

## Optimal WACC Using Linear Programming And Genetic Algorithm – An Analytical Study In Al- Mansour Hotel

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### **Abstract**

The optimal capital structure constitutes a fundamental in financial decisions, whether at the level of theory or practice, Since Modigliani and Miller put forward their theories, an intellectual debate has formed regarding to determining the optimal combination of components that reflect the performance of the organization, although simplicity of the components of the capital structure, determining the optimal percentage of Each component is still difficult because these decisions are related to the future of the organization, This research light on the nature of the capital structure in service organizations and financing mechanism, and then presents a working mechanism that is considered a development of financing by proposing an amendment to WACC. application of the WACC equation after making an adjustment on the side of the weights related to the cost of financing by debt and financing by equity to the superiority of linear programming and the genetic algorithm in providing a combination of weights that reduces the value of the objective function (total cost of financing), this research presented the logical mechanism that you can then and in the light of sources available financing and in a simplified manner by re-weighing the assets of the capital structure in a way that achieves a significant cost reduction by taking advantage of the genetic algorithm philosophy by selecting the Better, the scientific contribution was determined in light of the knowledge gap, and accordingly, the idea of re-weighing the assets of the capital structure was presented in a way that reduces the cost.

### **Keywords:**

Optimal capital structure, WACC, liner programing, genetic algorithm

**Introduction:**

A group of theories agreed with the existence of an optimal capital structure (the traditional approach, net income and the trade-off theory), the traditional approach Acknowledge possibility to determining the optimal capital structure by reducing the total cost of combination owned and borrowed, while, the net income approach provided by (Durand, 1952) acknowledges that the weighted rate of financing cost begins to decrease with the increase in the degree of financial leverage, trade-off theory, it presented the idea of trade-off between the tax savings generated by depending on debt financing and the costs of bankruptcy that the company might be exposed, seems this theory is an adjustment of Modigliani and Miller theory (Furajji & Mataroud,2017), all of these theories were a reaction to the work of (Modigliani and Miller, 1958) through their theories known as the MM model, Based on the outputs of this theory, there is no relationship between the capital structure and the value of company, This is due to assumptions, The value of company changes depending on the expected profit before interest, (Furajji & Mataroud,2017), The most important point of criticism for Modigliani & Miller theory is the exclusion of tax from the calculation the cost of capital and the no transaction costs, bankruptcy, growth, information symmetry and risk, at these assumptions, there is no relationship to financing with the wealth of shareholders on, and there is no concept of optimizing the capital structure on the other hand, later literature questioned Realistic of these assumptions (Aljamaan,2018), In 1963, Modigliani & Miller presented the tax as a basic criterion for judging the improvement of the capital structure, by the relationship between profit before interest and profit before tax, so the issue of preference between borrowed financing that provides the organization with the advantage of financing before taxes that suitable for organizations with high tax rates, or depending on Equity financing, whose cost increases as a result of the compensation obtained by its owners to Risk taking resulting from the high issuance of equity instruments, The value of the organization increases when the volume of loans increases in its financial structure vs owned financing (Krištofik et al ,2022), The field of finance has received great attention from researchers and is still the subject of great controversy, as it produced many theories that explained the scientific basis for

financing, especially the optimal structure of capital and the role of the two elements of financing owned and borrowed in building optimal financing depending on the cost of both components (Aljamaan,2018).

Many researchers studied the impact of the capital structure on different levels, (LÖÖF, 2003) began by asking the question (Does financial inefficiency affect profitability and growth?) Several literature studies before Modigliani & Miller showed the company is ability to make fundamental changes in growth and enhance its immediate value and future, as long as it is able to obtain an optimal ratio of mixing the costs of financing by debt and equity (LÖÖF,2003),while (Hackbarth & Mauer,2012) study the impact of capital structure on investment decisions through timing of investment between stockholders and bondholders on the one hand, and methods of financing future investments (Hackbarth & Mauer,2012), the previous studies concerned between the selection and employment of funding sources, The issue of optimization is achieved through the appropriate mixing of the elements of the capital structure to achieve the greatest benefit from the appropriate combination that helps to raise the performance of the organization, given that financing is the basic activity that provides sustainability for all its departments and thus receives This issue overshadows the financial managers to find that financing mixture that achieves the highest interest (Patrick et al, 2021), The optimal capital structure is defined as a structure that reduces the cost of capital, which leads to an increase in the value of the company, it is a guide of success the company (Ferdous,2019)· financing theory has not yet been able to develop a unified formula for the optimal capital structure that is suitable for all organizations in all sectors of different dimensions, that is led to emergence of many theories after the work of Modigliani & Miller that deals with building an optimal capital structure (Michalak,2014).This study is considered as an attempt to determine an optimal capital structure suitable all companies through a basis dimension that all companies agreed on in practice and literature represented by the cost of financing, all these push towards adopting the idea of research by trying to weigh the cost in the best way by use liner programming to reduce costs and genetic algorithm to finding the best weight for those costs.

