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Relevance of the Stochastic Dominance in selecting Optimal Portfolio in the Nigerian Oil and Gas Industry

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Relevance of the Stochastic Dominance in selecting Optimal Portfolio in the Nigerian Oil and Gas Industry

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Abstract
The study examined the relevance of the stochastic dominance in selecting optimal portfolio of eight (8) listed companies in the Nigerian oil and gas industry for the period 2012 to 2021. The Vose Model Risk Software was used to analyze the stochastic dominance of the portfolio assets of the sectors. From the stochastic dominance result obtained, it was observed that, Japaul Gold & Ventures Plc is first order stochastic dominance over all other companies in the oil and gas industry. By implication, the portfolio of Japaul Gold & Ventures Plc significantly dominates Ardova Plc, Conoil Plc, Oando Plc, Total Nigeria Plc, Seplat Petroleum Development Company Plc, 11 Plc, and MRS Oil Nigeria Plc in terms of investment options (choices), informed by the returns. Hence, the study concludes that, investors can only achieve optimal portfolio, only if they invest in the stocks of Japaul Gold & Ventures Plc and Ardova Plc, Conoil Plc and pairing them with stocks from less dominant companies in the oil and gas industry. The study therefore recommends that, in order to effectively optimize returns on portfolio in the market, investors must assign more weight/funds (asset allocation) to Japaul Gold & Ventures Plc stocks followed by the Ardova Plc, Conoil Plc, Oando Plc, Total Nigeria Plc, Seplat Petroleum Development Company Plc, 11 Plc, and MRS Oil Nigeria Plc stocks respectively.

Keywords: *Stochastic Dominance, Optimal Portfolio Selection, First Order, Second Order, Investors' Preference*

1. Introduction

One of the greatest desires of every investor is to invest in a company whose return on investment can compensate the cost of such investment. Given that, investors do not have full knowledge of the investment returns coupled with the fact that the investment environment is faced with myriads of investment risks, justifies one of the reasons why financial analysts advise investors to diversify the unsystematic components of such risks (Onuorah, Oboro & Agbogun, 2022). However, the major issue which the investors may be faced with is portfolio se portfolio optimization problems. To resolve these problems, Bernoulli (1738) introduced some of the fundamental ideas of expected utility theory in his famous paradox of gambling. Bernoulli's solution requires the choice of a diminishing marginal utility (DMU) function. However, the risk taking behaviours of investors were not explicitly captured in his definition of DMU function. According to Slamet, Agni, Wibowo and Zukhronah (2019), if the utility function which measures the

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relative value of a firm's income follows a particular pattern of distribution, then this information can enhance investors' decision making accuracy.

Over the years, three (3) main types of models have been developed to help resolve the portfolio selection problems. The first is the mean-variance (MV) model developed by Markowitz (1952, 1959, and 1987). According to the Markowitz technique, portfolio performance should be measured in two (2) dimensions: the expected rate of return (mean) and the risk or variance, which helps to quantify the volatility of the rate of return. Using a trade-off between the mean and variance, preferences among the distribution of returns are classified here (Markowitz, 1952, 1959, and 1987). The Markowitz technique, on the other hand, has been strongly attacked on the grounds that there is a restricted set of conditions and assumptions for which the mean-variance model may be applied (Roman & Mitra, 2009). This is based on the quadratic utility function premise, which imply that beyond a certain amount of return, investors' marginal utility of wealth function turns negative as their risk aversion grows with wealth. It also requires that the return distribution follow a specific distribution class, such as normal, lognormal, exponential, or uniform distributions (Bawa, 1975). Meanwhile, the expected utility theory of Von Neumann and Morgenstern (1962) is the second. In essence, the anticipated utility theory assigns a single scalar value to each random variable so that investors' preferences may be established by comparing expected utilities with a larger desired value.

The criticisms levied against the above two approaches give sufficient incentive for the development of the third model of portfolio selection and optimization, the stochastic dominance (SD) model, which has a superior theoretical foundation than the other two models (Meskarian, Xu & Fliege, 2012). Stochastic dominance theory has implications for the age-old question of whether one can judge a random variable (such as asset prices or returns) as more risky than another, regardless of who the judge is (fund managers, arbitrageurs, or noise traders), if the utility of wealth functions belong to a given class with certain common properties. Nevertheless, when employing the SD technique, the utility of wealth functions does not have to be quadratic.

