Training Risk Measure Models to Ascertain Which Continent's Equity Has the Highest Risk for Investment Based on Randomly Selected Individual Continents' Equities Listed on the New York Stock Exchange

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Abstract
Countries, institutions, and people from all walks of life, including Africans, have carried the notion that it is riskier to invest in African countries than countries in other continents. The purpose of this study was to affirm/refute this notion as being empirically established or merely born out of imagination and unfounded belief. One metal mining company listed on the New York stock exchange was selected from every continent using a systematic random sampling of period five. All daily stock data was obtained from Yahoo Finance for the period 6/2003 thru 6/2020. The Generalized Autoregressive Conditionally Heteroscedastic (GARCH) model was used for randomly varying volatility. However, the study trained several GARCH for a different order of the GARCH terms σ^2, and the ARCH terms ε^2, and for different distributions. Based on the AIC and BIC, the GARCH model that best fit the data was GARCH (1,1) based on student-t innovation. Risk measure was estimated using the following three approaches: risk metrics, Block Maxima Method under extreme value situations, and Generalized Pareto Distribution (GPD) for the tail ends of the distribution. None of the approaches or methods used in calculating VaR or conditional VaR (ES) of the stock supported the conventional beliefs and age-long-held purported gospel that African countries are the riskiest in which to invest on earth. The study proceeded to verify if these findings were statistically significant. Analysis of variance (ANOVA) was applied and found that none of the differences established above were statistically significant.

Keywords*: Continental investment, New York Stock Exchange, Value-at-Risk, Special Metal Industry, and Africa*

Introduction

The desire of investors to make the most out of their investment can never be overestimated; this has led to investors or potential investors continually and constantly being on the lookout for better investment opportunities. This claim is empirically supported by scholars (Aharoni, 2015; Nisar, 2006; Haines Jr, Madill, & Riding, 2003; Kelman, 2002), whose works claim that financial institutions, due-diligence private investors, etc. look for investment opportunities inside and outside their geographical locations. The search is so intense that scholars like Zelitchenko (2009) recommend investors should go to the digital world and social networks for these opportunities. It has resulted in an astronomical need for technical and fundamental analysts in the market (Murphy, 1999). While investors are seriously on the lookout, the desperateness of African countries to attract foreign direct investment can never be overestimated (Osei-Fosu and Osei-Fosu**,** 2014). This statement is empirically supported by scholars (Constant & Tien, 2010; Thupa, 2019). In the same vein, there is a constant noise that Africa is the best place to invest if you want the most out of your investment (Arunga, 2008). It appears to be the newest destination for emerging market investors; the continent is expected to double household consumption by 2030 (Signé, 2019). Not discounting all the above-stated investment opportunities Africa has to offer, the continent continues to struggle to attract investors (Pueyo, Spratt, Bawakyillenuo, Hoka & Osiolo, 2017; Enria, 2015). Both local and foreign investors search elsewhere for investment opportunities, while the continent of Africa is screaming with countless ones (Troost, 2018; Boya, 2016; Ndulu, & Kiweu, 2015; Ndulu, 2010).

The age-old, seemingly-justified, but not empirically-verified argument that the continent of Africa is the riskiest place on earth to invest continues to propagate unfortunate treatment for all (Dmitriev, 2018; Mensah, 2016, March; Vasić, Bubaš, & Dario, 2016,

January; Frobenius, n.d). Given the countless investment opportunities on this continent, how did the conclusion or claim regarding risk ever come about? Numerous armed conflicts on the continent (Berman, Couttenier, Rohner, & Thoenig, 2017; Williams, 2016), including insurgencies (Kleynhans, 2019; Bøås, 2019), militants (Awuni, 2013), insecurities (Chigbu, Paradza, & Mwesigye, 2019; Mawere, 2018), corruption (Fombad, 2020; Steytler, 2020; Adam, 2020), diseases (Iyioke, 2019) are quickly blamed as the reason. The list will go on and on to claim why the continent is the riskiest place on earth in which to invest (Becker & Payo, 2013). But is there any empirical evidence to support this age-old claim, other than what people have been made to believe? Is there any empirical evidence of risk-comparative analysis for investment opportunities among continents in which Africa has been deemed the riskiest? Unfortunately, a search for answers to these questions and many more related questions has proved futile. Without legitimate and empirically-verified answers to these questions, the continent will continue to lose opportunities due to these unvalidated beliefs. Good-willed individuals who are looking for the highest return from their investments will settle for suboptimal since the optimal has been relegated to an unfavorable position. The quest to find answers to these concerns and other thought-provoking questions has led to the investigation of this issue, and hence, this study. A study to offer legitimate answers to these questions has never been performed in the demographic and psychographic representation of Africa or any part of the world. Current research has essential relevance and significance, if for no other reason than to start a conversation that could lead to the idea and/or manifestation of investing in the continent.

It is imperative to investigate or, at least, help to estimate, the value of any would-be stock-purchasing risk investment from a country in Africa relative to other continents for the following reasons: First, this study can contribute to already existing literature that seems to lack information about a comparative analysis of the value of an investment that is at risk, given the country or continent in which the investment took place. It will also enrich and give future literature a new dimension since it aims to tread on a never-used theoretical framework of this phenomenon in a comparative manner. Second, attitudes, behaviors, and investment decisions toward idiosyncratic countries or continents will be critical factors influencing the development and management of "curse" resources (Paradox of Plenty) (Karl, 1997) in the future. "The resource curse, also known as the paradox of plenty, refers to the paradox that countries and regions with an abundance of natural resources, specifically point-source non-renewable resources like minerals and fuels, tend to have less economic growth and worse development outcomes than countries with fewer natural resources" (Ross, 2015, p. 241). If found that the categorization of the continent as the riskiest on earth is a mere myth, then investors would have the confidence to invest. This could then lead to a restructuring of resources, since, at the moment, they cannot be easily transformed into consumables. Third, Africa could equally offer cheaper labor, as have several countries to the east. This study could make it clear that Africa is one more option in which to outsource if the idea is to access cheaper labor and not expose their investment to the highest risk. If this opportunity is embraced, it will offer the world and humanity uniform distribution of consumable production centers around the globe. This would be unlike the current situation where productions are situated in a few areas, hampering the world's efforts to stop epidemics and pandemics when they strike at production hops.

