



Linear Programming and Investment Appraisal: A Review of Literature

Shobayo Peter Babatunde

Department of Business Administration, Faculty of Social and Management Science, Olabisi Onabanjo University, Ago Iwoye, Nigeria

Email address:

shobayopeterbabatunde@gmail.com

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Abstract: This report review international literature on linear programming and how it applies to investment appraisal. It highlights the acceptable methods on investment appraisal and describes the major aspect of investment appraisal. The research review literatures and identify the distinctions between the research as well as providing explanations for them. The discounted and non-discounted techniques of investment appraisal were examined and the study further studied the relationship between linear programming and how it applies to investment appraisal. Thus this study identifies the relationship between linear programming and investment appraisal.

Keywords: Net Present Value, Internal Rate of Return, Profitability Index, Linear Programming, Investment Appraisal

1. Introduction

The investigation aimed at a consistent technique of investment appraisal could be traced back to decades. This problem does not affect only academicians or managers; it has become a concern to investors and shareholders as well. There are a number of tools that could be used to ascertain the level of project profitability (Akalu, 2001). Nevertheless, these methods have failed to take into cognizance the dynamic nature of the business environment which has placed high importance on shareholders value. More so, their constant use has revealed their inability to fully find solution to the fundamental problems that have continued to face investment appraisal over the years as well as the complex requirement of the decision making process of some of these methods (Dramodaran, 2000; Akalu, 2001). Consequently, there has been difficulty in choosing a suitable appraisal method for project managers which needs a serious analysis of different tools.

There are several methods that have been proposed by scholars to resolve the fundamental issue in investment appraisal. The commonly used technique of this method is the traditional discounted cash flow (DCF) (Arnold & Hatzopoulos, 2001; Graham & Harvey, 2001). Furthermore, the real option method have been recommended by some researchers (Boer, 2000), while other researchers believe in

the value management technique (Stewart, 1991). Nevertheless, as good as these methods are, they have their own different disadvantages. For instance, the disadvantage of DCF technique is its inability to appraise easy project like research and development (R and D) which has limited management in proper appraisal of the project while adopting the rule of the thumb method in the selection of such projects (Tyrrall, 1998). The Real Option method meanwhile has been found to be difficult and requires huge computer works. More so, the value management technique has been condemned for its failure to measure Furthermore, the value management tools, such as the economic value added, are criticized for its inability to measure value creation of the shareholders (Fernandez, 2001).

There are different types of investments and projects that can be carried out by an organization. The different types and nature of the investment and project is dependent on the type of industry that the organization is located, and their mode of operation. For example, organizations in the financial sector carry out series of project which ranges from information technology to real estate. The appraisal technique that is dominant in this kind of industry is the DCF and the quantitative technique (Akalu & Turner, 2001).

However, organizations that are located in the chemicals and the oil and gas industry shift their focus on projects which include research and development (R and D). Projects like this create a high return on investment as well as play a

key role to such organization in the industry (Hess, 2001). Due to this, organizations in this industry adopt the qualitative method to appraise projects (Akalu & Turner, 2001). Choosing the best alternative investment and the best resources to achieve it can be solved using mathematical methods which include the linear programming method. Nevertheless, this can only be possible if there is a carefully formulated decision parameter as well as known efficient criteria.

2. Literature Review

2.1. Investment Appraisal

One of the most crucial responsibilities of a manager in an organization is the appraisal of investment. Investment appraisal could be described as the formulation and the financing of long term investment. The development and the efficiency of an organization are dependent on the decision of its investment appraisal process. This process helps in achieving high rate of effectiveness and efficiency in the organization. There are different techniques in appraising an investment which will be discussed in this study.

2.2. Investment Appraisal Techniques

There has been a great attention on investment appraisal techniques by researchers in capital budgeting literature. Resources are consumed by all investments, and insufficient appraisal brings about the allocation of these scarce resources to investments that do not yield maximum return above the cost of capital, thereby destroying the organization's image and value (Copeland & Tufano, 2004; Shapiro, 2005).