Given the scarcity of empirical evidence on portfolio optimization problems in emerging and frontiers markets (Nigeria inclusive), this study bridges this perceived gap by examining the relevance of stochastic dominance on investors' preference in the Nigerian oil and gas industry. Hence, the study contributes to

extant empirical documentations by examining the relevance of stochastic dominance in the oil and gas industry.

The main objective of this study is to examine the relevance of stochastic dominance in the oil and gas industry; while the specific objectives are to determine the optimal portfolio (combination of stocks) that a rational investor will prefer given a basket of stocks from listed oil and gas companies and their inherent risk-returns variability.

2. Theoretical Review

2.1 Stochastic Dominance Theory

The Stochastic Dominance theory (SDT) was used to underpin the study. This theory gives a systematic framework for analyzing investor behaviour under uncertainty (Danthine & Donaldson, 2014; Rothschild & Stiglitz, 1970). According to Wolfstetter (1996), SD theory has an impact on the age-old question of whether one may rate a random variable as more dangerous than another, independent of who is judging, if utility functions falls within certain similar qualities. For long years, economists believed that mean and variance were adequate measures of comparative risk. Yet this was not correct. Actually, "mean and variance can only serve this purpose if the utility functions of the agents are quadratic or if all probability distributions are normal; and normal distributions are unquestionably too limiting".

Wolfstetter (1996) stated that, the first order stochastic dominance is a higher relationship, but second order stochastic dominance is a noise with less dangerous relationship. While all agents that seek high realizations choose the bigger random variable, all agents who detest risk prefer the less volatile random variable. In this sense, SDT yields unanimity rules if utility functions have certain characteristics. Overall, SDT provides a further extension that account for all moments of the return distributions without requiring a specific family of distributions.

2.2 Optimal Portfolio

The concept of optimal portfolio is predicated on idea of diversification, which represents a portfolio that gives a very high return with a minimum risk (Markowitz, 1959). Therefore, constructing an optimal portfolio is an attempt to maximize returns while minimizing risk and vice versa. The idea of optimal portfolio selection is best understood by the theory of capital asset pricing model (CAPM). The CAPM was

developed in the early 1960s by Sharpe (1964), Treynor (1961), Lintner (1965a, b) and Mossin (1966); and it is predicated on the idea that not all risks can affect asset prices. Thus, in the context of the CAPM, optimal portfolio lies in the efficient frontier of the capital market line where investor can maximize return on its investment including risk free assets while at the same time lowered associated risk (William Sharpe, 1964; Mossin (1966). Therefore, this 'optimal portfolio' is often established at 'point of tangency' between capital market line and the 'efficient frontier' (Markowitz, 1959; William Sharpe, 1964; Chandra, 2009).

For instance, we assume in Figure 1 below that in a given market an investor can lend and also borrow money at a risk-free rate $R_{f.}$ Hence, R_f being a risk-free rate has a zero correlation with all the points in the feasible region containing risky portfolios (Chandra, 2009). So a combination of R_f and the other feasible region of risky assets is represented by a straight line Y; and if an investor combine R_f and Y and gets to any point along the line from R_f to Y and even beyond, we regard this line as line 1. However, even if the investor can get to any point on line 1, none of these points is optimal. Therefore, we consider line II which runs from R_f to W and even beyond. Line II is therefore tangent to the efficient set of risky assets, hence, it provides the best possible opportunities to the investor. It therefore follows that line II dominates line 1, and it also dominate any other line between R_f and any point in the feasible region of risky assets/securities (Chandra, 2009). Thus, since R_f WP dominates AFX, every rational investor would prefer some combination of R_f and W. However, a conservative investor may opt for a point like U; while and aggressive investor may prefer point V etc.