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## **Optimal Capital Structure**

The static theory came as a result of the work of Modigliani & Miller, which is based on the assumption that there is no cost of debt, which led to finding the optimal financial leverage through the factors of internal financing versus external financing (Fisseha,2010), with the high costs of bankruptcy, agency, debt and tax, in addition to the fact that the income Nontaxable, all of this gives preference to debt financing because its cost is lower compared to the cost of equity financing because tax advantages, accordingly the optimization is determined according to this approach through the comparison between tax advantages For borrowed financing and between equity financing (Niu,2008), (MIAO, 2005) presented the competitive equilibrium model of the capital structure and its relationship to the dynamics of the industry, the researcher indicates that companies make their financing decisions based on technical shocks, and from here the issue of the optimal capital structure arises (MIAO,2005), Based on the stakeholder theory presented by (Grinblatt & Titman, 2002), which states that the organization deals with non-financial stakeholders has a clear impact on the optimal capital structure (schauten & spronk,2010), According to the trade-off theory, the optimal capital structure is determined by the trade-off between the costs and benefits of debt, When thinking about the theory of trade-off with financing by borrowing, the focus will be on both sides of tax benefits and the cost of bankruptcy, From the agency of view, it focuses on the principle of balancing between stakeholders and managers on the one hand, and stakeholders and lenders on the other hand as a basis for the trade-off (Uribe et al,2021), Although many researchers provide various theories based on different hypotheses (net income theory, net operating income, traditional approach, Modigliani & Miller, trade-off, asymmetric of information, pecking order, signaling, agency, cash flow and market timing theory) for Achieving the optimal capital structure, any of them was not able to provide a model that suits all organizations of different financial structures , sizes and their ability to obtain appropriate financing (Afrasiabishaniet al,2012), Funding decisions must lead to a financing structure in a certain way, this starts from two options financing by equity and the borrower, who express them with the proportions of the debt and equity ,optimal trade-off must take the cost and benefits of components of the

optimal capital structure, the trade-off between these components will be at increasing units of the financing element owned in vs sacrificing units of borrowed financing, or vice versa (Zhiqiang, 2009). Researchers' assertions go to the fact that the issue of the optimal capital structure is still a dilemma, so the issue of determining the optimal percentage of borrowed financing or ownership is an unconfirmed issue for consideration, the most important of which is the cost of each source, ease and difficulty in obtaining it (Binsbergen et al., 2011). The important question is financing decisions have an impact on the formation of the optimal capital structure? Indeed, the capital structure is the place for employing various types of financing decisions, as they have an impact on cost, profit, liquidity, safety, company value, and other areas (Dhankar & Boora, 1996). Capital structure theories emphasize the conflict of decisions between management and stakeholders, and therefore the issue of depending on external borrowing as a primary source of financing may solve these conflicts to some extent, and at the same time generate conflicts and controversy risks bankruptcy (Novaes & Zingales, 1995).

