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Application of Non-Linear Programming to Portfolio Management on Some Insurance Companies Using Cash Ratio

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***Abstract* - This research is set to investigate non-linear programming problem that is, quadratic programming and its application to portfolio management. The data of return on asset of five different insurance companies namely: AIICO, LINKAGE, NIGER, MUTUAL BENEFIT, and LASACO insurance company was collected and a model was fixed. These data were analyzed using quadratic programming in conjunction with LINDO software. The result of the analyzed data revealed that the allocation of fund for each insurance company should be done with the same percent for LINKAGE, NIGER, MUTUAL BENEFIT and other percent to AIICO insurance company respectively with increment of 24% on return. The research has answered the question of how much an investor should allocate to each investment to minimize risk and maximize return.**

Keywords: Return on assets, insurance companies, funds, invest and cash ratio.

I. INTRODUCTION

Cash ratio is a liquidity measure that shows a company's ability to cover its short-term obligations using only cash equivalents. Portfolio is an appropriate mix of investments held by public or private individual while the portfolio management is the art and science of making decisions about investment mix, policy, matching investments to objectives, asset allocation for individuals and institutions, and risk balancing according to Emiola and Adeoye (2014).Return on invested Capital to investigate how much Dangote can invest on three of his subsidiaries Viz. Dangote Cement, Dangote Sugar refinery and Dangote Flour given an amount available to him by Emiola and Adeoye (2014).

Although, Emiola (2014) in his PhD thesis has looked at various tools of decision making in this direction but he left out the issue of using turnover as a trial to make decision for future investment.

Ayanlere (2017) in his project looked at three products of Dangote subsidiaries which are Dangote Flour, Dangote Salt, and Dangote Sugar because of their relativity and the common usage today.

Emiola et al., (2015) used dividend payout ratio as a determinant to investigate how to make selection of Bank shares in three different Banks, which are Zenith Bank, Guaranty Trust Bank plc, and First Bank plc.

Emiola and Adeoye (2014) looked at bonus on share as a determinant for portfolio selection of Bank shares in three different Banks, which are Zenith Bank plc, Guaranty Trust Bank plc and First Bank Nigeria plc.

Emiola et al., (2020) worked on Portfolio Selection on Some Insurance Companies (Aiico, Linkage, Niger, Mutual Benefit and Lasaco) using current ratio. The data of return on asset of five different insurance companies namely: AIICO, LINKAGE, NIGER, MUTUAL BENEFIT, and LASACO insurance companies were collected between 2008 to 2017 and a model was fixed. It shows that all current ratio of the insurance companies (Linkage, Niger, Mutual Benefit, LASACO and AIICO) contribute to the investor's return. The result revealed that for a good product mixed, 24% of investor's capital should be invest on Linkage insurance company, LASACO insurance company, Niger insurance company , AIICO insurance company and remaining 4% should be allocated in Mutual Benefit insurance company, so as to maximize the investor's return.

Also, in this research, cash ratio analysis will perform on five different insurance companies, which are AIICO insurance Company, Linkage Insurance Company, LASACO Insurance Company, Niger Insurance Company & Mutual Benefit Insurance Company to investigate the percentage to invest on each company:

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II. METHODOLOGY

METHOD OF DATA COLLECTION

Table 1: Shows the percentage of cash ratio invested

Source: Annual financial record on Cash ratio of five (5) selected insurance companies

Insurance company	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LINKAGE	8.0	10.23	8.11	8.31	10.51	15.38	12.78	17.93	30.92	31.36
MUTUAL BENEFIT	10.0	9.5	7.3	8.96	9.11	10.3	10.43	24.0	24.52	26.9
AIICO	11.10	8.32	12.01	11.74	10.93	14.64	13.0	12.06	10.0	11.0
LASACO	9.5	7.71	10.05	21.9	13.10	14.37	11.76	15.28	16.08	12.17
NIGER	10.01	12.02	18.32	23.39	19.66	18.06	16.48	22.3	22.51	13.57

For the purpose of this research, abstraction from established published sources was used to collect the data. The data used in these work has already been in existence but were extracted by this researcher for the purpose of this study and it is explained briefly below.

III. DESCRIPTIONS OF THE MODEL

An investor has fixed sum of money say K, to invest in fiv e (5) insurance companies namely; Linkage, Mutual Benefit, Niger, AIICO and LASACO.

The Portfolio problem is to determine how much money the investor should allocate to each insurance company so that total expected return is greater than or equal to some lowest acceptable amount say T, and so that the total variance of future payment is minimized.

