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Measurement Models for Market Risk Management in Nigeria

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Abstract: *Market risk is connected with the price fluctuations and other market factor movements on four of the most important economic markets: market of debt securities, stock market, currency market and commodity market. A major factor behind the rapid development of risk measurement and management is the high level of instability in the market in which firms operate. A volatile environment exposes firms to greater market risk, and therefore provides an incentive for firms to find new and better ways of modeling the risk. This paper generally analyses the performance of different models which try to solve, estimate, measure and manage various market risks in order to derive parameters which aid good decision making.*

Keywords: *Insurance market risk, volatility, risk management, value at risk (VaR).*

1.0 INTRODUCTION.

1.1 Background to the Study

According to Ama (2009), risk is the possibility that positive expectations of a goal oriented system may not be fulfilled. Anghelache, Voineagu, Culetu and Baltac (2013) viewed market risk as the risk of losses in positions arising from movements in market prices and other risk factors. There is no unique classification of market risks as each classification may refer to different aspects of market risks. Nevertheless, the most commonly used types of market risks are; equity risk, interest rate risk, currency risk, commodity risk, margin risk, shape risk, holding period risk, basis risk, image/reputational risk and so on. The risk that stock indices/prices or their implied volatility will change is known as the equity risk while the interest rate risk is the risk that interest rates or implied volatility will change. The risk of changes in foreign exchange rates is the currency risk. Margin risks result from uncertain future cash outflows due to margin calls covering adverse value changes of a given position. Image risk concerns itself with the reputation of an organization. If the image/reputation is dented in one way or the other, businesses in that market will be affected adversely. An example of this in Nigeria in 2017 was the case between the GTBank versus the chairman of Innoson Vehicle Manufacturing (IVM), Dr Innocent Ifediaso Chukwuma. Another illustration is the harm non-settlement of claims has done to the reputation of insurance industry in Nigeria.

All these market risks pose threats to the attainment of major objective and to maximization of advantages (such as the utility for the consumers and profit for the enterprise). All businesses take risks based on two factors; the business analysts' view of likelihood/probability of loss occurrences and view of money based on wealth (Banjo, 2019). Market risk is connected with the price fluctuations and other market factor movements on four of the most important economic markets: market of debt securities, stock market, currency market and commodity market.

1.2 Problem Analysis.

The great treasure which lies in the market is directly related to the adequate awareness of movements of prices and other market related factors which help to combat the adverse effects of various market risks. Salient potential in the market is left untapped due to absence of adequate skills or knowledge in recognizing appropriate future estimates of the treasure. Therefore, a framework is needed to measure market risk adequately so that the level of any uncertainty can be reduced to the barest minimum, if not totally eradicated. Lack of proper understanding of the true market state in Nigeria has influenced unnecessary inflation and scarcity of goods / products. It must be noted that certain aspects of many of the risk measurement / management standards have come under criticism for having no measurable improvement on market risks, whereas the confidence in the estimates and decisions seems to increase. Also, the variance, covariance and historical Simulation approaches to calculating VaR assume that the historical correlations are stable and will not change in the future or breakdown under times of market stress (Langrin and Roach, 2009). The duration periods of high volatility and market turbulence make this assumption inappropriate as historical correlations tends to break down, especially during financial crises where all industry sections experience a significant increase in correlations as opposed to an upward trending market. This phenomenon known as asymmetry correlation/dependence has great impacts on the market value.

The potential loss amount due to market risk may be measured in a number of ways/conventions. In a short term risk management practice, the conventions of value at risk (VaR) models are well established and accepted. It must be noted that VaR contains a number of limiting assumptions that constrain its accuracy. It is assumed that the composition of the portfolios measured remains unchanged over the specific period. As a matter of fact, this limiting assumption can be regarded as unreasonable over longer time horizons as many of the positions in the portfolio or market values may have been changed because we live in a dynamic world. The only thing constant is change.

One of the major problems in insurance business is claim settlement. It is of no news that many insurers in Nigeria are or have been involved in litigations as a result of non-settlement of claims. This situation has really affected the image/growth of the industry negatively. This problem arises when a claim or an insurance market risk which has a 100% probability of occurring is ignored due to lack of identification ability or wrong usage of underwriting risk model (such as using individual underwriting risk model for collective underwriting risk model and vice versa). The risk and return of insurance business is directly related. That is, the higher the risk the higher is the likelihood/probability of the returns. It may be too risky to invest insurance funds on securities of higher interest returns because higher returns also go hand-in-hand with high security volatility which can lead to loss of invested funds. Loss of invested funds will in turn affect insurance claim settlement. Therefore, there is a need to balance the discrepancy between the actuarial and the financial methods of assessing and measuring insurance risks, especially when dealing with single and group policies.