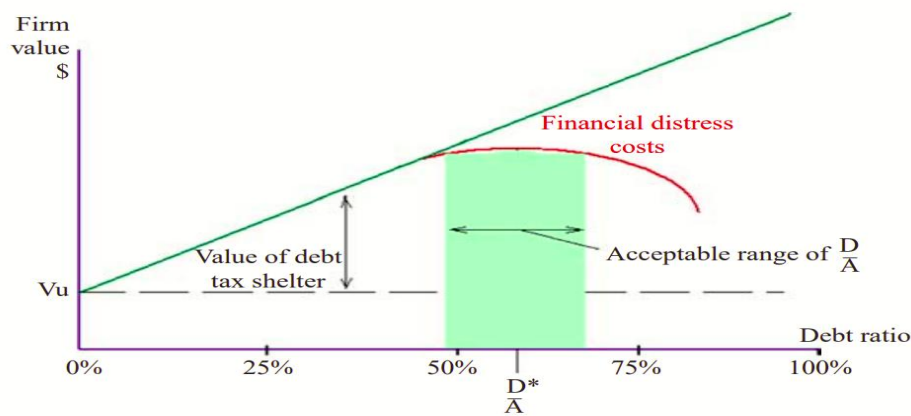
The optimal capital structure is a mixture of ownership rights and long-term debts, and this correct mixture will result in an increase in the value of the company, the most important element in the capital structure is the amount of cost that the establishment bears as a result of the formation of its financial structure, here comes the issue of optimization between the formation of that mixture. One of the elements of the capital structure in a way that leads to a reduction in the total financing cost in the end, which is reflected in the future decisions of the enterprise (Wet, 2006). Since all of these theories were based on two elements, the cost of owned financing and borrowed financing, and finding a weight for both costs to achieve WACC, from here our scientific contribution stems, by re-weighing both elements using linear programming integrated with the genetic algorithm to find multiple weights that give the same value to the objective function to reduce the cost of the capital structure.

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**WACC**

The capital structure theory provided two ways of financing, either through a certain or optimal level of debt and the company's ability to deal with it, depending on the speed of response associated with the conditions of the company and the market, or between depending on hybrid financing (Arzac ,2005), The cost of capital depends on the method that is used in its calculation, Weighted average cost of capital is one of the most common methods in use because it gives relative importance to each source used in financing and an adjustment of weights, which is reflected in the return on capital, at sixties of the twentieth century, Modigliani & Miller presented Weighted average cost of capital to reflects the problems that occur in the decisions of the capital structure, The two WACC components will lead to an additional reduction in the cost of debt in addition to the reductions resulting from tax savings by giving a weight to this component that is appropriate to its cost (abrowska et el,2021), the idea (Modigliani and Miller, 1963) was based on expectations of future cash flows, and accordingly the leverage ratio will become a random variable, and this idea was refuted by (Miles & Ezzell, 1980) With fixed ratios of leverage, we will not be able to extract correct values (HUSMANN et al,2001), (Cohen, 2003) refers to two important issues in calculating the WACC, the first is the accuracy of the calculation, and the second is the extent to which WACC can be used to evaluate the company's business, With the first, this can be done using CAPM or through the cost of debt and the tax rate (Cohen,2003), While the second can achieve through subsequent comparisons of the amount of improvement obtained by reflecting the impact of the capital structure on the company's value or profits, If the Weighted average cost of capital is used as an indicator for financial analyzes when making a decision, it is an indicator to determine the attractiveness of investment if it is used by investors to buy shares to determines the minimum expected rate of return on investment, and for the company, it uses it to determine the cost of (Dobrowolski et al,2022), The idea is based on maximizing the value of the enterprise by reducing the WACC, and despite the prevailing belief that investors want a low return with low levels of the cost of debt as a result of the low risks associated with bankruptcy and as a result of the company adding more debt in advanced stages, the WACC will start

to rise and the owners will try ask more compensation for the risks that began to rise, and through the figure (1), as it notes the direct relationship between the level of debt and the value of the company, which is reflected in the WACC, With the debt at 0%, the value of the WACC will be equal to the cost of the debt, and with the increase in the debt to 25%, we will move To the first quarter, and so on, up to the middle of the second quarter, to determine the best WACC ratio, and accordingly, the low levels of debt financing are directly related to the increase or decrease in the value of the company, and accordingly, there must be an optimal ratio of financial leverage so that the value of the company is in the best and balanced condition in light of The amount of leverage and equity financing (Stretcher & Johnson,2011).



