

Application of Linear Programming in Investment Portfolio Selection (Using Microsoft Excel 13)

AUTHOR(S): IBRAHIM DARAZO RABIU
AND
DR. L. B. AJAYI

Abstract

The mathematical techniques are applicable to most of the field of studies including investment or portfolio selection decision. The linear programming technique is one of the techniques used in general finance. The research work was on the application of linear programming in investment portfolio selection decision. The main objective of the study was to examine how the Linear programming model is applied in portfolio selection decision using Microsoft excel 13. The data were obtained from practical example of portfolio selection with some constraints. The estimation techniques in the paper was linear programming and a prior expectation was that, if the constraints were minimize, the maximum return on investment. This is because, the linear programming have been used in the study and assisted in the portfolio selection with the maximum return on the investment particularly using Microsoft excel 13. It is concluded that, if the assumption and the formulation of linear programming model are accurately applied in portfolio selection can aid financial managers in decision making. It is recommended that, linear programming model should be applied in various aspect of finance and investment.

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About Author

Author(s): **IBRAHIM DARAZO RABIU**

Department of Accounting & Finance Technology,
Abubakar Tafawa Balewa University, p. m. b 0248, Bauchi-Nigeria.

GSM: +2348039743459.

E-mail: darazo08@yahoo.com

AND

DR. L. B. AJAYI

Department of Finance, Faculty of Management Sciences,
Ekiti State University, P.M.B 5363, Ado Ekiti, Nigeria.

GSM: +2348033881328.

1. Introduction

There are a number of mathematical techniques that are been used in various field of studies. But in this article linear programming was discussed and its application in the field of finance. Linear programming is simply a more of generalised of linear algebra. This is because; linear programming has the capacity to handle a variety of problems, ranging from finding schedules for airline to distribution of oil from refineries to markets. The reason for this is that linear programming ease at which constraint can be incorporated into the model (Miller, 2007). In finance, financial decisions are taken based on the trench hold between risk and return. Investors are usually faced with problems of what asset to invest into and how to come up with an investment portfolio that can provide the highest return and also lowest risk level (Silva, Moreira & Francisco, 2014).

Therefore, some mathematical models have been used to assist investors to come up with best investment portfolio. Among the model that are been used is linear programming. Among the authors that used linear programming are Silva, Moreira and Francisco (2014). Linear programming deals with the problem of optimising a linear objective functions subject to linear equality constraints on the variables. Linear programing has many practical applications ranging from transportation, production planning and finance (Goemans, 2015). In addition, Agarana, Anaka and Adeleke (2014) used linear programming while conducting a research on application of linear programming model to unsecured loans and bad debt risk control in bank in Nigeria. The authors addressed the problem of non-performing loans, bad and doubtful debts in banks using linear programming model. As such, linear programing is not only applied in finance but also in banks. This is supported by the work of Balbirer and Shaw (1981) on an application of linear programming to bank financial planning purposely to assist bank managers with mathematical tools to manage their balance sheet items so as to achieve the organisational goals.

Ben-horim and Silber (1997) used linear programming approach to look at financial innovation, where some balance sheet items of US Bank, First National City Bank (FNCB) were used as the variables in linear programming and profit maximisation as the objective. According to Ikechi, Benedict and Ikechukwu (2014), the linear programming techniques should not only be studied as concept but also applied in a problem solving approach which could enhance decision making of financial manager, especially where such decision have some restriction or constraints.

According to Griffin (2014) linear programming is a sub-field of optimisation theory, which is itself a sub-field of applied mathematics. Applied mathematics is a very general area of study that could arguably comprises half of the engineering disciplines. Linear programming deals with optimisation which is about making better, which may include assisting company to make better decision with regard to profit maximisation. It can be seen that, linear programming technique has been used in some aspect of financial sector and other management decision making.

Therefore, the paper looked at the application of linear programming in investment portfolio selection problem solving with aim of solving a problems related to investment portfolio and maximising a return on the investment but also considering some constraints.

2. Literature Review

2.1 Historical Development or Evolution of Linear Programming (LG)

Linear programming approach has been considered as an aspect of operational research. LP has undergone some series of development, and Dantzig (1947) is considered among scholars as father of LP. He came up with LP when he was involve in military strategic challenges in

the US air force during the world war II and the area the author concentrated at in the initial stage were on transportation, assignment and deployment decision. The author first developed and formulated the simple method as a basic solution of the LP in the year 1947. After he has developed the simplex method, it has been used and extended to some business organisation in various countries after World War II. Since, it is new aspect of mathematical model, Koopmans (1949) while working with planning of optimal transportation of ships back and forth the Atlantic Ocean during the World War II further developed the LP theory/model.

In 1950, Kuhn and Tucker (1950) further developed the technique of LP independently in USA. The authors are the first to apply LP on a large scale, in the scheduling of iron and steel production, paper and oil industries and in the minimisation of freight or transport cost. According to Kantorovich (1953), with acceptance of LP, it can be used to improve economic planning in Russia. The author analysed efficiency conditions for an economy as a whole, demonstrating the connection between the allocation of resource and price system using LP approach. This is the first when LP was applied in resource allocation. Another author in 1957, that is Assar (1957) extended the work of Kantorovich (1953) to deal with more than one commodity and can also provide a measure of the opportunity costs of different combinations of inputs and outputs which must be linear. It's clear that, LP has undergone some development stage after World War II. That was why Cooper (1957) applied LP in scheduling refineries in oil and gas sector. In addition, Nueman (1958) applied LP in problem solving involving linear inequalities and the game theory. Charnes, Cooper and Miller (1959) argue that LP has been applied in mostly in production problems and demonstrated that, LP can be applied in financial planning. Therefore, their work looks at the application of LP in financial budgeting and costing of funds.

Another mathematician, Karmaker (1984) came up with a radically new procedure that may increase the speed of the routine handling of problems by a business and government agencies. Not only that, it may also makes it possible to handle problems that can be applied in a variety of commercial and government application that include allocating time on a communication satellite to routing millions of telephone calls over a long distance.

2.2 Application of Linear Programming Model

There are various optimisation models that are been used, such as linear, quadratic, integer, dynamic, stochastic and robust programming. But, linear programming and its application in finance will be discuss. LP is one of the most common optimisation problems which are sometimes called linear optimisation. LP deals with the problem of optimising a linear objective function subject to linear equality and inequality constraints. LP assumes straight line relationship between the variables in a linear function. The linear programming can give an opportunity for managers to allocate scarce resources to do with formulating a given problem as a linear programming model with the variables clearly stated, the constraints and applying standard method to solve the problem (Ikechi et al, 2014). In formulating a given problem as a LP model, the problem has to be restated in the mathematical form which include some stages; (a) State and define the decision variables (b) State the objective function to be optimised and the constraints attached to the achieving objective. (c) Write the mathematical expression that will indicate the variables and constraints by applying the appropriate relationship sign. (d) Express the non-negativity constraints mathematically. For example, LP model with X decision variables and "n" constraints are given as follows;

Maximise $P = a_1x_1 + a_2x_2 + \dots \dots \dots a_nx_n$

Or Minimise $C = a_1x_1 + a_2x_2 + \dots + a_nx_n$
 Subject to $b_{11}x_1 + b_{21}x_2 + \dots + b_{1n}x_n \leq d_1$
 $b_{12}x_1 + b_{22}x_2 + \dots + b_{2n}x_n \leq d_2$
 With $x_1, x_2, \dots, x_n \geq 0$

2.3 Linear Programming Model Formulation

The usefulness of LP as a tool for optimal decision-making on resource allocation is based on its applicability to many diversified decision problems. The effective use and application require some basic steps. According to Sharma (2011), the steps in LP model formulation are summarised as follows;

Steps 1: Identification of the decision variables.