1.3 Objective of the Study

To manage markets risks effectively, one needs to critically identify, actuarially assess and carefully prioritize the identified and assessed risks through the usage of an appropriate market risk model. The general objective of this study is to analyse the performance of different models which attempt to solve, measure and manage various market risks in order to derive estimates or parameters which appropriately aid decision making process and reduce/predict what the potential risk scenario could be. Therefore, the specific objectives, which must be attained in the course of this research work, are listed below.

- To develop a framework that will make future estimates/forecasts/predictions more reliable and authentic.
- To exhibit how a certain change in interest levels can impact on the market value.
- To modify concepts of VaR Model in order to aid informed decision making over longer period horizons.
- To derive an appropriate market risk model for a single policy and the overall market risk for a group of policies, whose volatility/deviation (of expected claim value and actual claim incurred) will be insignificant.

1.4 Research Questions

In this study, the following research questions must be addressed in precise format.

- How can we make our statistical estimates to measure market risks adequately in order to reduce uncertainty levels to the barest minimum?
- How can duration periods of high volatility and market turbulence during financial crises affect market value?
- How do other moments (third and fourth) help to modify VaR Method of risk measurement/modeling?
- How can we strike a balance between the actuarial and the financial methods of assessing insurance market risks in order to combat claim settlement problems?

1.5 Scope and Limitation of the Area of Study.

This study generally focuses on the analysis of various models that attempt to proffer solutions to market risk problems. Its scope shall be limited to situations in Nigerian markets (financial and insurance), although references will be made to global situations. The major limitation envisaged in this study is likely to be difficulty in getting appropriate/relevant data and/or unwillingness of market operators to release sensitive data for analysis for the fear of falling into the hands of competitors or leaking their financial operations/information to wise customers who can use such information against them in making more profit for themselves which leads to no or low profit for the servicing operators.

1.6 Significance of the Study

There is need to control various market risks and balance the possibility of gains. The dynamic interdependencies of market risks are determined by the optimal management of each type of market risks earlier mentioned, taking into account the models / systems of risks and potential for transformation of the risks. A major factor behind the rapid development of risk measurement and management is the high level of instability in the market in which businesses operate. The result of this study will be of great use to financial players/stakeholders in the market. It may also serve as an asset to students/lecturers and others in the related field of study. Finally, the study will be of immense benefit to policy makers, investors and the general public.

2.0 THEORETICAL OVERVIEW

According to Navarrete (2006), Monte-Carlo simulations with all specific multivariate models are excellent alternatives to the variance covariance and historical Simulation approaches to calculating VaR. They improve the estimation of the variance covariance matrix. One can generate a forecast of asset distribution via Monte-Carlo simulation based upon the Gaussian copula and well specific marginal. Allowing the modeling process to allow for empirical characteristics in stock returns (such as auto-regression, asymmetric volatility, skewness and kurtosis) is deemed important. Not accounting for these attributes lead to severe estimation error in the correlations and variance covariance that have negative bases. Fluctuations in market prices and other market factors play major role on the market value of an investment. A model risk is one of the most important and least appreciated areas of market risk measurement and modeling. It casts its shadow over everything in risk management, and prudence suggests that we should take it seriously. We rely on statistics and indices to provide us with an estimate of volatility. We should keep asking ourselves what would happen if our assumptions fail.

2.1 Financial Risk

According to Andre J. Blaauw, the Group Chief Risk Officer at United Bank for Africa PLC in 2009, market risk may arise when banks accept financial instruments exposed to market price volatility as collaterals for loans. Poor market risk management practices can lead to significant losses very quickly in volatile market conditions and also complete institutional collapse in severe situations. Kallestrap (2012) pointed out that the global market crisis has shown that markets are becoming more integrated, more complex and more volatile than what was commonly/previously known. The management of market risk is highly complex but size of the market risk exposure can be reduced in such a way to allow banks avoid potential losses that can be incurred under extreme and adverse market volatility (Hubbard, 2009).

The loss of finances as a result of the instability in the market has resulted to the steady decline of our economic base and foreign reserve. This has equally discouraged small and medium enterprises which are one of the cardinal thrusts of any economy. In banking, the knowledge of market risks and how to model them are very crucial to successful business operations. Enyi and Adebawo (2014) suspected that the collapse of the banking system witnessed in Nigeria in 2008 was as a result of improper risk assessment and exposure model. Portfolio selection theory and capital asset pricing model should be reviewed periodically in order to guide investors on risk of loss of financial value due to fluctuations in market prices and other factors as many forms of market risks arise. The most spectacular case of market risk management failure is bankruptcy. Deriving variance parameters from historical markets rates data can help to estimate, for a given statistical confidence limit, what the potential risk scenario could be. Elton and Gruber (1995) described Interest rate risk as the probability that variations in the interest rates will have a negative influence on the given financial instrument or portfolio. Emilia (2010) mentioned that discrepancy analysis, simulation method and duration method are the most frequently used method for measuring bank interest rate risk. The difference between the interest sensitive assets and liabilities over a particular period of time is measured by the Discrepancy Analysis Method. A bank will have a positive discrepancy when the sum of the assets being evaluated over a particular period is bigger than that of the liabilities. If a bank has a negative discrepancy and the interest rates rise, the net interest income will decrease as there are more liabilities than assets at higher interest rates.