**Methodology**

- 1) Problem: In light of the uncertainty and the availability of one option to determine the cost of financing sources, then give a weight to each asset based on the cost, the need arose to re-weight the financing cost assets based on the programmatic progress that searches for the survival of the fittest, and accordingly the problem was the inaccuracy of the weights given for debt financing and equity.
- 2) Objective: this research aimed to find a way that enables all types of organizations to give weights for financing elements accurately through the use linear programming and genetic algorithm.
- 3) Data collection :this data are collection as view in table (I):

**Table (I)**

**BASIC DATA**

Name of data	KE	KD
RF	0.038	-----
Ri	Use for calculate $\beta$	-----
RM	Use for calculate $\beta$	-----
estimation RM	By liner regression (0.050)	-----
Tx	-----	0.15
rd	-----	0.05
Value of equity	Capital (2923200000)	
	Reserves (2537093595)	
	long-term provisions (5709575)	-----
	total (5466003170)	
Value of debt	Long term reserved loans (3000000000)	-----

We can note the following:

- a. RF value was calculated based on the statistical reports of the Central Bank of Iraq, which were represented by the interest rate on Treasury bill.
  - b. Ri & RM was calculated based on the statistical reports of the Iraq Stock Exchange period 2007-2022.
  - c. To calculate  $\beta$  used liner regression for estimation RM.
  - d. The tax rate was obtained from the official report published by Al-Mansour Hotel.
  - e. rd :The cost of a long-term loan is the interest rate required by the bank.
  - f. The total value of the financing owned, consisting of capital, reserves, and long-term allocations
- 4) Mathematical formulas :
- a. The standard formula to calculate WACC is (Rahman & Raof, 2010:7):



$$WACC = K_E * WE + [K_D * WD * (1 - T)]$$

WD = Weightage of Debt in total Capital

$K_D$  = Cost of Debt

WE = Weightage of Equity in Total Capital

$K_E$  = Cost of Equity

T=tax

Our modifying on WACC model is to random weight between (0-1) for both cost of debt and equity: As the traditional formula for determining weights was dispensed with and reliance on the genetic algorithm by randomly determining weights for a value confined between 0-1.

$$WACC = K_E * W_{0-1} + [K_D * W_{0-1} * (1 - T)]$$

b. Calculate the capital equity cost by CAPM(Chen,2021:916):

$$CAPM (KE) = r_f + \beta_a(r_m - r_f)$$

Where:  $r_f$ = risk free

$\beta_a$ =beta

$r_m$ = market return

c. Calculate the Cost of Debt(Furaiji & Mataroud,2017):

$$KD = rd(1-tx)$$

5) linear programming and genetic algorithm :

A. The formula of linear programming is define as :

$$\{\text{minimize } WACC [KE \ w_1 + KD \ w_2]$$

s.to

$$0 \leq w \leq 1$$

B. While genetic algorithm define as: genetic algorithm is explain in **Table (II)**

**Application**

**A. : calculate the Weighted Average Cost of Capital (WACC) BY:**

$$WACC = K_E * \left[ \frac{E}{E + D} \right] + \left[ K_D * \left[ \frac{D}{E + D} \right] * (1 - T_X) \right]$$

$$WACC = 0.0380 * \left[ \frac{5466003170}{5766003170} \right] + \left[ 0.0425 * \left[ \frac{300000000}{5766003170} \right] * (1 - 0.15) \right]$$

$$WACC = 0.038$$

Until now we calculate the WACC by any adjustment, therefor the result of Weighted Average Cost of Capital 0.038 this represent cost of financing for AL-Mansour Hotel.

**B. : application the liner programing with genetic algorithm**

1. Define the model: we want to reduce the cost of financing, farther use the minimum function.

$$\{ \text{minimize } WACC [0.0380 w_1 + 0.0425 w_2] \}$$

s.to

$$0 \leq w \leq 1$$

2. Define the function fitness.
  - a) Number of variable (2).
  - b) Constraint ( $0 \leq w \leq 1$ ).
  - c) Genetic algorithm option Table (II) .