Let X_1, X_2, X_3, X_4, X_5 designate the amount of money to be allocated to Linkage insurance company, Mutual Benefit insurance company, Niger insurance company, AIICO insurance company, and LASACO insurance company respectively and let X_{is} denote the return per naira invested from invested from the investment i (i = 1, 2, 3, 4, 5) during the S period of time in the past (S = 1, 2, 3, … 10). If the past history on return on asset is indicative of future performance, the expected future return per Naira from investment 1, 2,3,4,5 is E_i = (1)

And the expected return from five investments combines is given as

$$E = E_1X_1 + E_2X_2 + E_3X_3 + E_4X_4 + E_5X_5. \quad (2)$$

The portfolio problem modeled as quadratic programming is

$$\text{Min } R = A^TCA \quad (3)$$

Subject to: $X_1 + X_2 + X_3 + X_4 + X_5 = N$

$E X_1 + E X_2 + E X_3 + E X_4 + E X_5$ K

X_1 0, X_2 0, X_3 0, X_4 0, X_5 0, where **C** is the covariance matrix which is positive semi – definite, given as

$$C = \begin{pmatrix} \sigma_{11}^2 & \sigma_{12}^2 & \sigma_{13}^2 & \sigma_{14}^2 & \sigma_{15}^2 \\ \sigma_{21}^2 & \sigma_{22}^2 & \sigma_{23}^2 & \sigma_{24}^2 & \sigma_{25}^2 \\ \sigma_{31}^2 & \sigma_{32}^2 & \sigma_{33}^2 & \sigma_{34}^2 & \sigma_{35}^2 \\ \sigma_{41}^2 & \sigma_{42}^2 & \sigma_{43}^2 & \sigma_{44}^2 & \sigma_{45}^2 \\ \sigma_{51}^2 & \sigma_{52}^2 & \sigma_{53}^2 & \sigma_{54}^2 & \sigma_{55}^2 \end{pmatrix}, \text{ and}$$

E is the mathematical expectation

$$\begin{pmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \end{pmatrix}$$

From table1 above, the covariance and expected return for each insurance companies was calculated and given below

Covariance matrix is given below

$$C = \begin{pmatrix} 79.739 & 62.809 & -1.897 & 6.430 & 6.140 \\ 62.809 & 059.318 & -2.168 & 6.516 & 6.708 \\ -1.897 & -2.168 & 2.870 & 2.249 & 2.039 \\ 6.430 & 6.516 & 2.249 & 17.053 & 15.450 \\ 6.140 & 6.708 & 2.039 & 15.450 & 20.931 \end{pmatrix},$$

And expected returns of Cash ratio for each insurance company are 15.353X1, 14.102X_2, 11.480X_3, 13.192X_4, and 17.633X5respectively. The budget constraint investment portfolio optimization problem has five candidate assets (X_1, X_2, X_3, X_4, X_5) for our portfolio.

IV. THE MODEL

Objective is to determine what fraction should be devoted (or of the Cash ratio that the investor should have) to each

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insurance company, so an expected return of at least 25% (equivalently, a growth factor 1.25) is obtained while minimizing the variance in return and not exceeding a budget constraint and restriction was imposed that any given assets can constitute at most 25% of the portfolio.

Table 2: The variance of entire portfolio with minimize the risk

MIN R = $79.739X_1^2 + 59.518X_2^2 + 2.870X_3^2 + 17.053X_4^2 + 20.931X_5^2 + 125.619X_1X_2 - 3.795\ X_1X_3 + 12.861\ X_1X_4 + 12.279X_1X_5 - 4.336X_2X_3 + 13.032X_2X_4 + 13.416X_2X_5 + 4.499X_3X_4 + 4.079X_3X_5 + 30.901X_4X_5$

Subject to:

! We start with #1.00

$X_1 + X_2 + X_3 + X_4 + X_5 = 1$

! We want to end with at least #1.20

$15.353X_1 + 14.102X_2 + 11.480X_3 + 13.192X_4 + 17.633X_5$

! No asset may constitute more than 25% of the portfolio

X_1 0.25

X_2 0.25

X_3 0.25

X_4 0.25

X_5 0.25

The research employs LINDO software. We create the Lagrangean expression. The input procedure for LINDO requires the model be converted to through linear form by writing the first order conditions. To do this we introduce Lagrangean multiplier for each constraint. There are seven (7) constraints, we shall use seven (7) dual variables devoted respectively as UNITY, RETURN, X1FRAC, X2FRAC, X3FRAC, X4FRAC, X5FRAC.