In the same vein, revenues will also decrease if the bank has a positive discrepancy and the interest rates drop. Therefore, the discrepancy helps to show the risk to which interest income is exposed. Unfortunately, this method does not register changes in payment dates which can occur as a result of interest environment changes. This method is suitable when there is identical movement of interest rates. A new model is necessary because the dynamic markets comprise non-similar movement of interest rates over different periods. The simulation method is based on the fact that the interest rate changes are not statics but dynamic. Monte-Carlo simulation is used as a standard for the evaluation of portfolios, and incorporates many market variables. But in order for this model to be reliable, it is necessary at each calculation to perform a sufficiently large number of repetition/recalculation. This is a very demanding task in terms of computing power. Due to the demands and complexity of this system, it is sometimes difficult for a bank's management to keep tract of what their risk managers are actually doing

Profit/loss is uncertain due to movement of the market factors. Therefore, a framework is needed to measure financial risk effectively. Berkowitz (2001) believed that the traditional solution is to assume a mean-variance framework. That is, we model market risks in terms of mean and variance or standard deviation of profit / loss. Nonetheless, the assumption of normality has its limitations as the distribution requires only two parameters (i.e. first moment (mean) and second moment (variance) (Dowd K, 2002). According to Elton and Gruber (1995), a good example is portfolio theory whose starting point is the assumption that the behaviour of the returns to any set of assets can be described in terms of a vector of expected returns and a variance-covariance matrix that capture the relationship between individual returns. As stated earlier, a deeper problem with VaR is that it is not sub-additive. In order to modify this problem, we need first to introduce the notion of sub-additivity. A risk measure p(·) is said to be non sub-additive if the measured risk of the sum of positions X and Y is less than or equal to the sum of the measured risks of the individual positions considered on their own.

i.e.

$$P(X+Y) \leq P(X) + P(Y) \quad \text{……(1)}$$

Sub-additive means that aggregate individual risks do not increase overall risks. If risks are sub-additive, then adding risks together would give us an overestimate of combined risk, and this means that we can use the sum of risks as a conservative estimate of combined risk. This facilitates decentralized decision making within a firm, because a supervisor can always use the sum of the risks of the units reporting to him as a conservative risk measure. But if the risks are not sub-additive, adding them together gives us an underestimate of combined risks, and this makes the sum of risks effectively useless as a risk measure. In risk management, we want our risk estimates to be unbiased or biased conservatively. Sub-additive is thus a highly desirable property for any risk measure. Unfortunately, VaR is not generally sub-additive, and can only be made to be sub-additive if we impose the usually impossible assumption that Profit/Loss or returns are slightly more generally or normally distributed. Also, coherent risk measures correctly reflect diversification effects and facilitate decentralized decision-making by satisfying the sub-additive condition.

For instance, if X and Y are the future values of two risk positions, a risk measure p (·) is said to be coherent if it satisfies the following properties:

$P(X) + P(Y) \leq P(X+Y)$ (sub-additivity) ……(2)

$P(tX) = tP(X)$ (homogeneity) ……(3)

$P(X) \geq P(Y)$, if $X \leq Y$ (monotonicity) ……(4)

$P(X+n) = P(X) - n$ (risk-free condition) ……..(5)

Where

n = any number

t = positive number

The sub-additive property has already been explained. The homogenous and monotonous properties are reasonable conditions to impose a priori, and together imply that the function $p(\cdot)$ is convex (Scaillet, 2000). The last condition means that the addition of a sure amount **n** to the position will decrease the risk by same amount, because it will increase the value of the end-of-period portfolio. The coherent risk measure can be regarded as the maximum expected loss on a set of loss values and their associated probabilities.

Risk modeling uses a variety of techniques in order to analyse a portfolio and make forecasts of the likely losses that would be incurred for a variety of risks. In financial risk modeling, econometric techniques are used to determine the aggregate risk in a financial portfolio (Almgren & Chriss, 2002). Many large financial intermediary firms use risk modeling to help portfolio managers assess the amount of capital reserves to maintain and to help guide their purchase and sales of various classes of financial assets. The past risk analysis was done qualitatively but now, with the advent of powerful computing software, quantitative risk analysis can be done quickly and effortlessly.

According to Mandelbrot and Richard (2006), modeling the changes by distributions with finite variance is known to be inappropriate. They found that changes in prices in financial markets do not follow a Gaussian distribution. Large changes up or down are more likely than what one would calculate using a Gaussian distribution with an estimated standard deviation. Also, the fair value or future cash flows of a given financial instrument often fluctuate as a result of changes in the currency exchange rates. Understanding and management of risk in currency exchange rate volatility can be very complicated because there exists an imperfect correlation between currency exchange rates and interest market rates (Alexander, 2001).