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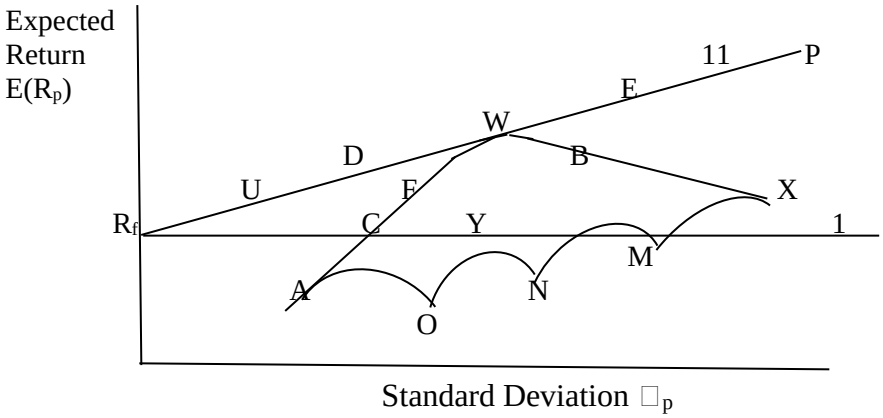

Figure 1: Optimal Portfolio Selection

2.3 Concept of Stochastic Dominance

Stochastic dominance represents the process of defining an order in relation to random variables predicated on some specific order on investment/wealth levels. In order words, it is a way of ordering preferences among related alternatives which could be either wealth or investment portfolio such that the choice of one of the wealth or investments over the other not chosen is regarded/interpreted to dominate the one not chosen (Torres, 2013). Thus, if there are two possible wealth or investment say M and N; if M is chosen rather than B, it is then stated that M dominates N*;* and this align with what is called 'first-order stochastic dominance' which is usually stated as M > 1 N, if for each (weakly) rising function *f* : X*!X*, there are: E{f(M)} _ E{f(N)}. On the other hands, if M >2 N, then it is stated that M dominates N, and this represents the second-order stochastic dominance; and if, for each (weakly) rising and (weakly) concave function *f* : X *!* X, there are: E{f(M)} _ E{f(N)} (Davidson, 2006; Torres, 2013; Garcia-Gomez, Perez & Prieto-Alaiz, 2019).

The specific impulse of M > 1 N is that all expected-utility maximizers associated with a weakly rising Bernoulli utility function will choose M instead of N; and M >2 N, meaning that all risk-averse and rational investors a weakly rising Bernoulli utility function will always choose M rather than N. Therefore, Torres (2013, p.1) stated that "*it is important to note that, since the definitions are based on the comparison of the expectations of functions of each single random variable, stochastic dominance will depend only on the distributions of the random variables (ie, all random variables that have the same distribution are ranked equally by the respective stochastic dominance ordering)".*

2.4 Empirical Review

Although studies have been conducted in the area of stochastic dominance, only very scanty ones have been conducted in relation to portfolio selection in the capital markets, especially in Nigeria. For instance, Ikponmwosa and Obazee (2021) evaluated the effect of stochastic dominance on investors' preference in the Nigerian Exchange Group with specific focus on the Agriculture, Conglomerates, Consumer Goods, Construction/Real Estate, Financial Services, Health Care, Industrial Goods and Oil and Gas. The study effectively confirmed the existence of a first order stochastic dominance across all the sector utilized in the study.

Eburajolo, and Ogbeide (2021) empirically investigated the test of SD application on portfolio selection in the Nigerian stock market over the period 2014 to 2020. The results also confirmed the first order stochastic dominance as well as those of Markowitz mean-variance relationship.

In another related study, Kouaissah and Lozza (2021) applied multivariate stochastic dominance (MSD) to a sector based portfolio selection model in the U.S. equity market; the finding from the study reveals that the MSD rule is effective and that the tail behaviour of returns is useful for portfolio optimization utility maximizing investors.

Similarly, Rahmanigrum, Slamet and Subanti (2020) investigated SD application on Jakarta Islamic Stock Index with normal distribution. The six (6) study showed that parametric approach with normal distribution improves the decision rule of stochastic dominance. It was also observed that the data obtained formed forty five (45) stock combinations with twenty nine (29) dominant stock combinations. In another related study by Alkhazali and Zoubi (2020) found that gold-Islamic stock portfolio noisily outperform a non-gold portfolio at the first, second and third order stochastic dominance respectively. Similar finding was also observed in the study of Wu, Wu, Shi and Chou (2021) which employed fuzzy theory and stochastic dominance.