**Table (II)**

Genetic algorithm option

GA option		
	Population type	Double vector
Population	Population size	50
	Creation function	Constraint dependent
Fitness function	Scaling function	Rank
Selection	Selection function	Tournament
	Tournament	4
Reproduction	Default	
Mutation	Constraint dependent	
Crossover	Default	
Migration	Direction	Both
Constraint parameters	Default	
Stopping criteria	Default	

Table (II) represent the optimal choose for our problem to gain best result

3. the code of genetic algorithm:

```
function [x,fval,exitflag,output,population,score] = untitled(nvars,lb,ub)
%% This is an auto generated MATLAB file from Optimization Tool.
%% Start with the default options
options = optimoptions('ga');
%% Modify options setting
options = optimoptions(options,'MigrationDirection', 'both');
options = optimoptions(options,'SelectionFcn', { @selectiontournament [] });
```

```
option=optoptions(options,'CrossoverFcn',{ @crossoverintermediate [] });
options = optoptions(options,'Display','off');
options = optoptions(options,'PlotFcn',{ @gplotbestf @gplotbestindiv });
[x,fval,exitflag,output,population,score] = ...
ga(@fatma,nvars,[],[],[],[],lb,ub,[],[],options);
```

4. The Result :in the table (III) viewed the result from analysis, value of WACC is 0.035 It is less than the previous value by 0.03 these reflect to reduce the cost from (5766003170) to (5044189264) as in table (IV),the histogram of the parents figure (3) ,shows you which parents are contributing to each generation

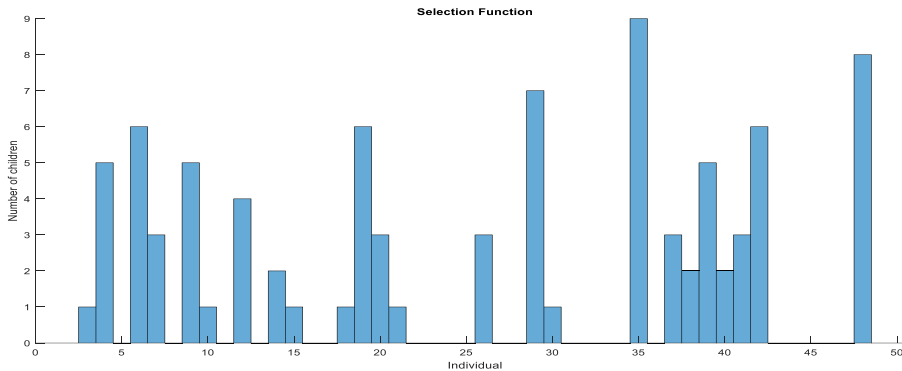


Table (III)  
Function and weight

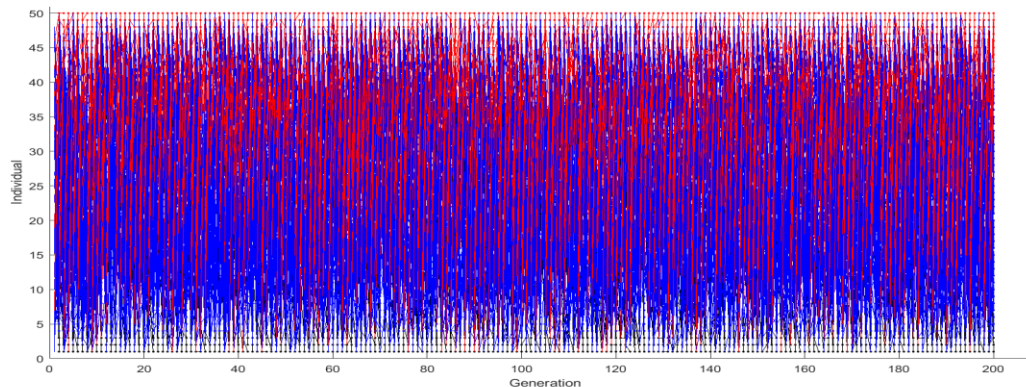
NO.	w1	w2	WACC	NO.	w1	w2	WACC	NO.	w1	w2	WACC
1	0.485	0.450	0.035	18	0.480	0.460	0.035	35	0.481	0.466	0.035
2	0.478	0.468	0.035	19	0.479	0.467	0.035	36	0.480	0.470	0.035
3	0.485	0.448	0.035	20	0.480	0.470	0.035	37	0.479	0.464	0.035
4	0.484	0.455	0.035	21	0.480	0.470	0.035	38	0.480	0.471	0.035
5	0.481	0.472	0.035	22	0.481	0.466	0.035	39	0.481	0.464	0.035
6	0.478	0.475	0.035	23	0.480	0.472	0.035	40	0.479	0.470	0.035
7	0.484	0.453	0.035	24	0.482	0.466	0.035	41	0.480	0.465	0.035
8	0.480	0.472	0.035	25	0.485	0.449	0.035	42	0.488	0.464	0.035
9	0.481	0.464	0.035	26	0.478	0.473	0.035	43	0.480	0.476	0.035
10	0.479	0.467	0.035	27	0.481	0.466	0.035	44	0.478	0.479	0.035
11	0.481	0.461	0.035	28	0.481	0.471	0.035	45	0.481	0.448	0.034
12	0.478	0.469	0.035	29	0.478	0.468	0.035	46	0.481	0.449	0.035
13	0.481	0.469	0.035	30	0.480	0.468	0.035	47	0.480	0.475	0.035
14	0.480	0.469	0.035	31	0.478	0.471	0.035	48	0.487	0.468	0.035