Once there is empirical liberation from this centuries-old unfair categorization, this will help African countries that have suffered unjustly. Investors looking for only dividends out of their investment do not even bother to consider Africa as their investment location because it is considered the riskiest continent in which to invest. For that same reason, it is equally suitable for good-willed individuals who are looking for the most out of their investments since, unlike before, they will not have to settle for suboptimal because the possibility of optimal is now in the equation. So, instead of spending time convincing investors that the continent is not the riskiest, the country will only have to advertise the opportunities it has to offer investors such as cheaper labor, available resources, etc.

On the flip side, if Africa is empirically established as the riskiest continent, then it must accept the challenge to change this in order to optimize its chances of gaining investments and improving the investment community’s future portfolio. Also, till

this status is changed, the critics, Africa, and its friends cannot blame investors for ignoring the continent.

Finally, non-governmental organizations, inter-governmental organizations, individuals, etc., who care about the stability of the world's monetary system, poverty reduction, healthy life, etc., will benefit from this knowledge and aid in their resource allocation campaigns, etc.

This study plans to do so by examining time-series data of the adjusted stock price of companies from different continents listed on the stock market. The process includes applying standard statistical procedures and Extreme Value Theory (EVT) to determine which continent's company stock has the highest value at risk or conditional value at risk. The model will then be evaluated by taking the data from Yahoo finance. The theory is extensively used and a popular conceptual framework for the likelihood of more extreme events than any already found. It has been used in several studies and many areas, including structural engineering, finance, earth sciences, traffic prediction, public health, and geological engineering.

Literature Review

Importance of uniform development

There are many familiar scenes worldwide, which include: inadequate infrastructural development for communities, cities, and countries; rising unemployment figures; porous security; corruption; mass migration; etc. It is not surprising for people to conclude that most of the above-listed problems are a result of each other. Nevertheless, could there not be some further explanation for these problems? Many scholars, researchers, and laymen have suggested (Antwi-Boateng, 2017; Isacson, Meyer, & Morales, 2014; Mawadza, 2008) or justified on some occasions that these factors affect the chances of attracting investment.

However, the importance of uniform development across continents, regions, countries, cities, and towns can never be overemphasized (Cheema, 2005; Qureshi, 2005). The importance and demand for it in the 21st century have been made apparent to humanity and systems by the surge in economic mass migration across continents, countries, and cities (Ketola, 2017; Lundgren, 2009). In some cases, those who do not migrate and stay behind may devour the environment for their survival (Masron & Subramaniam, 2019; Subramaniam, 2018), contributing to the current climate situation (Kolo, 1991). Others see it as a grossly unfair distribution of wealth, and this may result in the selective use of violence against people or groups felt to be the beneficiaries (Wojciechowski, 2017; Tasgin & Cam, 2016). Additionally, it becomes difficult or nearly impossible to stop a pandemic when it originates where production firms are situated (Didier, Huneeus, Larrain, & Schmukler, 2020).

Moreover, if these firms are the sole producers of a worldwide-needed product, it could conceivably put the whole of humanity at risk of extinction. All these happen in human history because jobs seem to have progressed in a few continents, countries, and cities, while most of the world population remains alienated from these advances (Ikhimwin & Obarisiagbon, 2020). It is the lack of uniform or adequate investment in certain parts of the world that has reinforced this dichotomy. The study feels some continents, countries, and cities, especially those in Africa, are not getting sufficient investment to channel their growth and development because investors fear losing their investments.

Inadequate Investment in Africa

Even though it appears as if the continent of Africa has inadequate investment opportunities, how can one tell? One way to show this is by examining what adequate investment leads to, comparing it to the current African situation, and seeing if they align. Conversely, scrutinize the contemporary African situation, and see if it depicts adequate investment. The latter is what this section will consider.

Several researchers and scholars (Rahman, 2020; Khan, Khan, Jiang, & Khan, 2020; Shaikh, Shaikh, & Talpur, 2019; Nanda, & Samanta, 2018; Gaal, & Afrah, 2017) have established that lack of infrastructure leads to a reduced standard of living, economic deficit, and poverty. Undoubtedly, most will agree that the effects of the lack of infrastructural development, as listed above, are the current definition of Africa (Dano, Balogun, Abubakar, & Aina, 2019; Chakamera, & Alagidede, 2018; Pieterse, Parnell, & Haysom, 2018). Knowing the devastating effects of a lack of infrastructural development on a country, and appreciating the idea that these are the typical scene in Africa, the next question is, what causes a lack of infrastructure? Several scholars, institutions, and researchers (Yilema, & Gianoli,

2018; Sewell & Desai, 2016; Mowarin & Tonukari, 2010) will ascribe several answers to this question, which include corruption, political influence, the inefficiency of the labor force, absence of incentives, poor accountability, and less political concern given to the sustainability of infrastructure service provision (Ngatia, Njoka, & Ndegwa, 2020; Kamoh, & Gyemang, 2018; Lawrence, 2016). All the above are legitimate causes of the lack of infrastructure development, but what we lose sight of is they can also be classified as byproducts of the lack of needed investment. For example, if the country's institutions are strengthened through the right education, personnel, resources, legislation, etc., corruption issues will be halted with these investments. If, in fact, it is empirically established that those mentioned above are the causes of the lack of infrastructure development, then they exist predominantly in African countries as a result of inadequate investment. By virtue of transitivity, we can claim that African countries are suffering from a lack of needed investment. But, how did investors decide to invest in some places but not others? Are the information and resources on which the investors based their actions and inactions empirically justified and legitimate?

Reasons for Choosing a Place for Investment

The fundamental reason for investing is an assurance of present and future financial security to acquire other services and fulfillment. Decision-making regarding investments is very crucial, given that both present and future needs are at stake. Understanding the factors that influence decisions as to where and in what to invest is vital, and is the purpose of this next section.

According to several scholars (Joshi, 2013; Horner & Aoyama, 2009), the cardinal factors that influence the decision as to what and where to invest are risk and reward; these two are highly intertwined (Bruce, Potter, & Roy, 1995). Thanks to a vast acquired body of knowledge, much work has been done, and markets, continents, countries, cities, towns, places, etc. have been classified in terms of how risky it is to invest in them (Butt, 2015; Rufino, Cariño, Ong, & Orbeta, 2013). Investment experts always advocate that investors should make sure the places in which they invest match the same level of risk they are willing or capable of taking on their portfolio (Pula, Berisha, & Ahmeti, 2012; Schooley, & Worden, 2003). Again, great work has been done on foretelling the level of risk for a place and aligning that with the risk level for an individual (Leiss & Nax, 2016; Terzić, & Milojević, 2013). The accepted norm for classifying place risk level is classifying place into developed and emerging markets (Worthington, & Higgs, 2004). Within these two big umbrellas, other factors such as security, economy, sector, market collapses, political upheaval, etc., should be considered to perceive the risk level. Once the place to invest has been identified, further investigation is needed based on other investment characteristics (demand, supply, security, stability, history, etc.) in order to determine the sector, even down to the very organization in which the investor wants to invest (Leiss, & Nax, 2016; Butt, 2015).