- Express each constraint in words. For this you should first see whether the constraint is of the form of \geq (at least as large as) or of the form \leq (no larger than or of the form $=$ (exactly equal to))
- You should then verbally express the objective function.
- Steps (a) and (b) should then allow us to verbally identify the decision variable. If there are several decision alternatives available, then in order to identify the decision variables you need to ask yourself the question- what decision must be made in order to optimise the objective function? Having established step 1(a) through (c) decide the symbolic notation for the decision variables and specify limits of measurement. Such specification of units of measurement would help in interpreting the final solution of the problem.

Step 2: Identify the problem data

For solving a problem, there is a need to identify the problem data so as to provide the actual values for the decision variables. For this reason, we need to enumerate all types of information with respect to the given problem in order to determine the values of these decision variables. These quantities constitute the problem data. It may be noted that the decision maker can control value of the variables but cannot control the values of the data.

Step 3: formulate the constraints

- Verbally express the constraints in terms of requirement and availability of each resource.
- Convert the verbal expression of the constraints imposed by the resource availability as linear equality or inequality, in terms of the decision variables defined in step 1. The constraints are the conditions that the decision variables must satisfy in order to constitute an acceptable (feasible) solution. These constraints typically arise due to physical limitations, management imposed restrictions, external restrictions, logical restriction on individual variable etc. wrong formulation can either lead to solution that are not feasible or to the exclusion of some solutions that are actually feasible and possibly optimal.

Step 4: Formulate the objective function

Identify whether the objective is to be maximise total profit/cost and then convert it into a linear mathematical expression in terms of decision variables multiplied by their profit or cost contributions. After having enough experience in model building, one may skip verbal description (Sharma, 2011).

The optimisation models have three major components; decision variables, objective function and constraints.

1. **Decision variables;** these are physical quantities controlled by the decision maker and represented by mathematical symbols. For example, the decision variable Y_j can represent

the number of units of product that a company will produce during some month. Decision variables take on any of a set of possible values.

2. **Objective function**; this defines the criteria for evaluating the solution. It is a mathematical function of the decision variables that converts a solution into a numerical evaluation of that solution. For example, the objective function may measure the profit that occurs as a function of the amount of various products produced. The objective function also specifies a direction of optimisation, either to maximise or minimise. The optimal solution for the model is the best solution as measured by the criteria.

3. **Constraints** are a set of functional equalities or inequalities that represent physical, economic, technological, legal, ethical, or other restrictions on what numerical values can be assigned to the decision variables. For example, constraints might ensure that no more input is used than is available. Constraints can be definitional, defining the number of available instruments that a bank can invest or the number of employees at the start of a period $t+1$ as equal to the number of employees at the start of period t , plus, those added during period t minus those leaving the organisation during period t . In constrained optimisation model we find value of the decision variable that maximise or minimise the objective function and satisfy all constraints.

In most of the LP model, these are some assumption that are expected to be satisfied which include;

1. **Linearity**; in LP model it is assumed that decision variable in the model are the first power. That means, there is no provision for higher power, such as square and cubes in any equations and inequalities. If production of one units of a product used 5 hours of a particular resources, then making 3 units of that product uses $3 \times 5 = 15$ hours of that resources.

2. **Divisibility**; in this assumption, the value of the decision variable in the LP model are allowed to be fractions and need not to be integers alone.

3. **Deterministic parameters**; it is assumed that the values of the parameters in LP model are known and also constant. By implication, the model assumes a static state in addition, it is pertinent to point out that in real life situation, and there are probabilistic model parameters.

4. **Non negativity**; in LP model, it is assumed that as decision variables must take on negativity values.

5. **Proportionality**; with regard to LP model that involve resource, it is assumed that the output obtained from a resource is proportional to the input of the resource.

6. **Additivity**; in LP model, in addition to linearity concept also implies that the total measure of the objective function and the total usage are additive in nature. For example, the profit earned from sale of two products A and B must be equal to the sum of the profit earned separately from A and B.

7. **Independence of variables**; in LP model, it is assumed that the various components of the model in maximisation or minimisation function work independently.

8. **Existence of optimal solution**; this is also an assumption in LP. In a LP model, there exists an optimal solution to the objective function, taken into consideration the identified constraint (Sharma, 2011, Ikechi, 2014).

2. 4 Benefits of Linear Programming

According to Sharma (2011) the main benefits or advantages of LP include the following;

1. LP helps in making optimum use productive resources. It also indicates how a decision maker can employ his productive factors effectively by selecting and distributing these resources.

2. LP techniques improve the quality of decisions. The decision-making approach of the user of this techniques becomes more objective and less subjective.
3. LP techniques provide possible and practice a solution since there may be other constraints operating outside the problem that must be taken into account. Because, a company may produce so many units does not mean that they can be sold. Thus necessary modification of its mathematical solution is required for the sake of convenience decision-maker.
4. Highlighting of bottlenecks in the production processes is the most significant advantage or benefit of LP technique. For example, when a bottleneck occurs, some machines cannot meet demand while others remain idle for some amount of the time.
5. LP also helps in re-evaluation of a basic plan for changing conditions. If conditions change when the plan is partly carried out, they can be determined so as to adjust the reminder of the plan for the best result.

2.5 Methods of Solving Linear Programming

There are basically two methods of solving linear programming problem; simplex method and graphical method.

2.4.1. The *Simplex method* was developed by Dantzig in 1947. The simplex method examines the extreme points in a systematic manner, representing the same set of steps of the algorithm until an optimal solution is found. It is for this reason; it is also called iteration method. Simplex method examines corner points of the feasible region, using matrix row operation, until an optimal solution is found. The use of the simplex method to solve a LP problem requires the problem be converted into its standard form. The standard form of the LP problem should have the following characteristics;

- i. All the constraints should be expressed as equations by adding slack or surplus and/or artificial variables.
- ii. The right-hand side of each constraint should be made non-negative if it is not already, this should be done by multiplying both sides of resulting constraint by -1.
- iii. The objective function should be of the maximisation type.

2.5.2 Graphical method

In LP problem that have only two variables, it is possible that entire set of feasible solution can be displayed graphically by plotting linear constraints on a graph paper in order to locate the best (optimal) solution. The techniques used to identify the optimal solution is called the graphical solution approach or techniques for an LP problem with two variables.

The steps of the method are summarised as follows;

- i. Develop an LP model; state the given problem in the mathematical LP model.
- ii. plot constraints on graph paper and decide the feasible region. Replace the inequality sign in each constraint by an equality sign. Draw these straight lines on the graph paper and decide each time the area of feasible solutions according to the in equality sign of the constraint. Shade the common portion of the graph that satisfies all the constraints simultaneously drawn so far. The final shade area is called the feasible region (or solution space) of the given LP problem. Any point inside this region is called feasible solution and this provides value of x_1 and x_2 that satisfy all the constraints.
- iii. examine extreme points of the feasible solution space to find an optimal solution. Determine the constraints of each extreme point of the feasible solution space. Compute and compare the value of the objective function at each extreme point and identify the extreme point that gives optimal (max or min) value of the objective function.

2.6 Application of Linear Programming in Finance

LP is the most widely used techniques of decision-making in business and industry and in many other field (Sharma, 2011). But, this paper put more emphasis on application of LP in investment portfolio selection. Other areas of application of LP are as follows;

1. Financial management.

Under financial management, two area usually applies LP. One is portfolio selection; this deals with the selection of specific investment activity among several other activities. The objective here is to find the allocation which maximises the total expected return or minimises risk under certain conditions. The second is profit planning; this deals with the maximisation of the profit margin from investment in plant facilities and equipment, cash in hand and inventory.