2.2 Insuance Risk

The market risk load represents an equilibrium price on a competitive insurance market (Zhang, 2006). It is convenient to split the total risk load for a policy into the market risk load and the insurer specific risk load, and calculate each separately. Through premium payments, uncertainty of future loss is eliminated or reduced by the insured. The premiums collected by the insurer serve as the reward for taking the insured risk. Therefore, the premiums serve as the cost of the insurance market risk. The actuarial calculation of insurance market risk has experienced considerable change. In the classic premium principles, a risk load is determined by the volatility of the insured loss itself and the volatility is measured by the variance or the standard deviation. According to Zhang, these methods have been considered inadequate because they measure the insured's risk but not the insurer's risk.

A good insurance risk model should not only take account of the volatility of the policy loss but also the insurance company's portfolio and market competitive risk because insurance market is competitive and the market players are rational decision makers as the supply and the demand determine an equilibrium risk load. The frictional cost of capital is one of the risk items related to the capital structure of a particular insurer. So it is natural to split the insurer total risk into two classes, the market risk and the specific risk, which may be calculated separately. Kato and Yoshiba (2000) observed that the risk model reflects two major pricing views: the actuarial view and the financial view. The risk/return of the insurance companies is addressed under actuarial view while the financial view examines portfolio of shareholders. The actuarial method addresses a mutual selection but pays little attention to the shareholders' welfare. The two models complement each other.

2.3 Backtest and Stresstest

2.3.1 Backtesting

We can get more information about the adequacy or inadequacy of the risk model being used by backtesting. This procedure helps to evaluate the market risk model. In order to do so, a particular VaR confidence level, particular positions in market instruments, and a particular set of market price/return data must be specified. Back testing is the critical issue when assessing market risk model. It requires the application of quantitative statistical methods for the purpose of determining whether a model for market assessment is adequate or not. It can be used for three complimentary purposes. The first is to enable the reaching of the conclusion that the assessments are statistically compatible with the relevant outputs. It also aids risk managers when diagnosing problems that are faced with within their risk models. Lastly, it helps to rank the performances of several alternative market models. As in all models, the validity of the value at risks models should be tested regularly.

2.3.2 Stress Tests

In the similar vein, stress tests are needed to determine whether the financial institution is strong enough to overcome extreme shocks on the financial market. We need to stress-test historical parameters to ensure robustness of maximum loss estimates because historical volatility might not hold in the future. This is best done using simulation approach where a portfolio is run through a large number of potential market scenarios (Jamshidian & Zhu, 1997). The tests measure the influence of exceptional, but not impossible, market conditions on income or financial positions. In doing this, a decision should be taken on whether to stress just one variable over time or a set of several variables. The stress test results can be used for different purposes, such as risk reporting and identification, establishment of risk limits, capital allocation and premium adjustment. With stress tests, the effects of exceptional events in the market are analysed.

3.0 METHODOLOGY AND MODEL SPECIFICATION

3.1 Introduction

This section gives insight into how data/materials were gathered in relation to the study. It states some problems encountered in the process of data gathering. It also focuses on the various models and measures aimed at providing empirical support for the study.

3.2 Research Design

Design refers to the plan and strategy of investigation conceived so as to control variances (Asika, 2004). The collection of data is not limited to a particular method. Visits were made to experts, friends and family members in the relevant organizations for personal interviews and/or corporate observations. The major secondary data were gotten from the internet, periodic reports, forums, articles, newspapers, textbooks, paper presentations, journals and other publications of business or business related organizations.

3.3 Population of the Study

This study focuses on the analysis of Nigerian market risks through the use of different models. The geographical scope of the study is not only limited to Nigeria industries but can also be applied to general situations

3.4 Sample Size of the Study

Based on the models, analyses will be carried out on insurance and financial risks. Also, in order to have an incomparable success of this study, the major analysis will be done on the lending interest rates in Nigeria (from 1970 to 2018) obtained from the Central Bank of Nigeria. The focus is to derive estimates for future interest rates so that the market players can position/prepare themselves against adverse movements of these rates. The sample size is specifically based on the size of the population study.

3.5 Problems Encountered

The major problem in this research was the reluctance of financial organizations to give out their data to be used for a research purpose. Some declared that the major reason was to prevent competitors from having the opportunity or access to their secret through the detailed analysis of their raw data, while some hid under the pretence that a letter or directive must be issued from the office of the "Governor of Central Bank or President of the Federal Republic of Nigeria (GCFR)" before sensitive data could be released for a research purpose. This caused delay in the duration of the study. Also, figures of the major data obtained from different sources were slightly different form each other. For instance, a lending rate of 16.23% in a particular year from one source could be 16.22% in another source. This might be due to approximation or fluctuation problems. Steps were taken to reduce the effects of this to the barest minimum through effectively structured and carefully formulated models. Nevertheless, the quality of data collected/used was highly commended by concerned lovers of this area of study and recommended for new researchers or people directly involved in the study.