It must be acknowledged that investors can choose places, sectors, and the exact organizations in which they want to invest based on the risk, as discussed above, and the associated rewards. This idea welcomes the concept of investors' risk tolerance level, and most of the time, the higher the risk the investment imposes, the higher the returns of reward it offers, and vice versa (Zhang, Huang, & Zhang, 2015; Pula, Berisha, & Ahmeti, 2012). Hence having all these at their disposal, the investors need to evaluate their willingness to lose their investment should things go wrong, in exchange for its equivalent rewards should everything go according to plan (Pula, Berisha, & Ahmeti, 2012). This is the trickiest part of investment decisions but, most of the time, investors are guided through this by professionals. It must be noted that all the above is the conventional investment search by investors. Still, there are situations where others invest in a place or organization for other uncountable reasons, such as nonprofit purpose, emotional attachment, control, etc. (Dreyer, 2014; Micheels, Katchova, & Barry, 2004).

Methodology

This part consists of two sections. Section 1 discusses the data sources and variable measurements. Section 2 then presents our financial, econometric, and machine learning techniques and identification strategy. The financial, econometric, and machine learning technique follow four steps. The first step examines the stationarity or otherwise of the individual series by applying a standard unit root test to each of the time series. The second involves determining the apt model

that best fits the data for the risk measure trying several GARCH for a different order of the GARCH terms σ^2 and the ARCH terms ε^2 for both Gaussian and student-t innovation. The above precedes the idea that the individual series are stationary given the measures taken after the standard unit root test. The third step evaluates the risk measure based on Risk Metrics (VaR and ES), the extreme value situation (using the block maximum), and experiments with Generalized Pareto Distribution with a different threshold to ascertain whether Value at Risk and Expected Shortfall are not sensitive to the chosen thresholds. Finally, the study proceeds to verify if the finding is statistically significant by applying analysis of variance (ANOVA).

Variable Description

Since the study aims to measure and compare the risk (using VaR and ES) of the individual stock price, the main variables of interest in this study are the adjusted closing prices of the selected stocks. The adjusted closing stock price is the change in stock value due to new offerings from the organization. New offerings are when an organization may offer additional shares of stock, which is done to generate extra money. According to Ganti (2019), the adjusted closing price is considered the stock's actual price. It is often used when examining or performing a detailed analysis of historical returns. All the adjusted closing prices of the stocks used in this study are measured in United States Dollars (USD). The study considered the stock prices of companies in the special metal industry because it is the only industry that has received a reasonable investment in the continent of Africa when compared with other industries. Hence, a comparison of companies in this industry among several continents will be more fair and equitable than any other industry. One special metal mining company listed on the New York stock exchange was selected from every continent using a systematic random sampling of period five. It must be acknowledged that more than one company selected from each continent would make the study far more robust, but only one from each continent was considered due to resource constraints. The selected six companies were AngloGold Ashanti Limited in Johannesburg, South Africa (Africa); BHP Group PLC in Melbourne, Victoria, Australia (Oceania); ArcelorMittal S.A. in Luxembourg, Luxembourg (Europe); Nucor Corporation in Charlotte, North Carolina (North America); POSCO in Pohang-si, South Korea (Asia) and VALE S.A. in Rio de Janeiro, Brazil (South America).

Source of Data

The daily stock data was obtained from Yahoo Finance from 2003-06 - 2020:06. The said duration was used for the analysis because one of the companies selected for the analysis, BHP Group PLC, only had stock data from 2003-06-25. Table 1 shows the selected companies, their symbols on the New York stock exchange, and their location.

Table 1: Information on Selected Companies for the Study

Company	Symbols on New York stock exchange	Location (Continent)
AngloGold Ashanti Limited	AU	Johannesburg, South Africa (Africa)
BHP Group PLC	BBL	Melbourne, Victoria, Australia (Oceania)
ArcelorMittal S.A.	MT	Luxembourg, Luxembourg (Europe)
Nucor Corporation	NUE	Charlotte, North Carolina (North America)
POSCO	PKX	Pohang-si, South Korea (Asia)
VALE S.A.	Vale	Rio de Janeiro, Brazil (South America).

Model Specification

In order to undertake the empirical comparative risk analysis of the selected stock return from individual continents, there is first the need to control for random varying volatility of the financial time series data before the model of interest can be specified. The appropriate model that best fits the data for the risk measure is found by trying several GARCH for a different order of the GARCH terms σ^2 and the ARMA terms ε^2 for both Gaussian and student-t innovation.

Let $\{R_t\}$ be the time series of the selected companies' (AU, BBL, MT, NUE, PKX, Vale) returns and then

center the returns, thus $\underline{R_t} = R_t - \mu$, then GARCH$(p, q)$ + ARMA(u, v) is given as

$$\underline{R_t} = \phi_1 \underline{R}_{t-1} + \ldots + \phi_u \underline{R}_{t-u} + \varepsilon_t - \psi_1 \varepsilon_{t-1} - \ldots - \psi_v \varepsilon_{t-v}$$

$$\varepsilon_t = \sigma_{t/t-1} \varrho_t$$

$$\sigma^2_{t/t-1} = w + \alpha_1 \varepsilon^2_{t-1} + \ldots + \alpha_q \varepsilon^2_{t-q} + \beta_1 \sigma^2_{t-1/t-2} + \ldots + \beta_p \sigma^2_{t-p/t-p-1}$$

where ϱ_t is an independent and identically distributed (iid) random variable with mean zero and variance 1, and $\sigma^2_{t/t-1}$ is the conditional variance of $\underline{R_t}$ (Tsay, 2005).