There are different methods of evaluating a project which can be subdivided into the traditional/ non-discounted method and the discounted method. The non-discounted method include the payback period (PB) and the accounting rate of return (ARR), while the discounted method include: net present value (NPV), internal rate of return (IRR), profitability index (PI), and the discounted payback period (DPP) (Graham & Harvey, 2001; Ryan & Ryan, 2002; Sandahl & Sjogren, 2003; Berkovitch & Israel, 2004; Marino & Matusaka, 2005).

Apart from these major investment appraisal methods, there are also some more strategic investment appraisal methods and these include: value chain analysis, strategic cost management and technology road mapping (Shapiro, 2005; Alkaraan & Northcott, 2006; Hopper, Northcott & Scapens, 2007; Tuomaala & Virtanen, 2011). The value chain analysis method assists businesses in the identification of activities which are of strategic important values, as well as assists the organization in making suitable competitive strategies (Hoque, 2001). The strategic cost management method is concerned with the application of cost analysis as well as taking into cognizance the strategic context of investment opportunity (Shank, 1996). While the technology road mapping method is described as "a process that contributes to the definition of technology strategy by

displaying the interaction between products and technologies over time" (Groenvelde, 1997, p. 48) which uses charts and graphs to develop the relationship between technology and business needs (Alkaraan & Northcott, 2006). However, findings from past research reveal that the commonly adopted investment appraisal methods are the payback period, net present value and the internal rate of return (Arnold & Hatzopoulos, 2000; Graham & Harvey, 2001; Sandahl & Sjogren, 2003).

2.2.1. The Net Present Value (NPV) Method

This method is calculated as the present value of the expected cash flows, less the cost of investment (Ross, Westerfield & Jaffe, 2005). The positive cash flow is the cash inflows, while the negative cash flow is the cash outflows and the initial investment. If there is a positive NPV of all the cash flows at the assumed minimum rate of return, it implies that the real rate of return of the investment is greater than the least anticipated rate of return, thus it should be accepted. However, if the overall NPV is negative, it implies that the actual rate of return is less than the least anticipated rate of return (Budnick, 1988). This technique is popular in making investment decisions because it takes into cognizance the time value of money invested in a business (Peel & Bridge, 1998). While there are many advantages of NPV method, there are however some limitations to the method. The method has failed to capture the overall economic attraction of capital outlays of which the size of the investment affects the size of the NPV (Helfert, 2001).

2.2.2. The Internal Rate of Return (IRR) Method

This method is also known as the marginal efficiency of capital or yield of investment (Kay, 1994). This method adopts a process of discounting the cash flow so as to make a decision on the long term feasibility of the investment or project. The investment or project should be accepted and would give more value to the organization if the IRR value is greater than the cost of capital of the project, however if otherwise, the project is rejected. The IRR technique is seen as the equivalent rate of return of the present value of the cash outflow and the present value of the future cash inflow (Copper, 1999).

2.2.3. The Profitability Index (PI) Method

This method is used in a case to examine investments that have been determined using the NPV. The computation of the PI is derived by the division of the present value of each investment by the initial capital. PI can also be referred to as benefit cost ration, and the investment is accepted if the PI is greater than 1. Otherwise, it is rejected.

2.2.4. The Discounted Payback Period (DPP) Rule

This method takes into cognizance the time value of money. The method signifies how long it will take for the present value of the cash flows to equate the investment. This method displays how long it will take an investment to payback the cost of capital while considering the time value of money. The rule of the payback indicates that it's only

investments that payback at the stipulated time that should be accepted. However, the limitation of this method is that it disregards the cash flow timing within the payback period, as well as ignores the present value of the project after the payback period (Brealey, Myers & Allen, 2006; Ross et al, 2005).