3.6 Model Specification

This section states the models to be used on the various measures that are aimed at providing empirical support for the study.

3.6.1 Financial Risk

VALUE at RISK (VaR) MODEL

Using a normal distribution, a random variable X is normally distributed with mean $\boldsymbol{\mu}$ and variance $\boldsymbol{\sigma^2}$ (or standard deviation $\boldsymbol{\sigma}$) for the probability that X takes the value *x*, *f*(x) obeys the following probability density function (pdf)

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left[(x-\mu)/\sigma\right]^2\right] \quad \text{.....(6)}$$

Where **x** is defined over $-\infty < x < \infty$

If the mean ($\boldsymbol{\mu}$) = o and the standard deviation ($\boldsymbol{\sigma}$) = 1, this is known as a standard normal

DURATION MODEL

To calculate the duration, one needs to calculate the Net Present Value (NPV) first.

The summation is then divided by the instrument value in order to arrive at the duration.

$$\text{NPV} = \sum_{i=1}^{n} \frac{P_i}{(1+r)^i} \quad \text{.....(7)}$$

Where i = year of payment
P = principal to be paid
r = interest rate

LEAST SQUARE MODEL

Table 1 will be analysed by Least Square Method which will give a practical estimate of the time trend. It is assumed that the trend is linear. Hence the equation of the linear trend is defined as:

$$\hat{\mathbf{Y}} = a + ь\,\mathbf{X} \quad \text{.....(8)}$$

Where:

X= transformed time (t)
$\hat{\mathbf{Y}}$= the estimated trend value for a given period
a= value of the trend line at time zero (i.e. @ t=0)
ь= the slope of the trend line (i.e. the change in $\hat{Y}$ per unit change in time)

Table 1: HISTORICAL LENDING INTEREST RATES IN NIGERIA (1970 - 2018)

YEAR	INTEREST RATE (%)	YEAR	INTEREST RATE (%)	YEAR	INTEREST RATE (%)	YEAR	INTEREST RATE (%)
1970	7	1982	10.25	1994	21	2006	16.90
1971	7	1983	10	1995	20.18	2007	16.94
1972	7	1984	12.5	1996	19.74	2008	15.48
1973	7	1985	9.25	1997	13.54	2009	18.36
1974	7	1986	10.25	1998	18.29	2010	17.59
1975	6	1987	17.5	1999	21.32	2011	16.02
1976	6	1988	16.5	2000	17.98	2012	16.79
1977	6	1989	26.8	2001	18.29	2013	16.72
1978	7	1990	25.5	2002	24.4	2014	16.55
1979	7.5	1991	20.01	2003	20.48	2015	16.85
1980	7.5	1992	29.8	2004	19.15	2016	16.87
1981	7.75	1993	36.09	2005	17.95	2017	17.88
						2018	18.00

Source: CBN Statistical Bulletin**(**www.cbn.gov.ng**)**

The constants **a** and **ь** can be calculated using:

$$ь = \frac{n\sum XY - \sum X\sum Y}{n\sum X^2 - (\sum X)^2} \quad \text{……(9)}$$

$$a = \frac{\sum X^2 \sum Y - \sum X \sum XY}{n\sum X^2 - (\sum X)^2} \quad \text{……...(10)}$$

At $\sum X = \mathbf{0}$;

$$ь = \frac{\sum XY}{\sum X^2} \quad \text{……...(11)}$$

$$a = \frac{\sum Y}{n} \quad \text{……...……(12)}$$

Standard Error of the estimate (**S_e**)

S_e is a measure that assesses the reliability of the result obtained. It measures the variability or scattering of the observed values around the regression line. It is evaluated using the formula below.

$$Se = \sqrt{\frac{\sum(Y - \hat{Y})^2}{n-2}} \quad \text{……...(13)}$$

3.6.2 Insurance Risk

Assuming an insurance market contains *N* policies with random losses $\mathbf{x_1}, \mathbf{x_2}$ ------- $\mathbf{x_N}$, where the market premium for policy ***i*** is $\mathbf{P_i}$. The premium will be invested in a risk free asset with rate of return $\mathbf{r_f}$. If $\mathbf{R_i}$ is the rate of return on premium, the mean and the covariance of the random returns are:

$$\boldsymbol{\mu_i} = E(R_i) = (1+r_f) - \frac{E(X_i)}{P_i} \quad \text{.....(14)}$$

$$\boldsymbol{\sigma_{ij}} = \text{Cov}\left(R_i, R_i\right) = \text{cov}\left(\frac{xi}{pi}, \frac{xj}{pj}\right) = \frac{1}{P_i P_j}\text{cov}\left(X_i X_j\right) \quad \text{……...(15)}$$

4.0 DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Insurance Risks

From the equations (14) and (15) stated in Section 3.6.2, it is easy to model the risk for a single policy **i** and the overall market risk for all **n** policies.