2. Marketing management

a. Media selection; the LP techniques helps in determining the advertising media mix so as to maximise the effective exposure, subject to limitation of budget, specified exposure rates to different market segments, specified minimum and maximum number of advertisement in various media.

b. Travelling sale man problem; the sales man's problem is to find the shortest route from a given city to each of the specified cities and then returning to the original point of departure, provided no city would be visited twice during the tour. Such type of problem can be solved with the help of the modified assignment techniques.

3. Production Management

a. Product mix; a company can be produce several or many different products, each of which requires the use of limited production resources. In such cases, it is essential to determine the quantity of each product to be produces, knowing its marginal contribution and amount of variables resources used by it. The objective is to maximise the total contribution, subject to all constraints.

b. Production planning. This deals with the determination of minimum cost of production plan, over the planning period of an item with a fluctuating demand, while considering the initial number of the units in inventory, production capacity, constraints on production, man power and all relevant cost factors. The objective is to minimise total operation cost (Sharma, 2011)

4. Agricultural application

These applications fall into categories of farm economics and farm management. The former deal with the agricultural economy of a nation or a region, while the latter is concerned with the problem of the individual farm. The study of farm economics deals with interregional competition and optimum allocation of crop production. Efficient production pattern can be specified by a LP model under regional land resources and national demand constraints. LP can be applied in agricultural planning. Example, allocation of limited resource such as acreage, labour water supply and working capital so as to maximise the net revenue.

2. 7 Empirical Review on Linear Programming in Finance

There are a number of researches on the application of LP in the field of finance. Some of the researches are reviewed here. Morris (1960) carried out a study on application of linear programming to financial budgeting and the costing of funds. The main objective of the paper is to explore ways in which LP might be used to allocate funds within a particular firm. The author showed that, LP can be applied in capital budgeting. This was demonstrated using warehouse example, in which a firm buys and sells a commodity under certain liquidity restrictions. Silva, Moreira and Francisco (2014) conducted a study on LP applied to finance-

building a great portfolio investment. The objective of the study is to build an optimal portfolio using LP, based on companies. The authors concluded that, model used in the study maximised constraints, and exceeded the average refund of the BOVESPA index portfolio in the analysed period. In Nigeria, Ikechi et al (2014) conducted a study application of linear programming techniques to practical decision making, where the main objective of the study is to show how the LP techniques are been applied in decision making process in various field. It was found that various decision making could be solve using LP, even though these was a phobia with regard to use of operational research. It is recommended that, managers shall adopt the use of LP as a tool for problem solving approach that could enhance decision making of managers, especially where there are restriction in the decision making.

Balbrier and Shaw (1981) shows that LP could be used in bank financial planning. The authors justified their argument, while concluding a study on an application of linear programming to bank financial planning. The aim of the paper was to find out how LP could help bank management in their financial planning process. The study concluded that, LP has assisted management of Central Carolina Bank and Trust Company (CCB) in their financial planning process.

3. Methodology

Practical application.

Example One

Assume an investor wishes to diversity his portfolio and make due allowance for long-term potentialities, but at the same time wishes to maximise his current dividend income. He has considered various securities in which he might invest, and has classified them into four types;

Type A, relative high element of risk, with commensurately high dividend and considered with growth potential. Type B, Speculative stock with considerable risk, high dividends, but less growth potentials than type A. Type C, Stock with little risk, considerable growth potential, but relatively low dividend income at present. Type D, Stock with little risk, not much growth potential, and fairly high dividends.

Because of the element of risk, the investor wishes to restrict purchases of type A and B to not more than 30% of his investment. To enhance prospects for long-term growth of his investment, he wishes to have at least 40% of his total outlay in types A and C. Within these restrictions, he wishes to maximise his current dividend income. Total investment is N1,000,000. Dividend returns on the four types of investments are A: 6%, B: 7%, C: 3%, D: 5%. Required; Formulate this problem as LP model to suggest the amount to be allocated.

Solution:

Let; x_1 be investment in relatively high element of risk.

x_2 be investment in speculative stock

x_3 be investment with little risk and considerable growth.

x_4 be investment in stock with little risk and not much growth.

Model Specification I

Maximise;

$$P = 0.06x_1 + 0.07x_2 + 0.03x_3 + 0.05x_4$$

Subject to;

$$x_1 + x_2 + x_3 + x_4 \leq 1,000,000$$

$$x_1 + x_2 \leq 300,000 \text{ (30\% of N1,000,000)}$$

$$x_1 + x_2 + x_3 \geq 400,000 \text{ (40\% of N1,000,000)}$$

$$x_1 + x_2 + x_3 + x_4 \geq 0$$

Total investment is N1,000,000

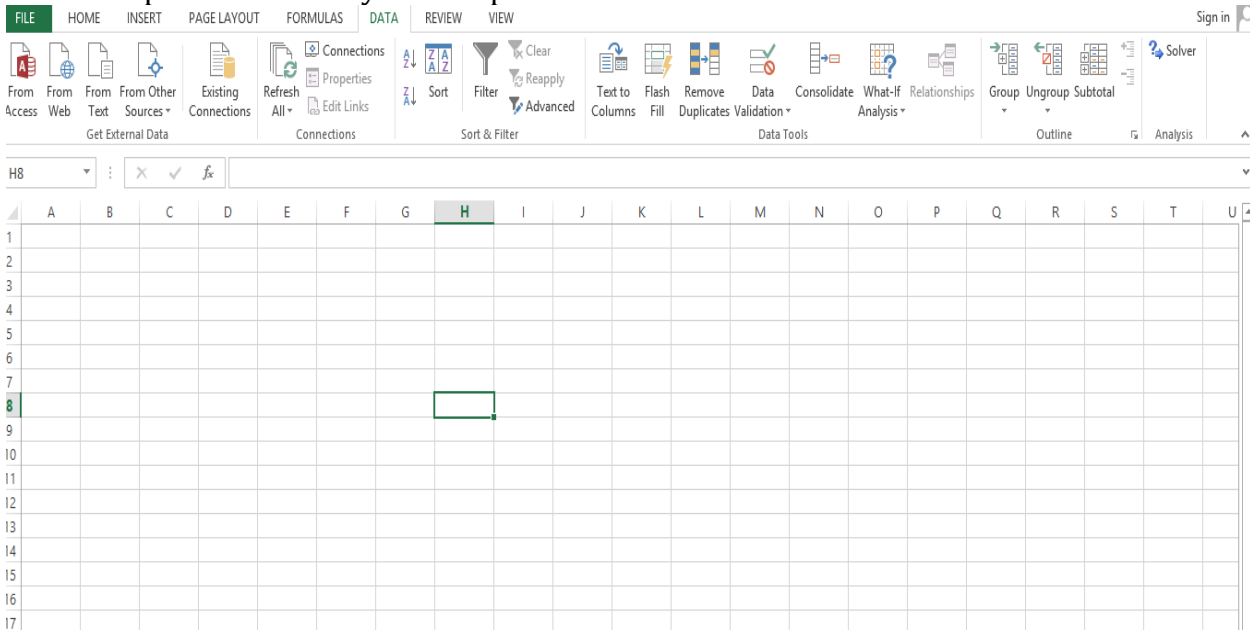
The estimation techniques is linear programming using Microsoft excel 13.

Prior Expectation

A prior Expectation is that, if the constraints were minimise, the expectation is that, maximum return will be achieved form the investment.

Linear programming can be used in excel. But, it’s important to note that, for any software to be use in solving LP problem; the objective function and the constraints must be formulated first before using the software. As such the following steps can help in solving LP problem in Microsoft excel; Formulating the problem in such a way that the objective and constraints functions are clearly stated.

