$ is the Ljung-Box Portmanteau statistic adjusted for ARCH effects following Diebold (1986) and $Q^2(5)$ is the Ljung-Box test for serial correlation in the squared residuals. The three Q statistics are calculated with 5 lags and are distributed as chi-squared with 5 degrees of freedom.

* and ** denote a skewness, kurtosis, BJ or Q statistically significant at the 5% and 1% level respectively. The Ljung-Box portmanteau, or Q, statistics with five lags was used to test for serial correlation in the data, and adjust the Q statistic for ARCH models following Diebold (1986). The results that no serial correlation is found confirm our assumption of a constant mean return μ in Equation (2.1). The evidence of linear dependence in the squared demeaned returns, which is an indication of ARCH effects, is significant for all the series.

4. Estimation Results

To estimate the GARCH(1,1) model with the Student's t and the NRIG distributions, the following log-likelihood function of equation is maximized:

$$\hat{\theta} = \arg \max_{\theta} \sum_{t=1}^T \log(f(\varepsilon_t | \varepsilon_1, \dots, \varepsilon_{t-1})) . \quad (4.1)$$

Table 2 reports estimation results of the GARCH(1,1) model with the two types of heavy-tailed distribution for all the daily platinum spot return series. All the parameters are significantly different from zero. With the results, one can see we have to incorporate heavy-tailed distributions into the GARCH framework to capture conditional heavy tails. Also, the NRIG distribution has better in-sample performance than the Student's t distribution. The Akaike information criterion (AIC) and the Bayesian information criterion (BIC) also indicate that the NRIG distribution has best goodness-of-fit.

	alpha1	beta1	1/nu (1/alpha)	log-likelihood	AIC	BIC
Normal	0.052**	0.917**		-14898	29802	29822
Student's t	0.049**	0.931**	0.152**	-14450	28908	28935
NRIG	0.043**	0.939**	0.718**	-14369	28746	28773

Table 2: Estimation of the GARCH model with heavy-tailed innovations

* and ** denote statistical significance at the 5% and 1% level respectively.



5. Conclusion

As indicated by Loferski (2016), of the 218 tons of platinum sold in 2014, 98 tons were used for vehicle emissions control devices (45%), 74.7 tons for jewelry (34%), 20.0 tons for chemical production and petroleum refining (9.2%), and 5.85 tons for electrical applications such as hard disk drives (2.7%). Since platinum is so widely used and serves as an important investment vehicle, the importance of risk management of platinum spot returns cannot be understated. In this paper, we have two important findings by using the conventional GARCH models in explain daily platinum spot returns. First, it is crucial to introduce heavy-tailed distribution to explain conditional heavy tails; and second, the NRIG distribution performs better than the most widely-used heavy-tailed distribution, the Student's t distribution. In this paper, we only consider the GARCH(1,1) model, and it would be interesting to adopt the asymmetric GARCH model as in Glosten, Jagannathan and Runkle (1993) to investigate the leverage effect.

References

1. Arouri, M., S. Hammoudeh, A. Lahiani and D. Nguyen (2012), "Long memory and structural breaks in modeling the return and volatility dynamics of precious metals." *Quarterly Review of Economics and Finance*, vol. 52, no. 2, pp. 207-218.
2. Bollerslev, T. (1987), "A conditional heteroskedastic time series model for security prices and rates of return data." *Review of Economics and Statistics*, vol. 69, pp.542-547.
3. Chinhamu, K. and D. Chikobvu (2014), "A Garch Model Test of The Random Walk Hypothesis: Empirical Evidence from The Platinum Market." *Mediterranean Journal of Social Sciences*, vol. 5, no. 14, pp. 77-83.
4. Diebold, F. (1986), "Testing for serial correlation in the presence of ARCH." *Proceedings of the Business and Economic Statistics Section of the American Statistical Association*, vol. 3, pp.323-328.
5. Glosten, L., R. Jagannathan and D. Runkle (1993), "On the relation between the expected value and the volatility of nominal excess return on stocks." *Journal of Finance*, vol. 5, pp. 1779-1801.
6. Guo, Z. (2017a), "A Stochastic Factor Model for Risk Management of Commodity Derivatives." *Proceedings of the 7th Economic and Finance Conference*, pp. 26-42;



7. Guo, Z. (2017b), "Models with Short-Term Variations and Long-Term Dynamics in Risk Management of Commodity Derivatives," mimeo.
8. Guo, Z. and Y. Luo (2017), "Dynamic Stochastic Factors, Risk Management and the Energy Futures." *International Business Research*, 2017, vol. 10, no. 9, pp. 50-59.
9. Klein, T. (2017), "Dynamic correlation of precious metals and flight-to-quality in developed markets." *Finance Research Letters*, forthcoming.
10. Loferske, P. (2016), "2014 minerals yearbook: platinum-group metals." USGS Mineral Resources Program.
11. Maree, A. (2017), "Stress Testing and Risk Management of the Equity Market in New Zealand." Working paper.
12. Maree, A., P. Card, A. Murphy and P. Kidman (2017), "GARCH Models with a New Class of Heavy-Tailed Distribution for the Silver Returns." Working paper.
13. McCown, J. and R. Shaw (2017), "Investment potential and risk hedging characteristics of platinum group metals." *Quarterly Review of Economics and Finance*, vol. 63, pp. 328-337.
14. Prause, K. (1999) "The generalized hyperbolic model: estimation, financial derivatives, and risk measures." Ph.D. Dissertation.
15. Su, J. and J. Hung (2011), "Empirical analysis of jump dynamics, heavy-tails and skewness on value-at-risk estimation." *Economic Modelling*, vol. 28, no. 3, pp. 1117-1130.
16. Tavares, A., J. Curto and G. Tavares (2008), "Modelling heavy tails and asymmetry using ARCH-type models with stable Paretian distributions." *Nonlinear Dynamics*, vol. 51, no. 1, pp. 231-243.
17. Oden, J., K. Hurt and S. Gentry (2017), "A new class of heavy-tailed distribution and the stock market returns in Germany." *Research in Business and Management*, vol. 4, no. 2, pp. 13-18.