The risk of **ith** policy can be derived by multiplying the premium discount factor $\left(i.e\ \frac{P_i}{(1+r_f)}\right)$ by its expected value in equation (14).

$$\frac{P_i}{(1+r_f)} \text{ X } \mu_i = \frac{P_i}{(1+r_f)} \text{ X } \left[(1+r_f) - \frac{E(X_i)}{P_i}\right]$$

$$= P_i - \frac{E(X_i)}{1+r_f} \quad \text{……..(16)}$$

Also, for **n** policies, the overall market risk load is;

$$P^N - \frac{E(X^N)}{1+r_f} \quad \text{……..(17)}$$

4.2 Financial Risks

VALUE AT RISK (VaR) MODEL

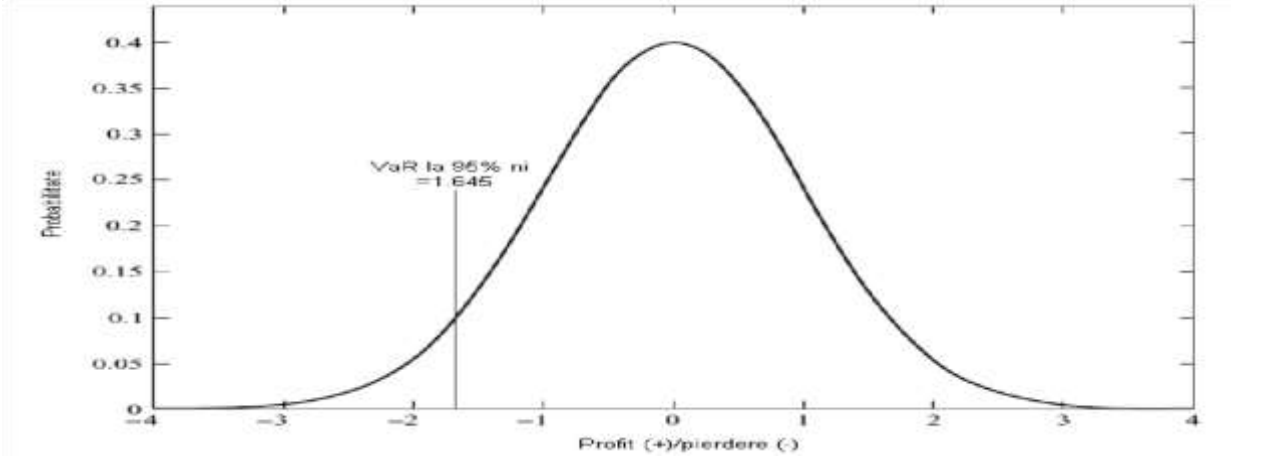
In line with equation 6, Figure 1 is derived and explained below.

INTERPRETATION

The graph depicts that the outcomes are more likely to occur close to mean $\boldsymbol{\mu}$. The spread of probability mass around the mean depends on the standard deviation, $\boldsymbol{\sigma}$. In other words, the greater the standard deviation, the more dispersed the probability mass.

Therefore, the pdf is symmetric around the mean. The random variable **X** is as likely to take a particular value $\boldsymbol{x-\mu}$ as to take the corresponding negative value $\boldsymbol{-(x-\mu)}$. The pdf tails away on both sides as the left-hand tail corresponds to extremely low realizations of the random

Fig 1: The Normal Probability Density



Variables, while the right-hand tail corresponds to high realization and more likely occurrence of random event. Assuming a particular ***x***-value (say **1.645**) is chosen from a normal distribution table, we can regard this value as a profit of **-1.645** (left-hand side) or loss of **1.645** (right-hand side). Invariably, it means that there is a 5% (**0.05**) probability of making a loss or 95% (**0.95**) probability of making profit.

The value **1.645** can then be described as the value at risk (VaR) at **95%** confidence level.

SUB-ADDITIVITY of VaR MODEL

A good counter-example that demonstrates the sub-additivity of VaR is a portfolio consisting of two short positions in very-out-of-the-money binary options. Suppose each of the binary options has a **6%** probability of a payout of ₦1.5m and a **94%** probability of a payout of ₦0.

The underlying variables on which the payouts depend are independently distributed, so the payout on one binary option is independent of the payout on the other. If we take the VaR confidence level (cl) to be **95%** and the holding period to be equal to the period until the options expire, then each of the positions has VaR of 0 at the **95%** level. If we combine the two positions, however, the probability of a ₦0 payout falls to less than **95%** and the VaR is positive and equal to ₦1.5m.