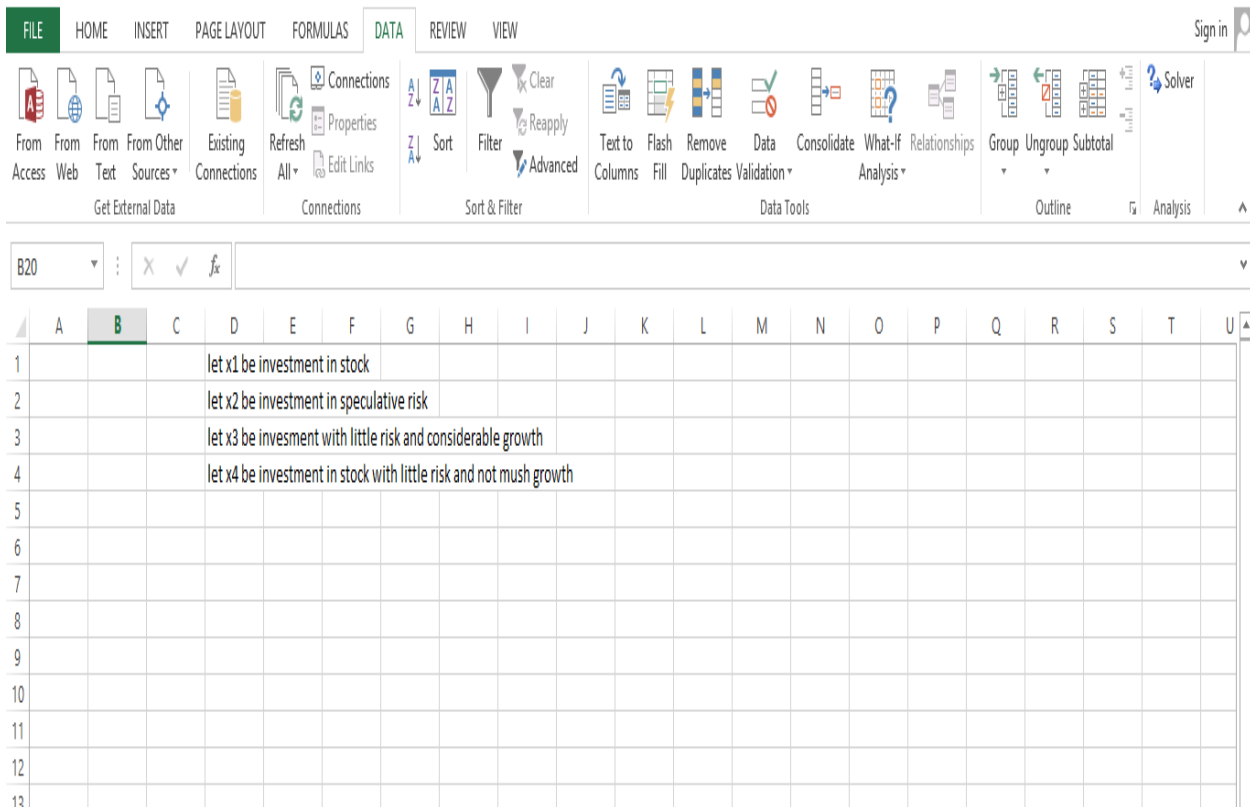
Table 1: Open an excel on your computer.



Source: Microsoft Excel 13, 2021.

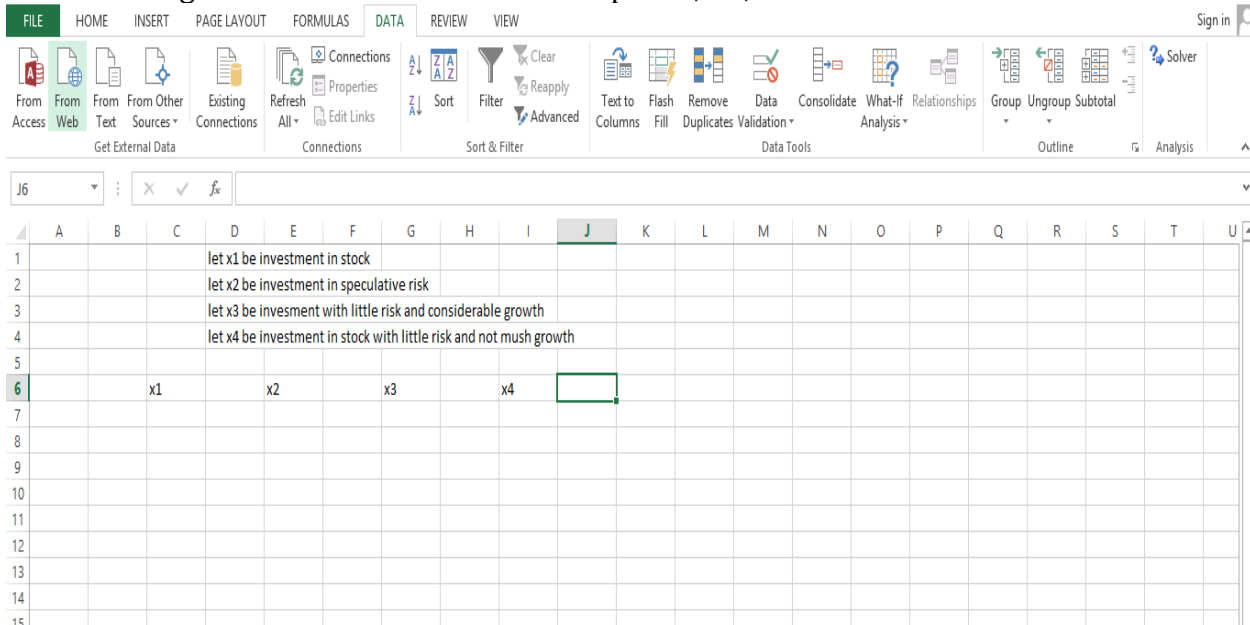


Table 2: Enter the variable assignment at the top of the spread sheet.



Source: Microsoft Excel 13, 2021

Table 3: Assign decision variable cells. Example C5, E5, G5.



Source: Microsoft Excel 13, 2021



Table 4. Construct table from data in the problem including constraints using <= or >= sign formulate the cell.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1					let x1 be investment in stock															
2					let x2 be investment in speculative risk															
3					let x3 be investment with little risk and considerable growth															
4					let x4 be investment in stock with little risk and not much growth															
5																				
6			x1		x2		x3		x4											
7																				
8			constraints																	
9																				
10			0 <=		100000															
11			0 <=		300000															
12			0 >=		400000															