2.2.5. Payback Period (PB) Method

This method can be defined as the number of years the cash inflow of an investment equates its cash outflow. In making decisions between two or more investments, it is standard to accept investment or project with the shortest payback. The payback method can also be used as the first screening method which implies how long it will take for an initial investment to pay back its cost.

2.2.6. Accounting Rate of Return (ARR) Method

This method deals with the ratio of the project's average income after tax, in relation to its average book value (Copper, 1999). The accounting rate of return method appraises a project using a standard cost accounting technique. This method can also be referred to as the book rate of return and it appraises projects on the average income and accounting data instead of the cash flows of the project. This method is different from the payback method in the sense that it gives a percentage rate of return for different projects which then is used to rank the investments.

2.3. Linear Programming Model

The need for organizations to achieve unlimited wants with its limited resources is one of the main problems facing organizations in recent time (Ozsan, Simsir & Pamukcu, 2010). Linear programming (LP) serves as an influential technique which can be used to reach an optimal solution that satisfies both the constraints and the existing situation requirements (Better, 1988).

Linear programming technique consists of three measurable mechanisms which include: the objective function (profit maximization or cost minimization), set of constraints (restrictions) and the decision variables (Chinneck, 2004). In generating the linear programming model, it is assumed that there is a linear relationship between the decision variables that exist over the different alternatives in the problem (Chinneck, 2004). The output of LP does not only offer optimal solution, it can as well bring about sensitivity analysis. Sensitivity analysis deals with the changes that occur in the coefficients of the objective function which have an effect on the LP model optimal solution. The sensitivity analysis also determines the effect of the changes in the coefficient of the objective function as well as the right hand value on the optimal solution (Anderson, Sweeney & Williams, 2000). LP technique is used to estimate and optimize raw materials; capital, machinery, equipment, manpower and time under some constraints in order to get the maximum value (Han, Huang & Maqsood, 2011). The LP model assists managers in the efficient allocation of resources especially in circumstances

where there are significant constraints on the resources.

The linear inequality problem solving can be traced back to Fourier in which the Fourier-Motzkin elimination method is named after. The first founders of the linear programming model are three scholars who include: Leonid Kantorovich, who was a Russian mathematician that developed the initial linear programming model in 1939, George Dantzig, the researcher who initiated the simplex method in 1947, and John von Neumann, who was involved in the duality theory in the same year. The first linear programming was advanced by Leonid Kantorovich, the Russian mathematician in 1939. This model was adopted in the World War II to organize income and expenditure so as to minimize the army's cost while increasing the enemy's losses. Linear programming in management and decision making was originated in the 1940s when a team of British scientists used it in making decisions among the military on how best to use war materials (Taha, 2011).

The model of LP has developed over the years to optimize operations in an organization. This operation includes the selection and scheduling logistic planning (Hassan, Kandeil & Elkhayat, 2011). Linear programming could be used as an instrument to select a production stock facing resources, marketing and preference constraints (Jansen & Wilton, 1984). Linear programming model has been used in numerous countries to optimally allocate resources as well as resource necessities (Onyenweaku, 1980; Alam, 1994; Alam, Elias & Rahman, 1995; Schipper, Jansen & Stoorvogel, 1995; Sama, 1997).

2.4. Theoretical Framework

2.4.1. Modigliani and Miller's Theory on Investment (1958)

It was argued by Modigliani and Miller (1958) that financing and dividend decisions should be seen as irrelevant and there should be an attention on the investment opportunity which will yield a positive net present value (NPV) that will optimize the value of the firm. Consequently, the framework for the determination of the NPV of a project which is derived the discounted cash flow analysis (DCF) serves a rational foundation to make collective decision. Modigliani and Miller's (1958)'s classical theory serves as a classy tool which evaluate how the organization maximizes its profitability.