Table 2: The VaR of Individual Positions

Position X		**Position Y**	
(₦' m) Payout	Probability	(₦' m) Payout	Probability
-1.5	0.06	-1.5	0.06
0	0.94	0	0.94
VaR at 95 cl	1.00	VaR at 95 cl	1.00

Table 3: The VaR of combined Positions

Payout (₦'000,000)	**Calculation**	**Probability**
-3	$0.06^2 = 0.06$ X 0.06	0.0036
-1.5	(0.06)(0.94)+(0.94)(0.06)=2(0.94)(0.06)	0.1128
0	$0.94^2 = 0.94$ x 0.94	0.8836
VaR at confidence level (cl)		1.00

The VaR of combined positions is therefore greater than the sum of the VaRs of the individual positions as indicated in equation (2). Therefore, VaR is not sub-additive. The illustration of the given example is explained in the Table 2. Moreover VaR is not sub-additive, and therefore not a coherent risk measure. As a result, other

suggestion for measuring market risk is the conditional value-at-risk (CVaR). This is sub-addictive and coherent for general loss distributions including discrete distributions.

Nonetheless, the assumption of normality has its limitations as the distribution requires only two parameters (i.e. first moment (mean) and second moment (variance) (Dowd K, 2002)). Other moments (thirds and fourth) can be of great importance. The third moment gives an indication of the asymmetry of the distribution. This leads to skewness.

$$\text{Skewness} = \frac{E(x-\mu)^3}{\sigma^3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(18)$$

The skewness coefficient will be zero for a symmetric or normal distribution, and non-zero for an asymmetric one.

If the distribution is skewed, we must therefore take the account of its skewness if we are to be able to estimate its risk probabilities correctly. The fourth moment (kurtosis) parameter gives an indication of the fatness of the tails of the distribution.

$$\text{Kurtosis} = \frac{E(x-\mu)^4}{\sigma^4} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(19)$$

If the kurtosis parameter is 3, the tails of the distribution will be the same with the normal distribution. A kurtosis parameter of more than 3 indicates fatter tails which connote an extreme event (i.e loss severity) is more likely and less likely to be large. A thinner tail parameter of less than 3 indicates extreme events are less likely to be larger than under normality. The extreme events here can either result to gain or loss. Normality assumption is inappropriate and can lead to major errors in market risk analysis except we are dealing with a symmetric (i.e. zero-skew) distribution with a kurtosis of 3. It is important to check for normality because of its close connection with some of the most popular approaches to financial risk measurement. For example, VaR coupled with daily market risk monitoring and control, cap the risk/loss at a certain level of confidence.

Based on changing market volatility, the implementation of volatility-based limits that will automatically adjust the size of the position limits, is worthwhile in order to ensure market risks can be capped at any pre-defined level.

DURATION MODEL

In line with equation (7), suppose a bank buys a 5-year bond at $2000 nominal value at a 10% annual interest rate.

$$\text{NPV} = \sum_{i=1}^{5} \frac{\$2000}{(1+0.1)^{i}} = \$7,581.57$$

$$\text{Duration (D)} = \frac{\$7,581.5}{\$\,2,000} = 3.79\ years$$

INTERPRETATION: The period of 3.79years is a measure of the average life-cycle of the interest sensitivity of the 5-year bond.

Unfortunately, this method does not register changes in payment dates which can occur as a result of interest environment changes. For resolution, the duration method shows the time and amount of cash flows which are received before the instrument\'s contractually agreed maturity period. The longer the maturity period and the period for the next change in the instrument price, the smaller the payments received prior to maturity. The longer duration means that a certain change in interest levels will have a greater impact on the economic value.

LEAST SQUARE MODEL

In this section, Table 1 was be analysed by using Least Square Model in relation to equations (8) to (13) already stated in the previous section.

Table 4: PRIME LENDING RATE ANALYSIS (2010-2018)

YEAR	**INTEREST RATE (Y)**	**TRANSFORMED TIME TREND (X)**	**XY**	**X²**	**Ŷ**	**(Y – Ŷ)²**
2010	17.59	-4	-70.36	16	16.52933	1.125014
2011	16.02	-3	-48.06	9	16.6545	0.40259
2012	16.79	-2	-33.58	4	16.77967	0.000107
2013	16.72	-1	-16.72	1	16.90483	0.034163
2014	16.55	0	0	0	17.03	0.2304
2015	16.85	1	16.85	1	17.15517	0.093127
2016	16.87	2	33.74	4	17.28033	0.168373
2017	17.88	3	53.64	9	17.4055	0.22515
2018	18.00	4	72.00	16	17.53067	0.220274

$\sum X_i = 0$

$\sum Y = 153.27$ **$\sum X_iY = 7.51$** **$\sum X_i^2 = 60$** **$\sum = 2.499198$**

From equation (12),

a= $\frac{153.27}{9}$ = **17.03**

Using equation (11),

ь = $\frac{7.51}{60}$ = **0.12517**

From equation (8),

$\hat{Y} = 17.03 + 0.12517\ X$ **…….....**(20)

From equation (13),

$S_e = 0.5975$ ……...(21)