Source: Microsoft Excel 13, 2021

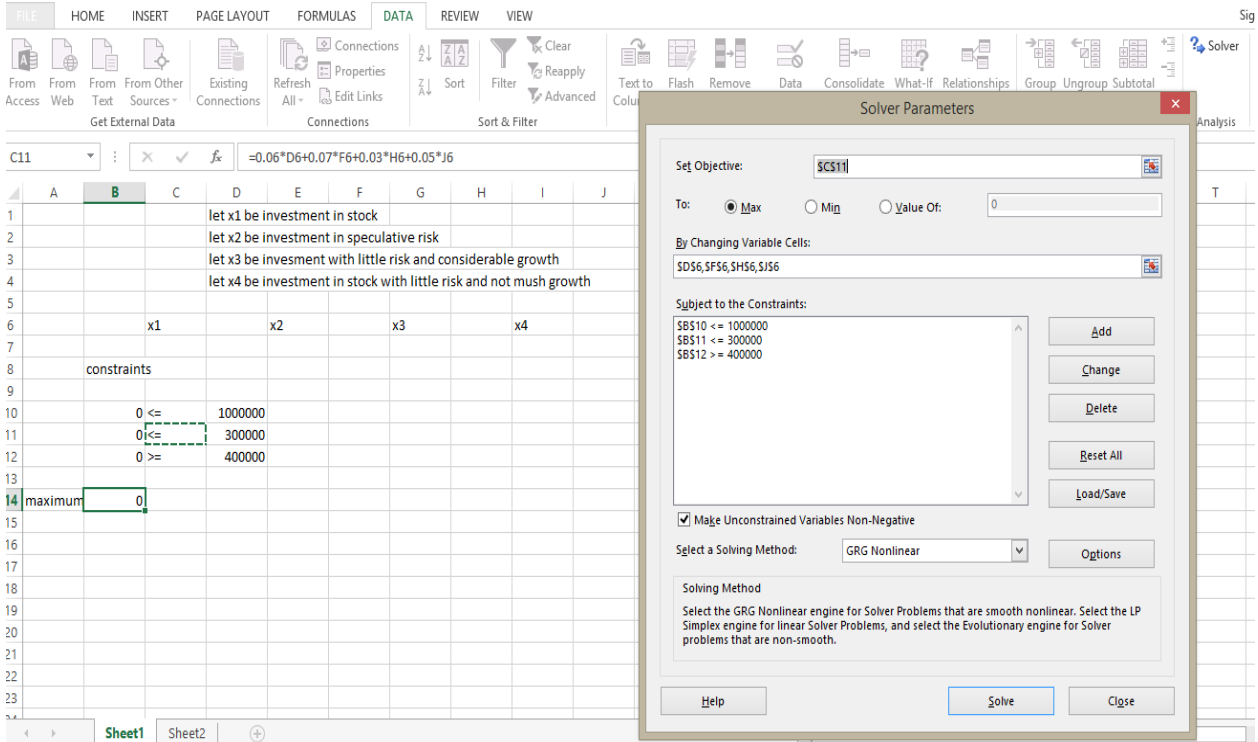
Table 5: Since the table has been setup, access the solver on your excel. Click on tools or Data. If you do not see solver then click on add-ins and select solver. Click on tools/data again and select solver.

	A	B	C	D	E	F	G	H	I	J
1					let x1 be investment in stock					
2					let x2 be investment in speculative risk					
3					let x3 be investment with little risk and considerable growth					
4					let x4 be investment in stock with little risk and not much growth					
5										
6			x1		x2		x3		x4	
7										
8			constraints							
9										
10			0 <=		100000					
11			0 <=		300000					
12			0 >=		400000					
13										
14		maximum	0,							

Source: Microsoft Excel 13, 2021.

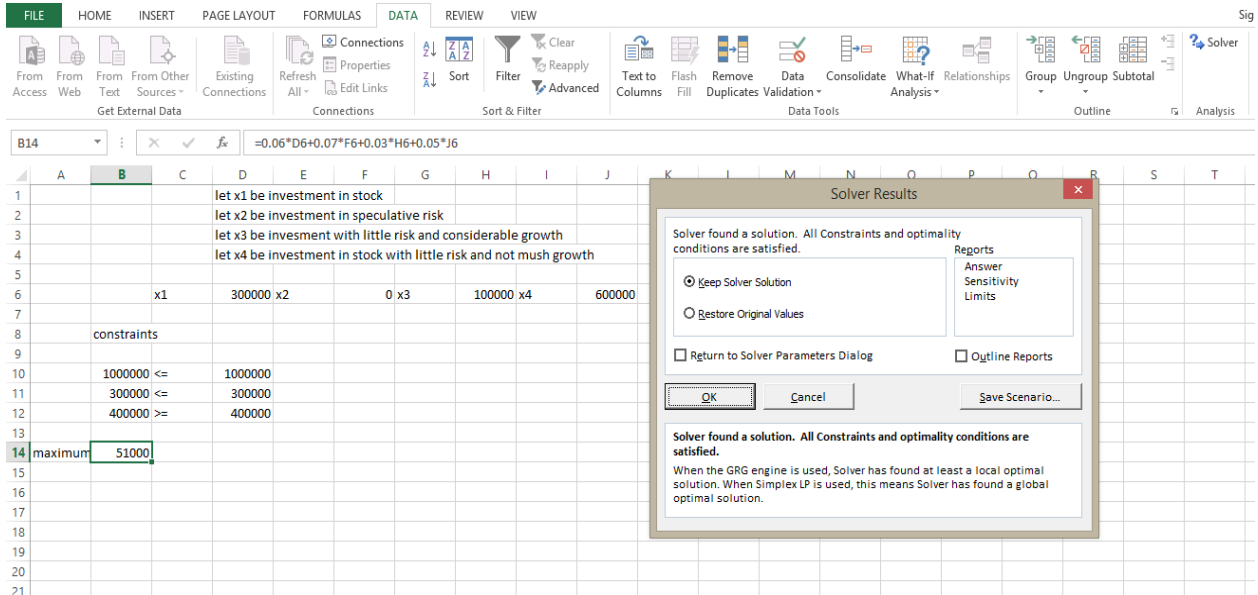


Table 6: The solver will be displayed; select maximise cell on target cell. “Max” on equal to. Enter decision variables on “changing cell”. To enter the constraints, click on add; click on cell reference and then click in the cell then click on constraint and then click the other constraints. Be sure the test listed between them is <=.