Slamet et al. (2019) applied stochastic dominance on stock return data in Indonesia by conducting a normality test on the stock returns. The study finds that SD criteria with normal distribution data can lead to better outcome. Clark and Kassimatis (2014) explored the use of SD with respect to realizing higher stock returns within the context of CAPM. It was confirmed the existence of portfolio abnormal returns.

From the survey of extant literature, it appears that the empirical application of Stochastic Dominance as criteria for portfolio selection is only beginning to gain traction. However, there is still dearth of empirical evidence on the application of SD in portfolio selection in frontier market of Nigeria. This dearth created a gap in the empirically literature that needed to be filled, hence the need for this current study.

3. Methodology

This study seeks to determine the risk and returns of the portfolio of securities of listed companies in the oil and gas industry. The study spanned from 2012 to 2021. The base year of 2012 was chosen to eliminate the effect of market anomaly witnessed in the market in the 10 preceding years. The study population covers all the eleven (11) oil and gas companies quoted on the Nigerian exchange group (NEG) limited as at 31st December, 2021. However, only eight (8) of these companies (see table 3.1).

"**Table 3.1: Sample Size**

S/N	Company Name	Ticker	Sector
1	11 Plc	Mobil	Oil And Gas
2	Ardova Plc	Ardova	Oil And Gas
3	Conoil Plc	Conoil	Oil And Gas
4	Japaul Gold & Ventures Plc	Japaulgold	Oil And Gas
5	MRS Oil Nigeria Plc	MRS	Oil And Gas
6	Oando Plc	Oando	Oil And Gas
7	Seplat Petroleum Development Company Plc	Seplat	Oil And Gas
8	Total Nigeria Plc	Total	Oil And Gas

Source: Researcher's Compilation (2023)

3.1 First and Second Order Stochastic Dominance Criteria

This study adopts the theorems of stochastic dominance as enshrined in Levy (1998).

Theorem I: Let X and Y be the return of 2 different assets, "for which the Cumulative Distribution Functions (CDFs) of the returns are denoted by F and G respectively, if we assume that X and Y are normally distributed random variables, that is: $X \sim N(\mu_1, \sigma_1)$ and $Y \sim N(\mu_2, \sigma_2)$, then F dominates (outperform) G for First Order Stochastic Dominance (FSD) if and only if;

$$\mu_1 > \mu_2 \text{ and } \sigma_1 = \sigma_2$$

Put differently, under the FSD, portfolio B is said to dominate portfolio A if and only if

$$F_A(Y) - F_B(Y) \geq 0 \quad \ldots\ldots (3.1)$$

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Theorem II: Let X and Y be the return of two different securities or portfolios, where the CDFs of the returns are denoted by F and G respectively with $X \sim N(\mu_1, \sigma_1)$ and $Y \sim N(\mu_2, \sigma_2)$, then, F dominates G for Second Order Stochastic Dominance (SSD) if and only if F dominates G based on mean–variance rules, that is":

$$\mu_1 \geq \mu_2 \text{ and } \sigma_1 \leq \sigma_2$$

Put differently, portfolio B dominates portfolio A based on the SSD criteria if and only if;

$$\int_{\infty}^{y} F_A(t) - F_B(t)dt \geq 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

Where ∞ is the infinity operator, t is time factor and every other element is as earlier defined.

The study employed the Vose Model Risk software that inherently estimates the risk and returns of the portfolios of securities in the various companies in the oil and gas industry.

4. Data Analysis and Presentation of Results

The results of the estimation and tests presented in the previous section are reported and analyzed in this section.

4.1 Summary Statistics

This section began by considering the summary statistics of the portfolio return analysis in order to have a clear picture of their characterization in terms of the two main indices used in analyzing portfolio (return and risk). For ease of reference, table 4.1 presents the descriptive statistics of the portfolio returns:

Table 4.1: Descriptive Statistics

Variable	Mean	Median	Max.	Min.	Std. Dev.
Market Return	3.48	3.71	7.02	1.36	12.20
11 Plc.	3.01	3.38	5.02	`1.67	14.30
Ardova Plc.	2.31	1.98	6.40	1.88	12.67
Conoil Plc.	3.30	4.78	9.02	1.60	12.09
Japaul Gold & Ventures Plc.	0.91	3.00	5.02	1.11	12.06
MRS Oil Nigeria Plc.	2.20	1.31	5.02	0.81	24.02
Oando Plc.	6.02	6.01	17.11	3.01	8.01
Seplat Petroleum Development Company Plc.	0.39	1.02	6.01	0.87	30.12
Total Nigeria Plc.	1.09	0.45	7.02	0.19	14.40