Table 5: PRIME LENDING RATE ANALYSIS (2011-2017)

YEAR	INTEREST RATE (Y)	TRANSFORMED TIME TREND (X_i)	X_iY	X_i^2	$\hat{Y}$	$(Y-\hat{Y})^2$
2011	16.02	-3	-48.06	9	16.1825	0.026406
2012	16.79	-2	-33.58	4	16.39214	0.15829
2013	16.72	-1	-16.72	1	16.60179	0.013975
2014	16.55	0	0	0	16.81143	0.068345
2015	16.85	1	16.85	1	17.02107	0.029265
2016	16.87	2	33.74	4	17.23071	0.130115
2017	17.88	3	53.64	9	17.44036	0.193286
	$\sum Y = 117.68$	$\sum X = 0$	**$\sum X_iY = 5.87$**	**$\sum X_i^2 = 28$**		**$\sum = 0.619682$**

$\hat{Y} = 16.8114 + 0.2096\ X$ **…….....**(22)

$S_e = 0.3520$ ……...(23)

Table 6: PRIME LENDING RATE ANALYSIS (2012-2018)

YEAR	INTEREST RATE (Y)	TRANSFORMED TIME TREND (X_i)	X_iY	X_i^2	$\hat{Y}$	$(Y-\hat{Y})^2$
2012	16.79	-3	-50.37	9	16.4225	0.135056
2013	16.72	-2	-33.44	4	16.64643	0.005413
2014	16.55	-1	-16.55	1	16.87036	0.102629
2015	16.85	0	0	0	17.09429	0.059676
2016	16.87	1	16.87	1	17.31821	0.200896
2017	17.88	2	35.76	4	17.54214	0.114147
2018	18	3	54	9	17.76607	0.054723
	$\sum Y = 119.66$	$\sum X_i = 0$	**$\sum X_iY = 6.27$**	**$\sum X_i^2 = 28$**		**$\sum = 0.672539$**

$\hat{Y} = 17.0943 + 0.2239\ X$ **……...**(24)

S_e =0.3668 ……...(25)

Table 7: Comparison of Results

TABLE	DECISION EQUATION	STANDARD ERROR(S_e)	PROBABILITY OF ERROR
4	$\hat{Y} = 17.03 + 0.12517\ X$	0.5975	35.70%
5	$\hat{Y} = 16.8114 + 0.2096X$	0.3520	12.93%
6	$\hat{Y} = 17.0943 + 0.2239\ X$	0.3668	13.45%

From Table 7, the best equation to be used for the estimates of future lending interest rate is $\hat{Y}$=16.8114 + 0.2096 **X** as derived from Table 5 because the standard error and the chance of error are the least.

FINAL RESULT

Table 8: Estimated Lending Rates (2023 – 2025)

YEAR	X	INTEREST RATE(%)
2023	9	18.70
2024	10	18.91
2025	11	19.12

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion and Summary

Any financial or non-financial institution that holds a portfolio of financial assets is exposed to different kinds of risks and consequently should implement risk measurement and management methods in order to optimize the manner in which a risk is taken. Doing so will reduce the probability of incurring big economic losses or even bankruptcy and will make the institutions more competitive. Once the estimates of the distribution of future changes are available (e,g as shown in table 8), it is necessary to employ a risk measure to quantify the risk. It is also necessary to validate the model through back-testing (as shown in Table 7). The risk attached to a particular investment is related to the return on such investment. Management of the risk can be effectively attained when historical information reflects the current market process of securities and insider privilege information is publicly available. Risks arise not only from market factor changes but also as a result of actions performed by market participants who can take risks upon themselves (i.e, risk seekers), transfer risks (i.e, risk averters) or are risk indifferent (i.e, risk neutrals). Market risk requires adequate management and analysis systems to assess significant risk elements and to use generally accepted financial concepts and techniques for risk measurement in order to have accurately documented quantities and parameters.

5.2 Recommendations

Faced with continuously changing market rudiments and increasing regulations, financial institutions (i.e, bank and non-bank) need to regularly review and optimize their models, processes and systems for measuring and managing risks. This will be followed by coordinated and economic application of resources to minimise, monitor and control the probability or impact of unforeseen circumstances or to maximize the realization of opportunities so that uncertainty of risks does not deflect the endeavor from business goals. Various financial institutions should have adequate systems reflecting their exposure to market risk

In agreement with Banjo (2019), strategies to manage market risks and other uncertainties with negative consequences typically include: avoiding the risks (i.e, risk avoidance); reducing the negative effect / probability of the risks (i.e, pre-loss and post-loss risk minimisation); transferring all or part of the threat to another party (insurance) (i.e, risk transfer mechanism); and even retaining some or all of the potential/actual consequences of the risks (i.e, risk retention).

Therefore, choice of a model depends on the positions for which the model is to be used; and the user's risk management capacities and technical possibilities.

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