Value at Risk(VaR)

i. Let t be the time index

ii. Let l be the periods of the financial position

iii. Let CV(l) be the change in value of the assets in the financial position from time t to $t + l$

iv. Let CDF be the cumulative density function of Generalized Pareto Distribution (GPD) as the two parameter distribution function below (McNeil e tal, 2005)

$$G_{\xi,\beta}(x) = \begin{cases} 1 - \left(1 + \frac{\varepsilon_t \xi}{\beta}\right)^{\frac{1}{\xi}}, \xi \neq 0 \\ 1 - exp\left(-\frac{\varepsilon_t}{\beta}\right), \xi = 0 \end{cases}$$

Where ξ is the tail index which is a measure of the shape of the tail,

$\beta > 0$ is the scaling parameter, and

$$\varepsilon_t \geq 0 \; when \; \xi \geq 0 \; and$$

$$0 \leq \varepsilon_t \leq -\frac{\beta}{\xi} when \; \xi < 0$$

v. Denote the CDF of CV(l) by $F_i(x)$

The VaR of a long position over the time horizon l with probability p under a probabilistic approach is given as $p\,[CV(l) \leq VaR] = F_l(VaR)$

For $CV(l) < 0$, the holder of a long financial position suffers a loss; the VaR above typically assumes a negative value when p is small, signifying a loss.

For $CV(l) < 0$, the holder of a short position suffers a loss when the value of the asset increases), hence VaR is defined as $p\,[CV(l) \geq VaR] = 1 - [CV(l) \leq VaR] = 1 - F_l(VaR)$

The VaR is concerned with tail behavior of the $F_i(x)$. The left tail of $F_i(x)$ is important for a long position (adopted for this study), while the right tail of $F_i(x)$ is for a short position. If $F_i(x)$ is known, then VaR is the same as pth quantile x_p

$$VaR = x_p$$

$$x_p = inf\{x / F_l(x) \geq p\} \; for \; 0 < p < 1$$

where inf denotes the smallest real number satisfying $F_i(x) \geq 0$ (Tsay, 2005)

Peak Over Threshold Approach VaR

Homogeneous case (parameters are fixed over time)

$$VaR = \begin{cases} \beta + \frac{\alpha}{k}\{1 - [-D(ln(1-p)^k]\} \; if \; k \neq 0 \\ \beta + \alpha\{-D(ln(1-p))\} \; if \; k = 0 \end{cases}$$

where D is the baseline time interval, mostly the number of days trading in a year, used in estimation.

Non-homogeneous case (parameters are time-varying, according to some explanatory variables).

$$VaR_q = u + \frac{\beta}{\xi}\{1 - [\frac{T}{N_u(1-q)}]^{\xi}\}$$

where u is the threshold,

T is the sample size,

N_u is the number of exceedances,

$\beta \; and \; \xi$ are the scale and shape parameters of the GPD (Tsay, 2005).

Expected Shortfall (ES)

$$ES_q = E(L / L > VaR_q)$$

Generalised Pareto Distribution GPD Approach to ES

$$ES_q = \frac{VaR_q}{1 + \xi} + \frac{\beta + \xi u}{1 + \xi}$$

Results and Analysis

The discussions and the results are presented in four steps. First, we discuss the stationarity or otherwise of the individual series by looking at individual series plots and presenting standard unit root test results. The second step involves presenting the results and analysis of GARCH (Gaussian and student-t innovation), given that the individual series are found to be non-stationary. The next step is to present and discuss the results for the risk measures (VaR and ES) after the best GARCH model is selected using AIC and BIC parameters. Finally, the study presents and discusses the results of the analysis of variance (ANOVA).

Time Series Plot

Figure 1 is the time series plot of the daily adjusted stock prices retrieved from the Yahoo finance repository for the six randomly selected companies.

Starting from the earliest date under consideration, all the stock prices appeared to exhibit random upward trends, even though they were mired with occasional insignificant dips. However, all made a significant downward trend in 2008, to the extent that some of the stocks have never fully recovered from that shock. Nonetheless, they all reverted to the initial behavior exhibited before the 2008 dip. The behavior shown by individual series means they are non-stationary, but formal approaches such as the augmented Dickey-Fuller test and the Phillips and Perron test are needed to justify that empirically.

Unit Root Test

The time-series properties of the variables are determined individually. The formal approaches used to ascertain the order of integration, as stated above, are the ADF and PP tests. ADF and PP tests are executed for this purpose, and the results are presented in Table 2. The results indicate that the null hypothesis of unit root cannot be rejected at the log level, irrespective of whether a deterministic trend term is included or not. BBL, NUE, PKX, and VALE for the ADF test and AU and MT (OILP) for the PP test with the linear trend are, however, stationary at the log level, thus integrated of order zero I(0). The first differencing of the rest of the variables achieved stationarity, which indicates that the order of integration for the other variables, aside from the above listed, is of order one, I(1), and thus non-stationary.

The main objective is to determine the order of integration of each variable, and how many times a variable has to be differenced for the series to achieve stationarity. This implies that a shock to any of the non-stationary variables would have a permanent effect. The variables thus illustrate the absence of a mean-reverting process. The order of integration is essential here since most time series variables are non-stationary, and using them in a regression might lead to spurious relationships, even if the regressors are exogenous (Granger, 1969). Even though some of the series are empirically stationary at integrated of order zero I(0), when comparing Figure 1 and Figure 3 it is advisable to difference individual series since, other than few sparks which is still revert to the mean (Figure 3 does not show any evidence of a trend, unlike Figure 1).

Figure 3, the plot of the log first difference of the adjusted individual stock price, seems consistent with the ADF and PP outcomes. This goes an extra way to justify the need to integrate order one I(1) to make the series stationary. The idea that the analysis of the log first difference of the adjusted stock price is better than the adjusted stock price is supported by Figure 2, histogram of the adjusted stock price, as when compared with Figure 4, the log first difference of the adjusted stock price. The histograms of the adjusted stock prices have asymmetrical distributions while the histograms of the first difference of the adjusted stock prices are approximately symmetrical. According to Chen (2019), symmetrical distribution is used by traders to establish the value area for stock on a set time frame, and it is most often used to put price action into context. It must be acknowledged that in as much as the symmetric distribution helps in trading analysis, so too according to Chen (2019), skewness is often an essential component of a trader's analysis of a potential investment return.

The distribution of the transformed data is further verified by plotting a Q-Q plot. The Q-Q plot, which is a quantile-quantile plot, is a plot that helps to foretell if a set of data plausibly came from some theoretical distribution. Q-Q plot is a plot of two sets of quantiles against one another in terms of the axis. If the data is normally distributed, the plot, which is made up of scattered points, ends up being a straight diagonal line from the plot's origin to the upper right corner. Looking at Figure 5, it seems none of the variables is normally distributed. For that matter, there is a need to consider other distributions in the GARCH model, and then select the best, or most adequate, based on AIC and BIC parameters.