Based on the individual companies in the Nigerian oil and gas sector, the sector's portfolio clearly dominated all the other portfolios in terms of average returns. The oil and gas industry's portfolio maintained consistent higher returns over the consideration period, as the sector performed creditably, with performance indices that surpassed the entire market performance in terms of return and risk (variability). The sector's portfolio also had the lowest standard deviation (volatility/risk) value compared to most of the other portfolios in the sample. Invariably, using return on asset portfolio and risk (measured by standard deviation), the oil and gas industry's portfolio outshined all other sectors. This outcome underscores the fast moving nature of the consumer goods sector, making it less susceptible to economic and market vulnerabilities. The overall market return was however positive, and relatively high.

Seplat Petroleum Development Company Plc. and MRS Oil Nigeria Plc. had the highest standard deviation values, suggesting higher market risks, but lower returns in the market. The sector (Oil and gas industry) on the overall had good returns, but with somewhat high level of risk due to the high capital-intensive nature of the sector, coupled with global market vulnerabilities.

4.2. Stochastic Dominance Outputs

This section accounts for the stochastic dominance output for the various asset portfolios in the Nigerian oil and gas industry using the Vose Model Risk software. Justifiably, the stochastic dominance model facility is better than other portfolio selection models as it can be used to compare as many portfolio options. Evidently, its output is presented in Table 4.2:

Table 4.2: Stochastic Dominance Outputs

"**Dominance**	Japaul Gold & Ventures Plc	Ardova Plc	Conoil Plc	Oando Plc	Total Nigeria Plc	Seplat Petroleum Development Company Plc	11 Plc	MRS Oil Nigeria Plc
Japaul Gold & Ventures Plc		Ardova Plc is 1d over Japaul Gold & Ventures Plc	Japaul Gold & Ventures Plc is 1d over Conoil Plc	Japaul Gold & Ventures Plc is 1d over Oando Plc	Japaul Gold & Ventures Plc is 1d over Total Nigeria Plc	Japaul Gold & Ventures Plc is 1d over Seplat Petroleum Development Company Plc	Japaul Gold & Ventures Plc is 1d over 11 Plc	Japaul Gold & Ventures Plc is 1d over MRS Oil Nigeria Plc
Ardova Plc	Ardova Plc is 1d over Japaul Gold & Ventures Plc		Ardova Plc is 1d over Conoil Plc	Ardova Plc is 1d over Oando Plc	Ardova Plc is 1d over Total Nigeria Plc	Ardova Plc is 1d over Seplat Petroleum Development Company Plc	Ardova Plc is 1d over 11 Plc	Ardova Plc is 1d over MRS Oil Nigeria Plc
Conoil Plc	Conoil Plc is 1d over Japaul Gold & Ventures Plc	Oando Plc is 1d over Ardova Plc		Conoil Plc is 1d over Oando Plc	Conoil Plc is 1d over Total Nigeria Plc	Conoil Plc is 1d over Seplat Petroleum Development Company Plc	Conoil Plc is 1d over 11 Plc	Conoil Plc is 1d over MRS Oil Nigeria Plc
Oando Plc	Oando Plc is 1d over Japaul Gold & Ventures Plc	Total Nigeria Plc is 1d over Ardova Plc	Total Nigeria Plc is 1d over Conoil Plc		Oando Plc is 1d over Total Nigeria Plc	Oando Plc is 1d over Seplat Petroleum Development Company Plc	Oando Plc is 1d over 11 Plc	Oando Plc is 1d over MRS Oil Nigeria Plc