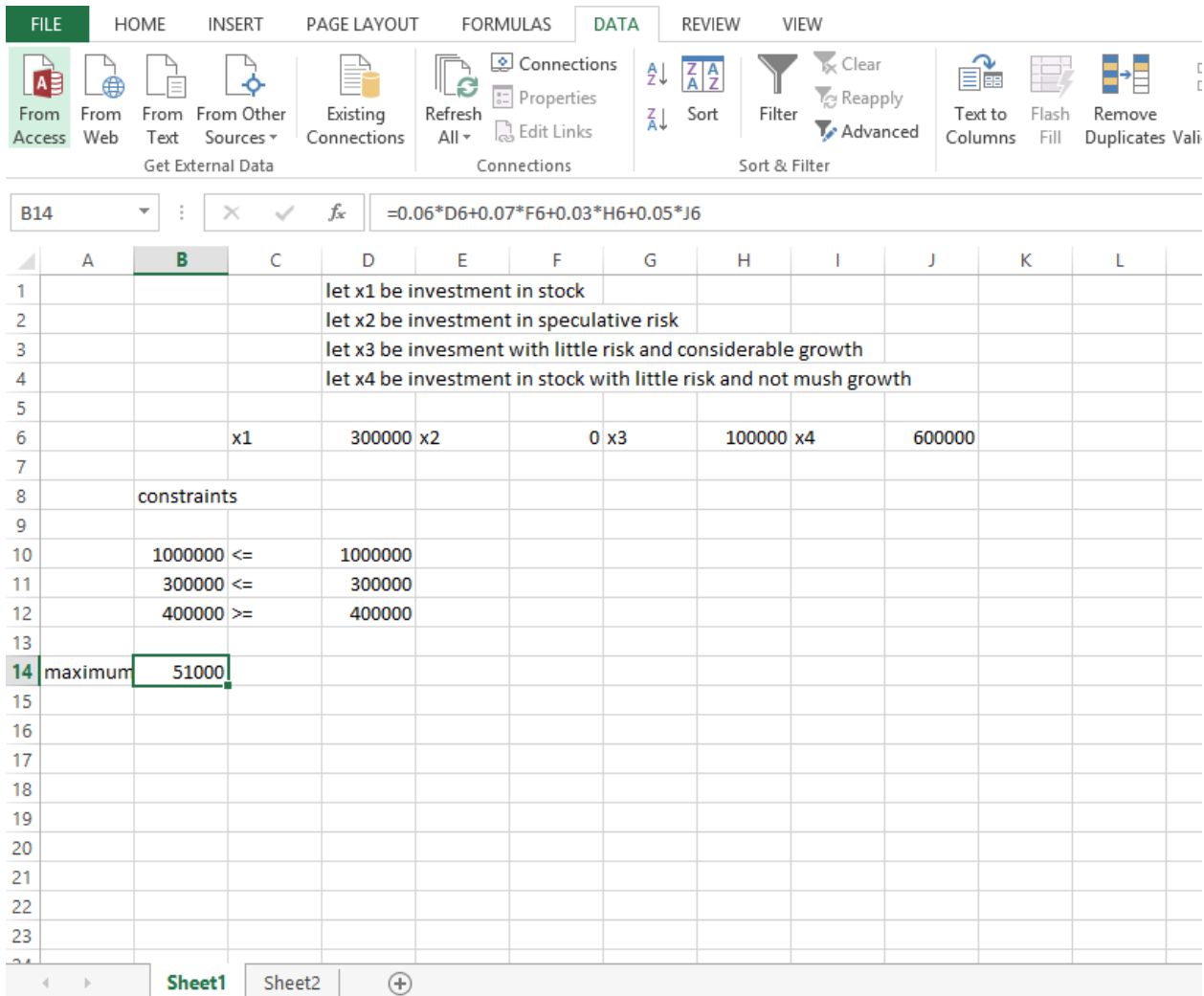
Source: Microsoft Excel 13, 2021

Table 7: Click on solver, it should yield the solution. Click on keep solution. The solution will be shown indicating the values in your decision variable cell and also maximum value cell. It shall be noted that such value has to be interpreted as shown at the beginning.



Source: Excel window 13, 2021.





Source: Microsoft Excel 13, 2021

Therefore, based on the solution obtained, the amount to be invested in x1 that is investment in relatively high element of risk is N300,000, in x2 that is investment in speculative stock is 0., x3 that is investment with little risk and considerable growth is N100,000, x4 that is investment in stock with little risk and not much growth is also N600,000.

Example Two

Mr Abba is a retired government officer, has recently received his retirement benefits. He is contemplating how much money he should invest in various alternative open to him so as to maximise return on his investment. The investment alternative are: government securities, fixed deposit of a public limited company, equity share, time deposit in a bank, and house construction. He has made a subjective estimate of the risk involved on a five-point scale. The data on the return on investment, the number of years for which the funds will be blocked to earn this return on investment and the subjective risk involved are as follows:



	Return(%)	Number of years	Risk
Government Securities	6	15	1
Company deposits	13	3	3
Time deposits	10	5	2
equity share	20	6	5
House construction	25	10	1

He is wondering as to what percentage of funds he should invest in each alternative so as to maximise the return on investment. He has decided that the risk should not be more than 4, and funds should not be locked up for more than 15 years. He would necessary invest at least 25% in house construction. Formulate this problem in LP and find the percentage of the total fund that should be invested in the entire five schemes?

Solution:

Model Specification II

Let X_1 , X_2 , X_3 , X_4 , and X_5 be the percentage of the total fund that should be invested in all given five schemes, respectively,

$$\text{Max } Z = 6X_1 + 13X_2 + 10X_3 + 20X_4 + 25X_5$$

Subject to:

$$15X_1 + 3X_2 + 5X_3 + 6X_4 + 10X_5 \leq 15$$

$$X_1 + 3X_2 + 2X_3 + 5X_4 + X_5 \leq 4$$

$$X_5 \geq 0.25$$

$$X_1 + X_2 + X_3 + X_4 + X_5 \geq 0$$

The estimation techniques is linear programming using excel windows 13. A prior Expectation, if the constraints were minimise, the expectation is that, maximum return will be achieved form the investment.

The remaining aspect of the solution could should be solve using excel.

As such the following steps can help in solving LP problem in excel;

Formulating the problem in such a way that the objective and constraints functions are clearly stated.

$$\text{Max } Z = 6X_1 + 13X_2 + 10X_3 + 20X_4 + 25X_5$$

Subject to:

$$15X_1 + 3X_2 + 5X_3 + 6X_4 + 10X_5 \leq 15$$

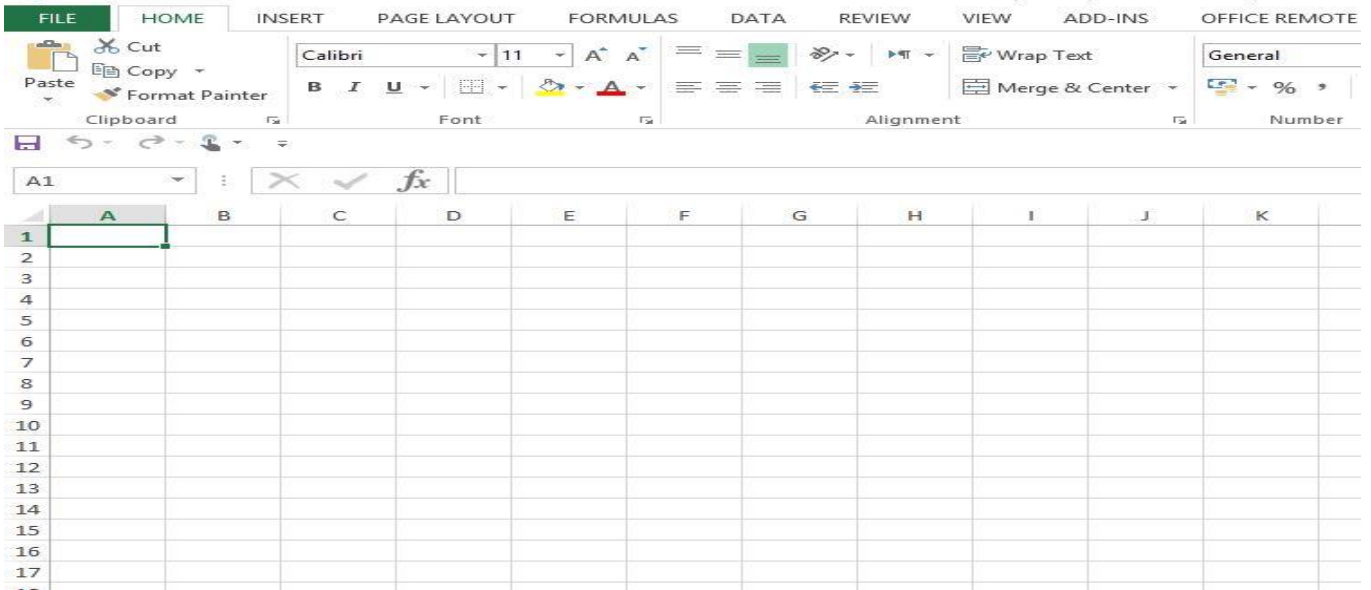
$$X_1 + 3X_2 + 2X_3 + 5X_4 + X_5 \leq 4$$