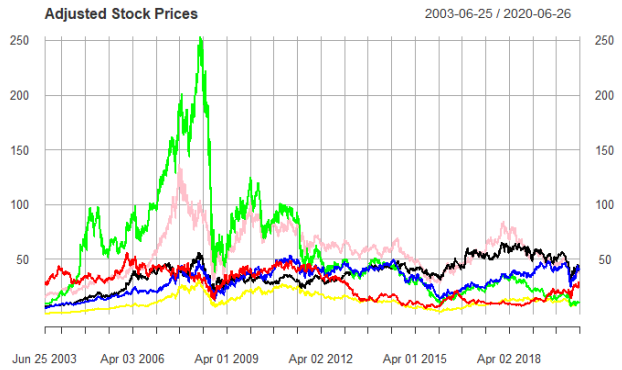

Figure 1: Time Series Plot of all the Adjusted Stock Prices

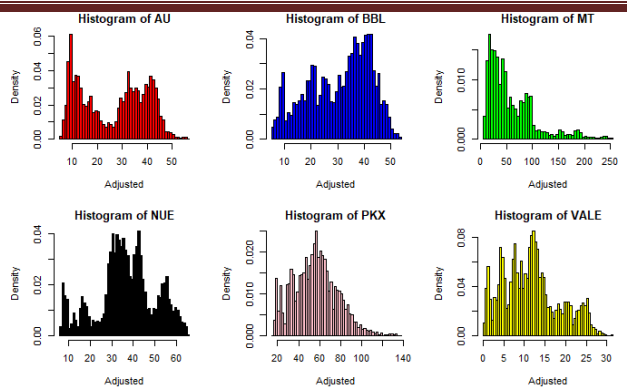

Figure 2: Histogram of the Adjusted Stock Prices

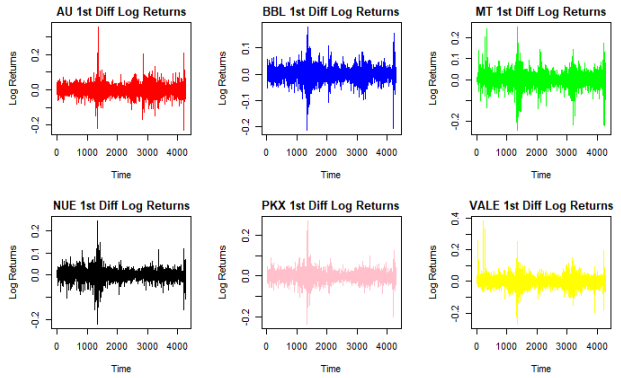

Figure 3: Plot of the Log Difference of the Adjusted Stock Prices

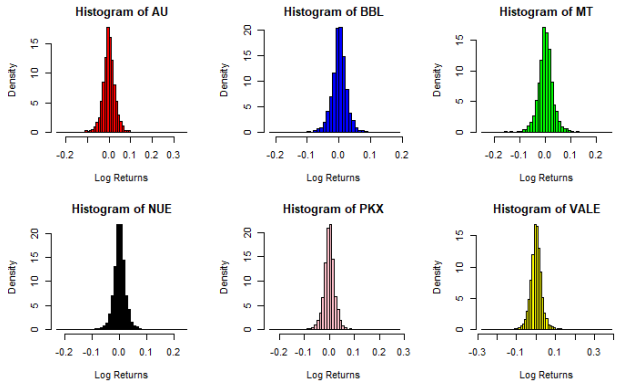

Figure 4: Histogram of Log Difference of the Adjusted Stock Prices

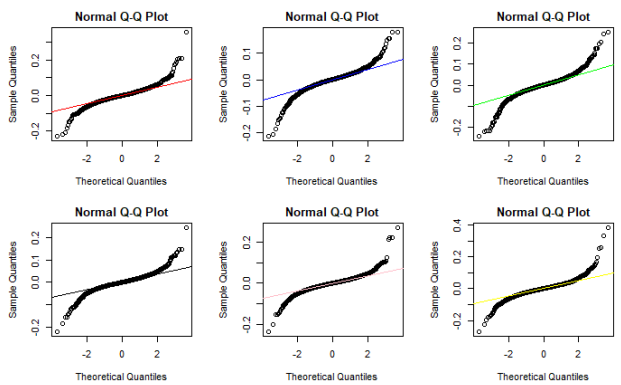

Figure 5: Normal Q-Q Plot

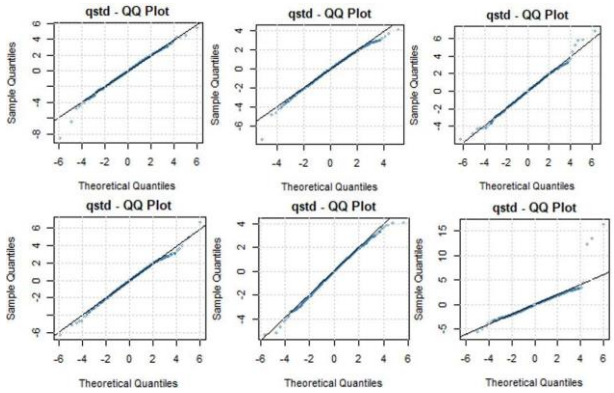

Figure 6: Qstd QQ plots of the Standardized Residuals of all the Stocks

Model Selection

Accurate modeling is of great importance to the financial world. Volatility clustering is a constant behavior of financial market data. Financial data's time-varying volatility is more common than constant volatility. This study acknowledges the need for better time series models. In its quest to model the non-constant volatility, the GARCH model was used because of its ability to model the conditional randomly varying volatility. With the intention of determining the GARCH model that best fits the data under consideration, the study trained several GARCH for a different order of the GARCH terms $\sigma^{2,}$ and the ARCH terms ε^2 for both Gaussian and student-t innovation, as seen in Table 3. The best model was selected using AIC and BIC outputs. Based on the AIC and BIC, the GARCH model that best fit the data was GARCH(1,1), order one of the GARCH terms σ^2 and order one of the ARCH terms ε^2 based on student-t innovation. It must be noted that the AIC and BIC values presented in Table 4 have been normalized by dividing by n (sample size). Hence, the actual values should be attained by multiplying by n = 4286.

GARCH Model

As stated above, the GARCH model selected for estimating the risk is GARCH(1,1) based on student-t innovation. The output of the model is presented in Table 5. In the output, autoregressive is denoted by ar1, mu denotes the mean, and the variance intercept is denoted by omega. Alpha1 denotes how volatility reacts to new information, and beta1 denotes the persistence of the volatility. From Table 5, all the stocks had statistically insignificant ar1 except MT

and VALE, implying that there is no amount of positive autocorrelation in all the stocks under study except for MT and VALE. Both alpha1 and beta1 are highly significant for all the stocks, which implies rather persistent volatility clustering, making GARCH an adequate model for the data.