15	0.483	0.461	0.035	32	0.479	0.470	0.035	49	0.477	0.460	0.035
16	0.481	0.453	0.035	33	0.481	0.452	0.035	50	0.485	0.460	0.035
17	0.481	0.474	0.035	34	0.482	0.461	0.035				

The results generated by the genetic algorithm present different combinations of weights to redistribute the cost of owned financing versus borrowed financing, And as we note, despite the existence of different combinations of weights for costs, the WACC value remains constant and is less than the old WACC value. By use the genealogy of individual's figure (2), Lines from one generation to the next are color-coded as follows:

- Red lines indicate mutation children.
- Blue lines indicate crossover children.
- Black lines indicate elite individuals

Figure (2)  
The genealogy of individuals



**5. The amount of the exchange :** To determine the amount of change in the cost of capital, a set of function was established to be used in determining the owned capital and borrowed that is supposed to be used to achieve the new percentage of WACC :

a) New equity :

$$w_1 = \frac{E}{E + D}$$

$$E = w_1 * E + w_1 * D$$

$$E - w_1 * E = w_1 * D$$

$$E(1 - w_1) = w_1 * D$$

$$E = \frac{w_1 * D}{1 - w_1}$$

E = 277885789.6

b) New debt :

$$w_2 = \frac{D}{E + D}$$

$$D = w_2 * E + w_2 * D$$

$$D - w_2 * D = w_2 * E$$

$$D(1 - w_2) = w_2 * E$$

$$D = \frac{w_2 * E}{1 - w_2}$$

D = 4766303474

Table (IV)

Comparison between old and new value

	Old value
Total equity	5466003170
Totally debt	300000000
Total capital	5766003170
	New value
Total equity	277885789.6
Total debt	4766303474
Total capital	5044189264

The table (IV) is presented to quantify the change in the cost of capital based on the results from the point a) and b), as noted old value of WACC is (5766003170) and then we of improvement the result to be (5044189264)

## Conclusion

This paper reviews the theoretical foundations of optimal capital structure, with focus on the cost of capital, and suggests a framework for weight the elements of capital structure. This is useful in undergraduate the best way for financing, in particular compression between debt or equity or both.

By comparing the results of the cost of capital under the traditional formula and the improved formula by us, we concluded that the proposed formula is able to provide a combination of weights to determine the percentage of the participation of the debt and property financing components in reducing the cost of capital so that it is possible to obtain the same value for the objective function, although use of different weights for the same two elements we get one value for objective function, the use of linear programming was for reducing the value of the objective function, and as mentioned above, the genetic algorithm was employed to obtain those distinct mutations from the parental chromosomes, the cost of debt and the cost of property,

This study concluded by presenting results on the feasibility of using the two tools for the purpose of reaching that optimal combination of capital structure, and our knowledge by making an improvement on WACC in terms of the weight of its assets, And since the basis adopted in preparing the financial statements for the service organizations operating in Iraq is unified, it is possible to rely on the results generated by the article, What the article presented opens the door for future researchers to verify the validity of ideas and the possibility of generalization.

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