Table 3: Lagrange Multiplier corresponding to this model

MIN R (X_1, X_2, X_3, X_4, X_5) = $79.739X_1^2 + 59.518X_2^2 + 2.870X_3^2 + 17.053X_4^2 + 20.931X_5^2 + 125.619X_1X_2 - 3.795\ X_1X_3 + 12.861\ X_1X_4 + 12.279X_1X_5 - 4.336X_2X_3 + 13.032X_2X_4 + 13.416X_2X_5 + 4.499X_3X_4 + 4.079X_3X_5 + 30.901X_4X_5 + (X_1 + X_2 + X_3 + X_4 + X_{5-1})$ UNITY + $[1.20 - (15.353X_1 + 14.102X_2 + 11.480X_3 + 13.192X_4 + 17.633X_5)$RETURN + $(X_1 - 0.25) X_1$ FRAC + $(X_2 - 0.25) X_2$ FRAC + $(X_3 - 0.25) X_3$ FRAC + $(X_5 - 0.25) X_5$ FRAC

Next we compute the first order conditions

$= 159.478X_1 + 125.619X_2 - 3.795X_3 + 12.861X_4 + 12.279X_5 +$ UNITY – 15.353 RETURN + X_1 FRAC 0

$= 125.619X_1 + 118.637X_2 - 4.336X_3 + 13.032X_4 + 13.416X_5 +$ UNITY – 14.102 RETURN + X_2 FRAC 0

$= - 3.795X_1 - 4.336X_2 + 5.741X_3 + 4.499X_4 + 4.079X_5 +$ UNITY – 11.480 RETURN + X_3 FRAC 0

$= 12.861X_1 + 13.032X_2 + 4.499X_3 + 34.106X_4 + 30.901X_5$ +UNITY – 13.192 RETURN + X_4 FRAC 0

$= 12.279X_1 + 13.416X_2 + 4.079X_3 + 30.901X_4 + 41.863X_5 +$ UNITY – 17.633 RETURN + x_5 FRAC 0

$= X_1 + X_2 + X_3 + X_4 + X_5 - 1$

$= 1.20 (E_{x1}X1 + E_{x2}X_2 + E_{x3}X_3 + E_{x4}X_4 + E_{x5}X_5)$

Adding the real constraints

$X_1 + X_2 + X_3 + X_4 + X_5 = 1$

$15.353X_1 + 14.102X_2 + 11.480X_3 + 13.192X_4 + 17.633X_5$ 1.20

X_1 0.25

X_2 0.25

X_3 0.25

X_4 0.25

X_5 0.25

The final model is

Min $X_1 + X_2 + X_3 + X_4 + X_5$+ UNITY + RETURN + X_1FRAC+ X_2 FRAC + X_3FRAC + X_4FRAC + X_5 FRAC

First order condition for X_1:

$159.478X_1 + 125.619X_2 - 3.795X_3 + 12.861X_4 + 12.279X_5 +$ UNITY – 15.353 RETURN + X_1 FRAC 0

First order condition for X_2:

$125.619X_1 + 118.637X_2 - 4.336X_3 + 13.032X_4 + 13.416X_5 +$ UNITY – 14.102 RETURN + X_2 FRAC 0

First order condition for X_3:

$- 3.795X_1 - 4.336X_2 + 5.741X_3 + 4.499X_4 + 4.079X_5 +$ UNITY – 11.480 RETURN + X_3 FRAC 0

First order condition for X_4:

$12.861X_1 + 13.032X_2 + 4.499X_3 + 34.106X_4 + 30.901X_5$ +UNITY – 13.192 RETURN + X_4 FRAC 0

First order condition for X_5:

$12.279X_1 + 13.416X_2 + 4.079X_3 + 30.901X_4 + 41.863X_5 +$ UNITY – 17.633 RETURN + x_5 FRAC 0

……. Start of "real" constraints……

Budget Constraint, multiplier is UNITY.