The output in Table 6 also included tests applied to standardized residuals and squared residuals. The Jarque–Bera test of normality null hypothesis that the white noise innovation process is Gaussian is firmly rejected for all the stocks. Figure 6 shows qstd Q-Q plots of the standardized residuals of all the stocks, and they all nearly show a straight line except for a few outliers in the tails. The sample size is 4286, so the outliers are a tiny fraction of the data. Thus, given the above information, the t-model is suitable for the white noise. Still, for an adequate model, the study also considered Generalized Pareto Distribution (GPD) for the distribution's tail ends. The kurtosis output presented in Table 7 supports the recommendation of using GDP for the tail end of the distribution. The Ljung–Box tests with R are applied to the residuals, while the Ljung–Box tests with R^2 are applied to the squared residuals. At a stringent p-value of 0.01, none of the tests is significant, which indicates that the model fits the data well, except for the tail ends of the distribution, as noted earlier. Once again, at a stringent p-value of 0.01, the LM Arch Test is insignificant, indicating that the model fits the data well, as stated above.

Table 8 presents VaR and ES outputs using several approaches. The first block of the table presents VaR and ES using the Risk Metrics; the second block, Table 9, presents the Block Maxima Method to VaR calculation using Extreme Value Theory and the last block, Table 10 presents the Computation of Expected shortfall from Generalized Pareto Distribution. VaR and ES estimated using risk metrics were calculated for three different probabilities, as shown in Table 8.

For the probability of 0.95, which also means 95% confidence level, AU was estimated to have 6.17% and 7.77% of VaR and ES, respectively; while BBL was 4.74% and 5.92% of VaR and ES. MT was 8.04% and 10.06% of VaR and ES; while NUE was 5.84% and 7.29% of VaR and ES. PKX was 5.26%, and 6.59 of VaR and ES, and VALE was 5.14% and 6.43. It must be acknowledged that as the probability or level of confidence goes up, individual stock's percentage of loss in terms of VaR and ES goes up, and can be seen in Table 8. However, it must be pointed out that 95% or 99% or 99.9%, MT still had the highest percentage of loss, meaning it is the riskiest stock of all the stocks, followed by AU, NUE, PKX, VALE, and BBL. Thus, BBL was the least risky of all the stocks.

The study estimated the extreme value situation (using the block maximum approach) presented in the second block, Table 9. In that regard, the data was multiplied by a negative one, which means holding a long position. This is conceptually justified because if one wants extreme value, then by the bullish view, one has to hold stock for a long time with the expectation that it will rise in value. Again, in this situation, just like above, MT was established to be the riskiest stock to hold, but unlike above, it was followed by VALE, then AU, BBL, PKX, and NUE, meaning NUE was the least risky stock when the long position was held.

In the final block, Table 10, the study experiments with Generalized Pareto Distribution since it is often used to model the tails of another distribution, in this case, the Student T distribution. The study also experiments with different thresholds and 0.99 vectors of probability levels to verify if the Expected Shortfall is or is not sensitive to the chosen thresholds. It can be observed from Table 10 that the numbers for both thresholds are very close. Hence, it can be concluded that the Expected Shortfall is not sensitive to the chosen thresholds in terms of GPD. Unlike the other approaches discussed above, with ES based on GPD, the most risky stock is VALE, followed by MT, AU, BBL, PKX, and then NUE. Based on GPD as shown in Table 10, NUE is the least risky stock.

Based on the magnitude of individual stocks' VaR or ES, the study can rank the riskiest to the least. But the question is, are any of the stocks statistically significantly riskier than the other? The output of risk metrics was transformed into a data frame, and it was used to estimate one-way ANOVA, and the output is resulted in Table 11? From the ANOVA result, the study can establish that none of the stocks is statistically significantly riskier or less risky in which to invest than any other stock.

Conclusion, Findings, and Recommendations

Conclusion

Western countries, institutions, and people from all walks of life, including Africans, have carried the notion that it is riskier to invest in African countries

than countries in other continents. (Dmitriev, 2018; Mensah, 2016, March; Vasić, Bubaš, & Dario, 2016, January; Frobenius, n.d). The purpose of this study was to affirm/refute this notion as being empirically established or merely born out of imagination and unfounded belief. Based on that, this study stated and conducted the test hypothesis that Africa has not been treated fairly by investors due to the fear that their investment could be more at risk in Africa when compared to investing in another continent. The study applied advanced econometric, financial, statistical, and machine learning techniques. Unit roots in the variables were examined using the econometric techniques, the Augmented Dickey-Fuller (ADF) (Dickey & Fuller, 1981, 1979) test, and Phillips-Perron (PP) (Phillips & Perron1988), which are more powerful and widely used. Once the study found that all variables have unit roots, it proceeded by differencing the individual series of the stocks. It then continued to train Generalized Autoregressive Conditionally Heteroscedastic (GARCH) models because of its ability to model the conditional randomly varying volatility. The study tried several GARCH models for a different order of the GARCH terms σ^2 and the ARCH terms ε^2 and for different distributions. The best GARCH model was selected using the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Based on the AIC and BIC, the GARCH model that best fit the data was GARCH (1,1), that is, order one of the GARCH terms σ2 and order one of the ARCH terms ε^2 based on student-t innovation. It was empirically established that there was no positive autocorrelation in the stocks, and there was persistent volatility clustering, establishing GARCH as an adequate model for the data. Based on The Jarque–Bera test of normality and qstd QQ plots of the standardized residuals, it was established that the t-model is suitable for the white noise for an adequate model. The study considered Generalized Pareto Distribution (GPD) for the tail ends of the distribution.

In the first place, the study estimated the VaR and ES of individual stocks using the risk metrics approach. Based on that approach, as can be seen in Table 8, at a 99.9% confidence interval, MT, which is ArcelorMittal S.A. in Luxembourg, Luxembourg (Europe), is the riskiest stock. Thus, by investing in it, it is estimated that 15.04% of the investment will be at risk in terms of VaR and 16.38% in terms of ES. At the same confidence interval, the second riskiest stock is AU, AngloGold Ashanti Limited in Johannesburg, South Africa (Africa). It is estimated that 11.71% of the investment will be at risk using VaR and 12.77% in terms of ES. The least risky stock of all is BBL, which is BHP Group PLC in Melbourne, Victoria, Australia (Oceania), estimated that 8.81% of the investment will be at risk in terms of VaR and 9.59% in terms of ES. The outcomes of the rest of the stock investments from the other continents can be seen in Table 8.