$$X_5 \geq 0.25$$

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

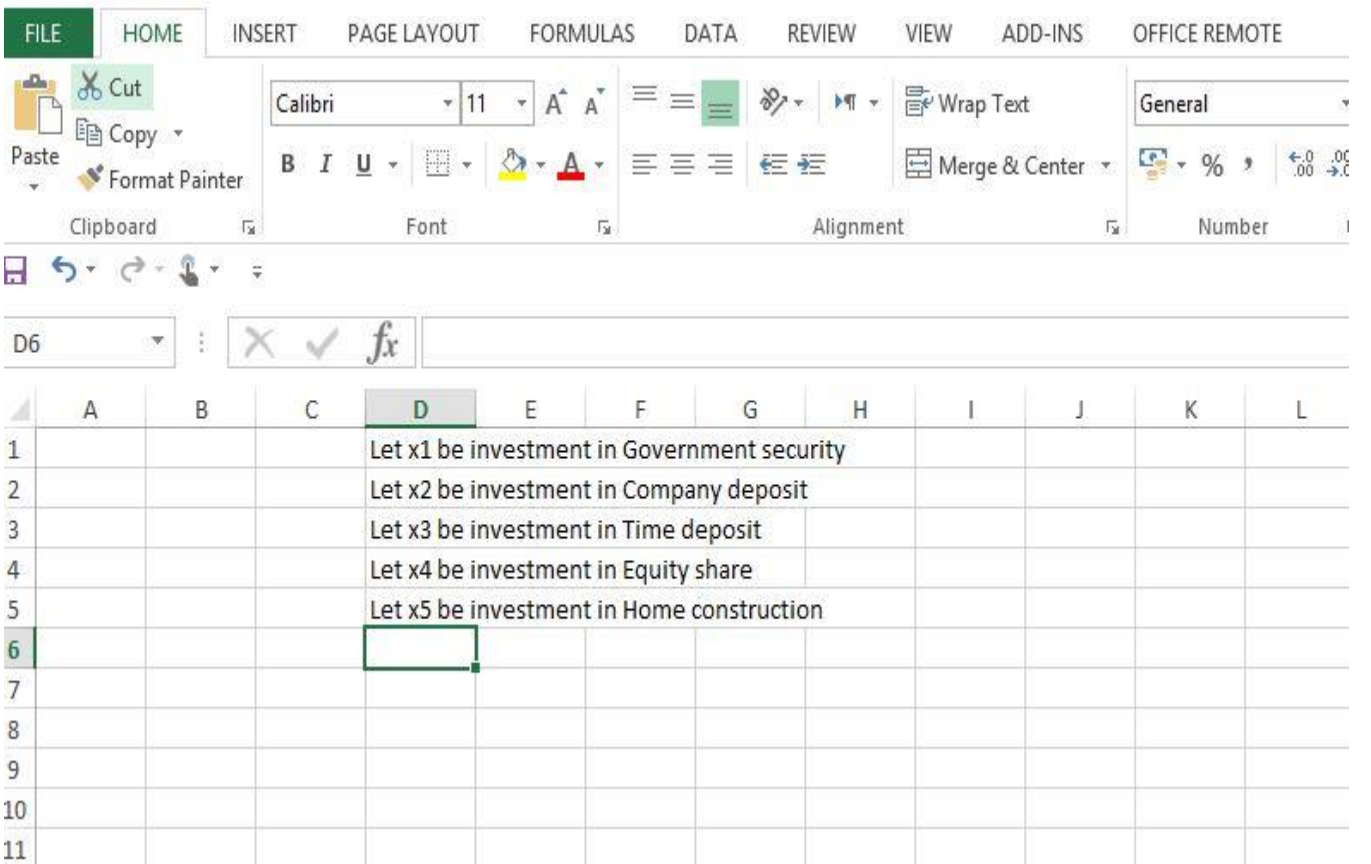
And $x_j \geq 0$, for all j .

Table 8: Open excel on your computer.



Source: Microsoft Excel 13, 2021

Table 9: Enter the variable assignment at the top of the spread sheet.



Source: Microsoft Excel 13, 2021

Table 10: Assign decision variable cells. Example C7, E7, G7, I7, K7.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				Let x1 be investment in Government security									
2				Let x2 be investment in Company deposit									
3				Let x3 be investment in Time deposit									
4				Let x4 be investment in Equity share									
5				Let x5 be investment in Home construction									
6													
7			x1		x2		x3		x4		x5		
8													
9													
10													

Source: Microsoft Excel 13, 2021

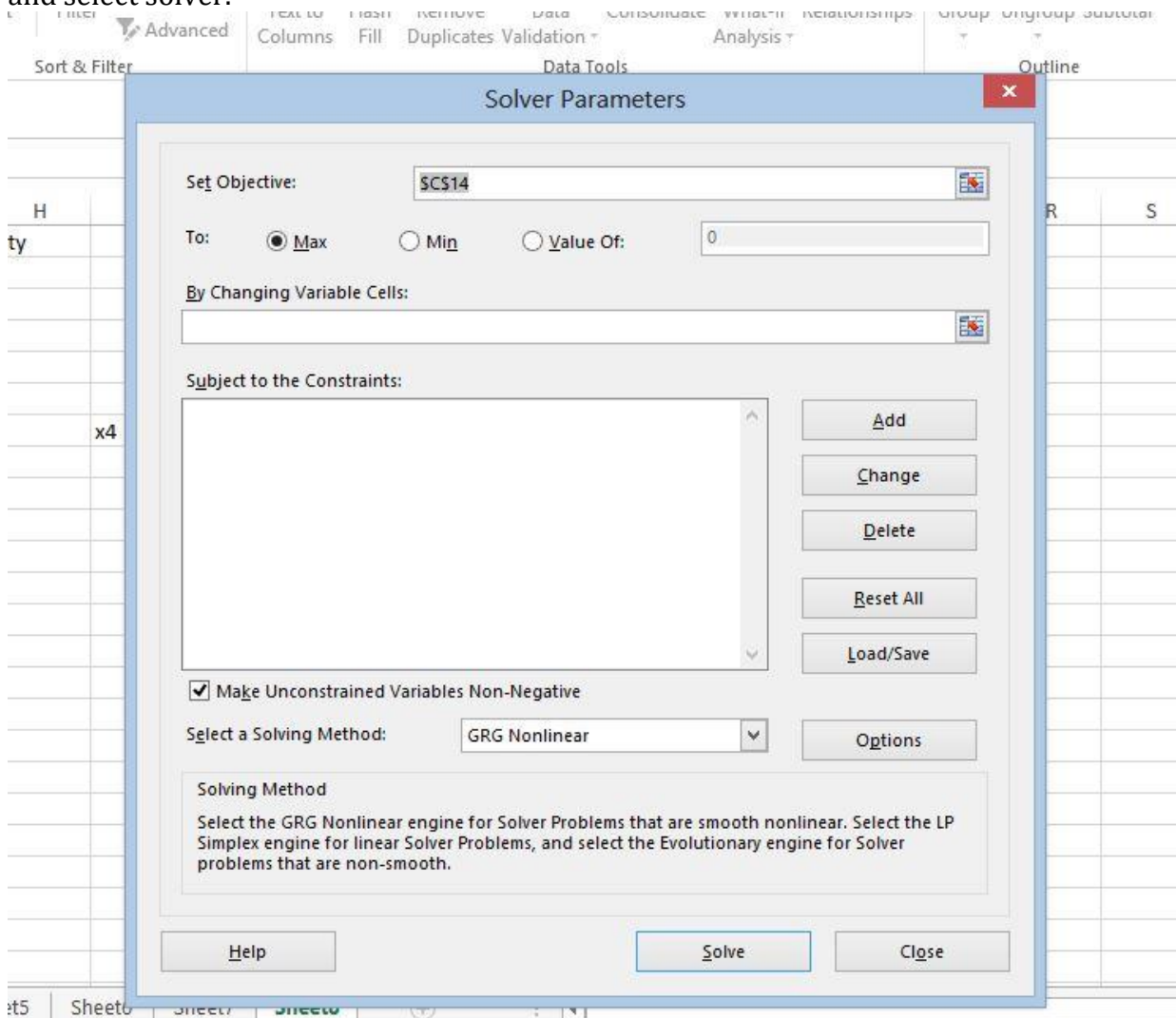
Table 11: Construct table from data in the problem including constraints using <= or >= sign formulate the cell.