$X_1 + X_2 + X_3 + X_4 + X_5 = 1$

……..Growth constraint, multiplier is RETURN:

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$15.353X_1 + 14.102X_2 + 11.480X_3 + 13.192X_4 + 17.633X_5$ 1.20

Max Fraction 0f X_1, multipliers is X_1 FRAC:

X_1 .25

Max Fraction 0f X_2, multipliers is X_2 FRAC:

X_2 .25

Max Fraction 0f X_3, multipliers is X_3 FRAC:

X_3 .25

Max Fraction 0f X_4, multipliers is X_4 FRAC:

X_4 .25

Max Fraction 0f X_5, multipliers is X_5 FRAC:

X_5 .25

END
QCP7

V. EXPERIMENT: THE RESULTS OF THE MODEL

AT 20%, we obtain the iteration below
LP OPTIMUM FOUND AT STEP 0
Objective function value
1) 1.000000

Table 4: The Result

VARIABLE	VALUE	REDUCED COST
X1	0.200000	0.000000
X2	0.200000	0.000000
X3	0.200000	0.000000
X4	0.200000	0.000000
X5	0.200000	0.000000
UNITY	0.000000	1.000000
RETURN	0.000000	1.000000
X1FRAC	0.000000	1.000000
X2FRAC	0.000000	1.000000
X3FRAC	0.000000	1.000000
X4FRAC	0.000000	1.000000
X5FRAC	0.000000	1.000000
NO. ITERATIONS=	0	

AT 21%, we obtain the iteration below
LP OPTIMUM FOUND AT STEP 0
Objective function value
1) 1.000000

Table 5: The Results

VARIABLE	VALUE	REDUCED COST
X1	0.220000	0.000000
X2	0.220000	0.000000
X3	0.220000	0.000000
X4	0.120000	0.000000
X5	0.220000	0.000000
UNITY	0.000000	1.000000
RETURN	0.000000	1.000000
X1FRAC	0.000000	1.000000
X2FRAC	0.000000	1.000000
X3FRAC	0.000000	1.000000
X4FRAC	0.000000	1.000000
X5FRAC	0.000000	1.000000
NO. ITERATIONS=	0	

AT 23 %, we obtain the iteration below
LP OPTIMUM FOUND AT STEP 0
Objective function value
1) 1.000000

Table 6: The Result

VARIABLE	VALUE	REDUCED COST
X1	0.230000	0.000000
X2	0.230000	0.000000
X3	0.230000	0.000000
X4	0.080000	0.000000
X5	0.230000	0.000000
UNITY	0.000000	1.000000
RETURN	0.000000	1.000000
X1FRAC	0.000000	1.000000
X2FRAC	0.000000	1.000000
X3FRAC	0.000000	1.000000
X4FRAC	0.000000	1.000000
X5FRAC	0.000000	1.000000
NO. ITERATIONS=	0	

AT 24%, we obtain the iteration below
LP OPTIMUM FOUND AT STEP 0
Objective function value
1) 1.000000

Table 7: The Result

VARIABLE	VALUE	REDUCED COST
X1	0.240000	0.000000
X2	0.240000	0.000000
X3	0.240000	0.000000
X4	0.040000	0.000000
X5	0.240000	0.000000
UNITY	0.000000	1.000000
RETURN	0.000000	1.000000
X1FRAC	0.000000	1.000000
X2FRAC	0.000000	1.000000
X3FRAC	0.000000	1.000000
X4FRAC	0.000000	1.000000
X5FRAC	0.000000	1.000000
NO. ITERATIONS=	0	

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Table 8: Summary of the results for the purpose of comparison and decisions

T	X1	X2	X3	X4	X5	Variance	Lp optimum step
1.20	0.200000	0.200000	0.200000	0.200000	0.200000	1.000000	0
1.21	0.210000	0.210000	0.210000	0.160000	0.210000	1.000000	0
1.22	0.220000	0.220000	0.220000	0.120000	0.220000	1.000000	0
1.23	0.230000	0.230000	0.230000	0.80000	0.230000	1.000000	0
1.24	0.240000	0.240000	0.240000	0.40000	0.240000	1.000000	0

From the table 8, the increment that yields the minimum percent with mixed investment opportunity is 4%. Hence the optimum solution to the model is X_1= 24%, X_2 = 24%, X_3 = 24%, X_4 = 4%, and X_5 = 24%

VI. CONCLUSIONS

For the purpose of this research is to show how portfolio selection of Cash ratio of the five selected insurance company in Nigeria has been done using the past financial records of each insurance company for ten years. It also shows how allocation of available fund by investors should be allocated to available investment open to investors. The research has answered the question of how much an investor should allocate to each investment to minimize risk and maximize return. I hereby conclude that all Cash ratio of the insurance companies (Linkage, Niger, Mutual Benefit, LASACO and AIICO) contribute to the investor's return.

VII. RECOMMENDATION

From the above I recommend, for a good product mixed or investment, equal percentage of investor's capital should be invest on Linkage insurance company, Mutual Benefit insurance company, Niger insurance company , AIICO insurance company and other remaining percent should be allocated in LASACO insurance company, so as to maximize the investor's return.

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