Secondly, the study evaluated the VaR of individual stocks using the Block Maxima Method under extreme value situations. This was done to project outcomes when holding the stocks for a long with the expectation that the stock might rise in value. Based on that approach, as shown in Table 9, again the riskiest stock is ArcelorMittal S.A. in Luxembourg, Luxembourg (Europe), which estimated 7.81% of the investment would be at risk under extreme value situations. Under this condition, the second riskiest stock is VALE S.A. in Rio de Janeiro, Brazil (South America), estimated that 7.24% of the investment would be at risk, and AngloGold Ashanti Limited follows it in Johannesburg, South Africa (Africa), estimated that 7.22% of the investment would be at risk. Under this condition and approach, the best stock is Nucor Corporation in Charlotte, North Carolina (North America), with a 5.59% investment estimated at risk.

Finally, the study examined the tails of the individual distribution using Generalized Pareto Distribution. It is often used to model the tails of another distribution, in this case, the Student T distribution. In contrast to the conventional beliefs and purported gospel, Table 10 shows African stock was not the riskiest stock estimated to be 11.62%. Rather, South American stock was estimated to be 13.13%, the riskiest, followed by European, estimated to be 12.40%. The best stock in which to invest in this case is North American, estimated to be 9.08%.

It must be acknowledged and stated that none of the approaches or methods used in calculating VaR or ES of the randomly selected stocks from the six continents supported the conventional beliefs and age-long-held purported gospel that African countries are the riskiest in which to invest on earth. Using the risk metrics approach, African stock was found to be second riskiest to European stock, while in extreme

value situations, it was found to be third to European and South American, and using GPD, African stock was third once again to South American and European stocks.

The study proceeded to verify whether or not the findings and differences in VaR and ES between stocks were statistically significant. By using analysis of variance (ANOVA), as can be seen in Table 11, none of the differences in VaR and ES between stocks were statistically significant. This means that, statistically, the value and conditional value of one's investment that will be at risk is not different based on the continental location. Thus, it is not statistically riskier to invest in one continent than any other. In a nutshell, statistically, risk should not be the deciding factor when choosing an investment location, given the outcome of this study.

The question as to whether or not there could have been statistically significant differences among these stocks if other macroeconomic variables were included in the analysis, comes to mind with the result obtained at the end of the study. It is a legitimate question worthy of entertaining. The study did not revert to that thought, since it was beyond the research scope, restricting risk interpretation. It needs to be pointed out that although there are no statistically significant differences among these stocks as established, it is sometimes difficult to interpret the underlying fundamental economic reasons based on the outcome of the study.

Recommendations

There are important policy implications from the above findings. Studying and analyzing the value and the conditional value of the amount of one's investment that will be at risk among continents is vital for formulating policies that can help investors in their investment decisions and choice of investment locations. With this model, investors now know that there are no advantages in terms of the amount of their investment that will be at any greater risk due to the continent or the location in which they decide to invest. For that matter, investors will need to look at other factors that can help them in their investment optimization, instead of worrying about conventional beliefs and the age-long-held purported gospel that African countries are the riskiest in which to invest on earth. This will help African countries who have suffered the wrath of this centuries-old unfair categorization now that there is empirical liberation. Before this model, investors looking only for dividends out of their investment would not even bother to consider Africa as their investment location, due to the riskiest tag attributed to the continent.

It is equally useful for good-willed individuals who are looking for the most out of their investments; they will not have to settle for suboptimal with the possibility of optimal in the equation. Additionally, it is good for the continent, since now it only has to advertise the opportunities that the continent offers investors, such as cheaper labor, available resources, etc., and not how it is not the riskiest in which to invest. Nevertheless, it must be pointed out to the continent that, as a result of the long-term neglect by investors, it will need to aggressively develop its financial market to take advantage of the current bliss this study is hoping to offer. The development of the financial market will significantly affect the economy, given the proposed parity in investment opportunities with other continents. With these results, it is essential to highlight a need to implement prudent macroeconomic policies for the continent to derive maximum benefits from the rightfully embraced fact of fortune. To enable the capital market, in general, and the derivative market, in particular, to take full advantage of the various opportunities and cope with the expected challenges, the interest rates, and inflation must be reduced, rather than spending critical and lengthy time on looking at foreign exchange rate movement. This must be done with appropriate monetary policies to ensure macroeconomic stability.

The world and most investors have been fearful of the amount of risk their investments could be subjected to if invested in Africa due to the unsubstantiated conventional belief. If the idea is to access cheaper labor, and also not expose their investment to the highest risk, this study shows that Africa can also be a place in which to outsource. If this opportunity is embraced, it will offer the world and humanity uniform distribution of consumable production centers worldwide, unlike the current situation where productions are situated in few areas hampering the world's efforts to stop epidemics when they strike at production hops.

Practical Limitation

It now seems to be a fact that any study involving an African country or the continent will be limited by

data quality. This study would be far more profound and robust if stocks of companies from several sectors of the world economy were used for the analysis. However, due to centuries of neglect of the African continent by investors, which is the main idea of the study, several of these sectors in the African economy are not developed well enough to be considered for any meaningful comparison against the same sectors in other continental economies. For that reason, the study could only consider one sector for the complete analysis, the mining sector. The mining sector is the only sector worthy of meaningful comparison in the African economy that the study feels is developed to almost the same standard as those in other continents. The study could also be limited due to the selection method of companies from individual continents for the analysis. A better knowledge of all the mining companies in every continent and selecting them randomly for the continental representation of the study would have been better than googling for all the mining companies in a continent and selecting using systematic random sampling. Finally, the study could be far more robust if a significant number of the approaches used in evaluating risk were considered, instead of just the three used by this study.