	A	B	C	D	E	F	G	H	I	J	K
1				Let x1 be investment in Government security							
2				Let x2 be investment in Company deposit							
3				Let x3 be investment in Time deposit							
4				Let x4 be investment in Equity share							
5				Let x5 be investment in Home construction							
6											
7			x1		x2		x3		x4		x5
8											
9		Constraints									
10			0								
11			0								
12			0								
13											
14		maximum	0								

Source: Microsoft Excel 13, 2021

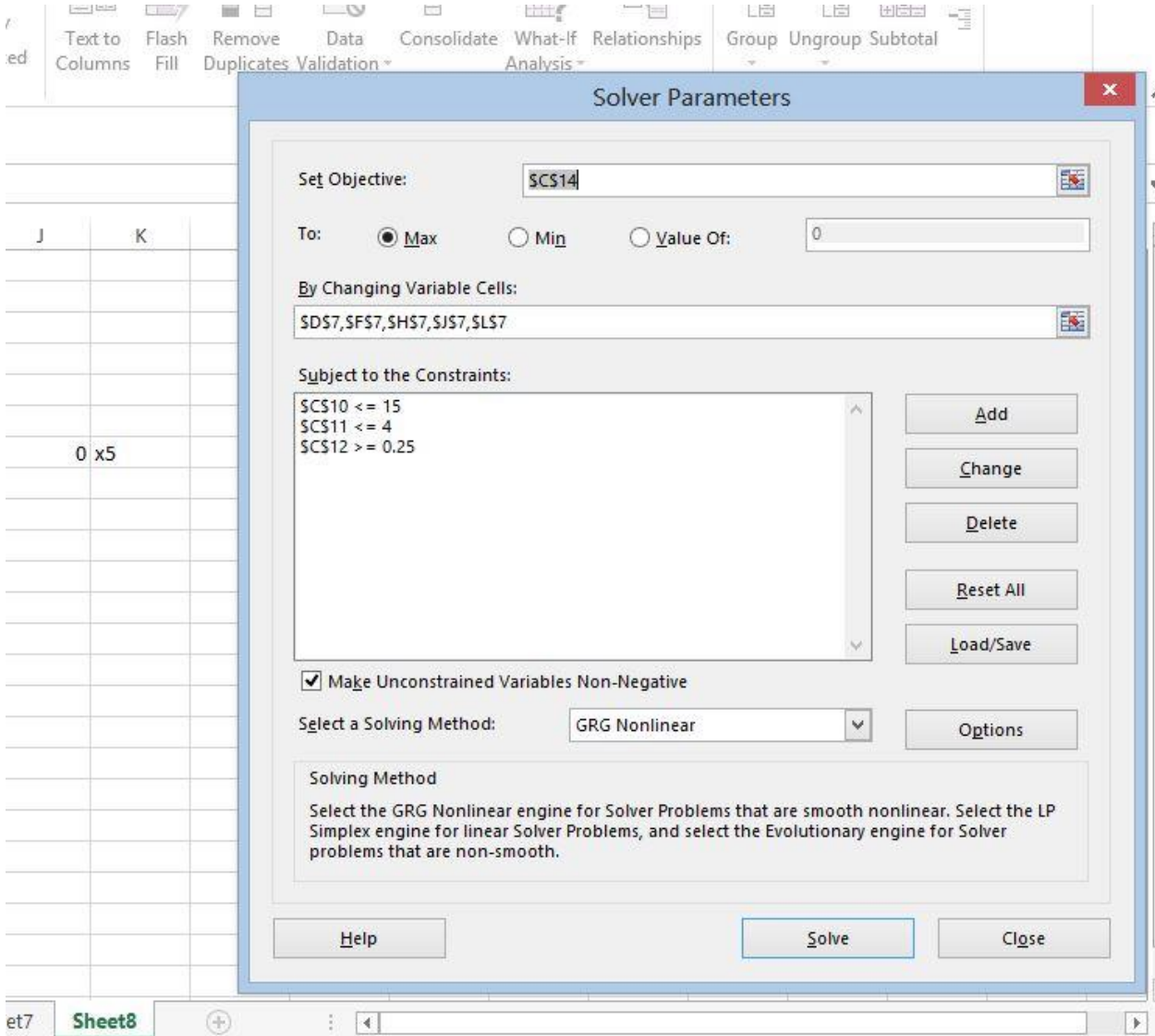


Table 12. Since the table has been setup, access the solver on your excel. Click on tools or Data. If you do not see solver then click on add-ins and select solver. Click on tools/data again and select solver.



Source: Microsoft Excel 13, 2021

Table 13: The solver will be displayed; select maximise cell on target cell. “Max” on equal to. Enter decision variables on “changing cell”. To enter the constraints, click on add; click on cell reference and then click in the cell then click on constraint and then click the other constraints. Be sure the test listed between them is <=.



Source: Microsoft Excel 13, 2021

Table 14: Click on solver, it should yield the solution. Click on keep solution. The solution will be shown indicating the values in your decision variable cell and also maximum value cell. It shall be noted that such value has to be interpreted as shown at the beginning.

The screenshot displays an Excel spreadsheet with a Solver Results dialog box open. The dialog box title is "Solver Results" and contains the following text: "Solver found a solution. All Constraints and optimality conditions are satisfied." Below this, there are two radio button options: "Keep Solver Solution" (which is selected) and "Restore Original Values". There are also two unchecked checkboxes: "Return to Solver Parameters Dialog" and "Outline Reports". At the bottom of the dialog box, there are three buttons: "OK", "Cancel", and "Save Scenario...".

The background spreadsheet shows a formula bar with the formula $+13*F7+10*H7+20*J7+25*L7$. The spreadsheet data includes the following table:

E	F	G	O
Investment in Government			
Investment in Company de			
Investment in Time deposit			
Investment in Equity share			
Investment in Home constr			
	0.925926	x3	
15			
4			
0.25			

Get External Data		Connections		Sort & Filter							
C14		=6*D7+13*F7+10*H7+20*J7+25*L7									
A	B	C	D	E	F	G	H	I	J	K	L
			Let x1 be investment in Government security								
			Let x2 be investment in Company deposit								
			Let x3 be investment in Time deposit								
			Let x4 be investment in Equity share								
			Let x5 be investment in Home construction								
		x1	0	x2	0.925926	x3	0	x4	0	x5	1.222222
		Constraints									
			15	<=		15					
			4	<=		4					
			1.222222	>=		0.25					
		maximum	42.59259								

Therefore, based on the solution obtained, the percentage to be invested in x1 that is government security is 0%, in x2 that is company deposit is 0.925%, x3 that is Time deposit is 0%, x4 that is Equity share is also 0%. Whereas, x5 that is investment in home construction is 1.222%.

4. Summary of Findings

After the application of the linear programming using excel, based on the solution obtained from example one, the amount to be invested in x1 that is investment in relatively high element of risk is N300,000, in x2 that is investment in speculative stock is 0., x3 that is investment with little risk and considerable growth is N100,000, x4 that is investment in stock with little risk and not much growth is also N600,000. Whereas the maximum return on the investment is N51,000

On the other hand, based on the solution obtained from example two, the percentage to be invested in x1 that is government security is 0%, in x2 that is company deposit is 0.925%, x3 that is Time deposit is 0%, x4 that is Equity share is also 0%. Whereas, x5 that is investment in home construction is 1.222%.

5. Conclusion

The paper aimed at looking at the application of LP in the field of investment portfolio selection using excel. Finance is very important aspect of all organisations and companies, which involves commitment of funds into available investment option so as to maximise return or minimise cost of production. It is clear that, if assumptions if LP model and the formulation are accurately applied in finance, it can aid finance managers in decision making for their organisations or companies. This is in line with the conclusion of Silva et al (2014) where the authors concluded that, LP model used in the study maximised the return on the portfolio given the established constraints. Even though, LP has some limitations. But, its benefits have overcome the limitations. Therefore, it is recommended that, LP should be

applied in various aspect of finance including banks. Since evidence has shown that its application could solve many problems ranging from investment to portfolio management and marketing.

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