Total Nigeria Plc	Total Nigeria Plc is 1d over Japaul Gold & Ventures Plc	Seplat Petroleum Development Company Plc is 1d over Ardova Plc	Seplat Petroleum Development Company Plc is 1d over Conoil Plc	Seplat Petroleum Development Company Plc is 1d over Oando Plc		Total Nigeria Plc is 1d over Seplat Petroleum Development Company Plc	Total Nigeria Plc is 1d over 11 Plc	Total Nigeria Plc is 1d over MRS Oil Nigeria Plc
Seplat Petroleum Development Company Plc	Seplat Petroleum Development Company Plc is 1d over Japaul Gold & Ventures Plc	Seplat Petroleum Development Company Plc is 1d over Ardova Plc	Seplat Petroleum Development Company Plc is 1d over Conoil Plc	Seplat Petroleum Development Company Plc is 1d over Oando Plc	Seplat Petroleum Development Company Plc is 1d over Total Nigeria Plc		Inconclusive	
11 Plc	11 Plc is 1d over Japaul Gold & Ventures Plc	11 Oil Nigeria Plc is 1d over Ardova Plc	11 Oil Nigeria Plc is 1d over Conoil Plc	11 Plc is 1d over Oando Plc	11 Plc is 1d over Total Nigeria Plc	Inconclusive		Inconclusive
MRS Oil Nigeria Plc	MRS Oil Nigeria Plc is 1d over Japaul Gold & Ventures Plc	MRS Oil Nigeria Plc is 1d over Ardova Plc	MRS Oil Nigeria Plc is 1d over Conoil Plc	MRS Oil Nigeria Plc is 1d over Oando Plc	MRS Oil Nigeria Plc is 1d over Total Nigeria Plc	Inconclusive	Inconclusive”	

Source: Author’s Computation (2023) Extracted from Vose Model Risk software

4.3 Discussion of Results

The Vose Model Risk software was used to analyze the stochastic dominance of the portfolio assets of the sectors. From the stochastic dominance result obtained, it is observed that, Japaul Gold & Ventures Plc is first order stochastic dominance over all other companies in the oil and gas industry. This means that, the portfolio of Japaul Gold & Ventures Plc significantly dominates Ardova Plc, Conoil Plc, Oando Plc, Total Nigeria Plc, Seplat Petroleum Development Company Plc, 11 Plc, and MRS Oil Nigeria Plc in terms of investment options (choices), informed by the returns. The implication of this is that the portfolio returns of the Japaul Gold & Ventures Plc are in order of first choice/acceptability among other quoted oil and gas companies in Nigeria. This further reveals that, "Japaul Gold & Ventures Plc has stochastically larger returns and stochastically less volatile or less risky relationship; invariably, portfolio with larger return are preferred by all investors who prefer high realizations, while less volatile stock is preferred by those investors who dislike risk". In this sense, the Japaul Gold & Ventures Plc is the most preferred in the market in terms of maximizing investment returns and minimizing risk. Meanwhile, Ardova Plc, Conoil Plc is the second most prepared company, followed by Oando Plc, Total Nigeria Plc, Seplat Petroleum Development Company Plc, 11 Plc, and MRS Oil Nigeria Plc respectively.

5 Conclusion

The study examined the relevance of the stochastic dominance in selecting optimal portfolio in the Nigerian oil and gas industry for the period 2012 to 2021. The Vose Model Risk software was used to analyze the stochastic dominance of the portfolio assets of the oil and gas sectors. It results from the analysis of data generally revealed that, Japaul Gold & Ventures Plc is first order stochastic dominance over all other companies in the oil and gas industry. By implication, the portfolio of Japaul Gold & Ventures Plc significantly dominates Ardova Plc, Conoil Plc, Oando Plc, Total Nigeria Plc, Seplat Petroleum Development Company Plc, 11 Plc, and MRS Oil Nigeria Plc in terms of investment options (choices), informed by the returns. Thus, the study conclude that, investors can only achieve optimal portfolio, only if they invest in the stocks of Japaul Gold &

Ventures Plc and Ardova Plc, Conoil Plc and pairing them with stocks from less dominant companies in the oil and gas industry.

5.1 Recommendations

Based on the findings of this study, the following recommendations are made:

(i) First, investors should optimize their portfolio returns by placing more weight or allocating more funds (asset allocation) to Japaul Gold & Ventures Plc stocks followed by the Ardova Plc, Conoil Plc, Oando Plc, Total Nigeria Plc, Seplat Petroleum Development Company Plc, 11 Plc, and MRS Oil Nigeria Plc stocks respectively.

(ii) Lastly, investors and fund managers in the Nigerian oil and gas industry should pair negatively correlated stocks if they are to effectively build an efficient portfolio.

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