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Table 2: Formal Unit Root Test

Variable	ADF Test Statistic			PP Test Statistic		
	Constant	Trend Levels	First Differences	Constant	Trend Levels	First Differences
Ln AU	0.0442698	-0.0016529	-0.0337372*	9.810e-02**	-2.790e-05*	9.963e-01***
Ln BBL	0.0847775**	-0.0024877*	-0.0513969***	1.061e-01**	1.111e-05	9.968e-01***
Ln MT	0.0757122	-0.0012707	-0.0406684**	1.430e-01*	-7.951e-05*	9.976e-01***
Ln NUE	0.0950681*	-0.0023655*	-0.0827590***	1.972e-01***	3.673e-05	9.948e-01***
Ln PKX	0.158756*	-0.002734*	-0.039419**	1.587e-01*	-1.401e-05	9.973e-01***
Ln Vale	0.0238162*	-0.0018326*	-0.0148477	2.346e-02*	-3.524e-06	9.982e-01***

S	Table 3: Model Comparison					
	Normal Distribution			Student's T Distribution		
M	ARMA(1,1) + GARCH(1,1)	ARMA(2,1) + GARCH(2,1)	ARMA(2,2) + GARCH(2,2)	ARMA(1,1) + GARCH(1,1)	ARMA(2,1) + GARCH(2,1)	ARMA(2,2) + GARCH(2,2)

Table 4: Akaike Information Criterion (AIC) / Bayesian Information Criterion (BIC)

	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
AU	-4.3509	-4.3419	-4.3494	-4.3375	-4.3509	-4.3360	-4.4005	-4.3901	-4.3995	-4.3861	-4.3991	-4.3827
BBL	-4.8138	-4.8049	-4.8135	-4.8016	-4.8148	-4.7999	-4.8357	-4.8253	-4.8351	-4.8217	-4.8339	-4.8176
MT	-4.2886	-4.2796	-4.2875	-4.2756	-4.2890	-4.2741	-4.3408	-4.3304	-4.3395	-4.3261	-4.3399	-4.3236
NUE	-4.9468	-4.9379	-4.9467	-4.9348	-4.9462	-4.9313	-4.9899	-4.9795	-4.9896	-4.9762	-4.9899	-4.9735
PKX	-4.8926	-4.8837	-4.8921	-4.8802	-4.8917	-4.8768	-4.9211	-4.9107	-4.9207	-4.9073	-4.9204	-4.9040
VALE	-4.2213	-4.2124	-4.2216	-4.2097	-4.2214	-4.2065	-4.3567	-4.3462	-4.3562	-4.3428	-4.3555	-4.3392

Table 5: Error Analysis

Parameters	AU		BBL		MT		NUE		PKX		VALE	
	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
mu	-7.7e-5	0.644	1.1e-3	0.073	2.6e-4	NA	6.8e-4	0.049	5.6e-4	0.209	1.3e-3	0.034
ar1	5.5e-1	0.168	-2.4e-1	0.676	6.2e-1	NA	-2.6e-1	0.293	-2.4e-1	0.698	-6.1e-1	0.006
ma1	-5.7e-1	0.147	2.2e-1	0.688	-6.2e-1	NA	2.1e-1	0.412	2.4e-1	0.695	6.4e-1	0.003
omega	5.9e-6	0.001	4.9e-6	0.000	1.1e-5	0.000	4.0e-6	0.000	4.0e-6	0.001	1.4e-5	5.9e-5
alpha1	4.4e-2	1.3e-14	6.0e-2	< 2e-16	7.1e-2	5.8e-12	5.1e-2	1.2e-12	5.3e-2	5.3e-15	5.8e-2	3.8e-11
beta1	9.4e-1	< 2e-16	9.3e-1	< 2e-16	9.1e-1	< 2e-16	9.4e-1	< 2e-16	9.3e-1	< 2e-16	9.2e-1	< 2e-16
shape	6.6	< 2e-16	9.4	4.5e-14	6.175	< 2e-16	6.710	< 2e-16	7.482	< 2e-16	6.559	< 2e-16

Table 6: Standardised Residuals Tests

Tests	Statistic	p-Value	Statistic	p-Value	Statistic	p-Value	Statistic	p-Value	Statistic	p-Value	Statistic	p-Value
Jarque-Bera	1404.9	0	391.30	0	999.83	0	712.26	0	280.26	0	118269	0
Shapiro-Wilk	0.9816	0	0.9907	3.7e-16	0.9815	0	0.9851	0	0.9906	2.8e-16	0.9182	0
Ljung-Box Q(10)	6.9743	0.727	8.0894	0.620	17.548	0.0630	4.3647	0.929	3.7507	0.958	17.149	0.071

Ljung-Box Q(15)	10.581	0.781	14.288	0.503	18.200	0.2522	10.914	0.759	7.1546	0.953	24.777	0.053
Ljung-Box Q(20)	14.537	0.802	17.593	0.614	31.239	0.0521	26.122	0.162	19.232	0.507	30.818	0.058
Ljung-Box R^2 Q(10)	6.1465	0.802	20.081	0.028	13.950	0.1753	20.583	0.024	19.288	0.037	1.2236	0.999
Ljung-Box R^2 Q(15)	8.0008	0.923	26.089	0.037	20.776	0.1441	25.362	0.045	22.6043	0.093	1.7516	0.999
Ljung-Box R^2 Q(20)	11.748	0.924	29.262	0.082	25.103	0.1975	28.110	0.107	25.9372	0.168	2.2967	0.999
LM Arch R TR^2	6.3814	0.895	23.493	0.023	18.048	0.1142	21.881	0.039	19.438	0.079	1.5979	0.999

Table 7: Symmetric Test						
Kurtosis	12.16094	10.29291	10.35899	12.28703	15.79347	15.82918

Table 8: VaR and ES Using Risk Metrics Approach

			BBL		MT		NUE		PKX		VALE	
	VaR	ES	VaR	ES	VaR	ES	VaR	ES	VaR	ES	VaR	ES
0.950	0.0617	0.0777	0.0474	0.0592	0.0804	0.1006	0.0584	0.0729	0.0526	0.0659	0.0514	0.0643
0.990	0.0878	0.1008	0.0666	0.0762	0.1134	0.1298	0.0820	0.0937	0.0742	0.0850	0.0725	0.0830
0.999	0.1171	0.1277	0.0881	0.0959	0.1504	0.1638	0.1084	0.1180	0.0985	0.1072	0.0962	0.1048

Table 9: Block Maxima Method To VaR Calculation Using Extreme Value Theory						
	0.07218284	0.05897343	0.07808176	0.05594045	0.05873252	0.07243328

Threshold	**Table 10: Computation of Expected shortfall From Generalized Pareto Distribution Parameters**					
0.02	0.1132879	0.09270069	0.1240665	0.08885494	0.09182042	0.1275974
00275	0.1161673	0.09328255	0.1240318	0.09083769	0.0929634	0.1312741

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '

Table 11: ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
VaR	Between Groups	.004	5	.001	1.274	.337
	Within Groups	.008	12	.001		
	Total	.012	17			
ES	Between Groups	.006	5	.001	2.056	.142
	Within Groups	.007	12	.001		
	Total	.012	17			