On the contrary, it has been argued by Hastie (1998) who sees the financial theory as a recommendation on the use of classy investment appraisal technique such as the net present values to make a better decision as well as increase the organization's value as been unnecessary. The researcher based his arguments on the basis that there are many seemingly acceptable projects which can be approved by an organization either due to limited capital or raw materials, or due to limited management or technical talent. It was also observed by the researcher that the adoption of incorrect assumptions has resulted into a wrong investment decision rather than the use of the measurement methods. There could be an enhanced investment decision making if attention was focused on suitable tactical questions, as well as utilizing a

better assumption instead of increasing the measurement techniques.

The position of Adler (2006) was that there should be a removal of the discounted cash flow (DCF) from the financial theory because it is unconnected to modern business practice as well as that it is risky in using it to evaluate investments. The researcher further demonstrated that the DCF works well and can be correctly used from the position of one's perception; however, it is not useful to predict the future direction of a business. He asserted that there is less meaning to the DCF, and therefore it should not be used to appraise capital budgeting decisions, instead it should be substituted with a less restrictive and more positive techniques. The internal rate of return technique adopts the re-investment of funds at the IRR, while the net present value (NPV) technique adopts a suitable discount rate to value the expected cash flows. The NPV could undervalue an investment's worth and could make management to forego worthy investment opportunities, thus, generally the technique do not give managers the flexibility need when making strategic investment decisions.

2.4.2. Pecking-Order Theory

It was argued by the pecking-order theory that an organization choose to utilize their retain earnings to finance investments because of information irregularity (Myers, 1984; Myers & Majluf, 1984). Organizations first issue debt after which lastly issue equity in a case when the internal financing is not sufficient. This model does not allow for firm to have a set target ratio. It has been evidenced by studies that financial flexibility is valued by many finance officers, especially when there is a higher proportion of managerial ownership. The position of most managers is that the inability to use their internal funder to carry out activities brings about the issuance of debts. The inability of an organization to sometimes get fund through debts has an effect on their decision to issue common stock (Graham & Harvey, 2001).

2.5. Review of Empirical Literature

Numerous researchers have find solution to numerous problems with the use of linear programming technique, some of which are reviewed in this research. Isa (1990) adopted linear programming (LP) as well as other mathematical techniques to appraise watershed and perpetuity constraints on forest land use for certain setting in Terengganu, Peninsular Malaysia. The model showed series of feasible solutions for decision making. Equations were generated for the model in order to demonstrate interface of sedimentation because of the construction of road, harvesting of timber as well as other forest management related activities. The study also adopted sensitivity analysis to test the model behavior, and it was discovered that there are constraining effects of sedimentation on revenues from forest when sedimentation varied within the feasible region of the model.

Kuo, Schroeder, Mahaffey & Bollinger (2003) studied the

data from the division of general surgery at duke university medical center from December 1, 2000 to July 31, 2002 on allocated OR time, case mix as explained by CPT codes, total operation research time used and the normalized professional charges and receipts. The linear programming routine in the Microsoft excel was adopted to ascertain the best combination of surgical OR time allocation that will yield the maximum professional receipts. Their findings indicated that the mathematical modeling techniques that are adopted in operations research and management science could judiciously enhance OR allocation so as to maximize profit and minimize cost. The techniques could enhance distribution of scarce resources in the context of the goals specific to individual academic departments of surgery.

Matthews (2005) assessed and optimized nurse personnel utility at the internal medicine outpatient clinic of wake forest university Baptist medical center. The researcher used linear programming to know the active combination of nurses that should be used to achieve the weekly clinic tasks in the least possible cost to the department. The study performed a sensitivity analysis in order to ascertain the stress of adding or removing a nurse from and to the payroll. The study adopted five certified nurse assistants (CNA), three licensed practicing nurses (LPN), and five registered nurses (RN) as the employee cost structure, and it was discovered in the linear programming solution that the clinic should staff four certified nurse assistants, three licensed practicing nurses and four certified nurse assistants with 95% confidence of covering nurse demand on the floor.

Gassenfert & Soares (2006) in their study obtained a practical proposition in applying linear programming quantitative method so as to help plan and control customer circuit delivery activities in telecommunications companies working with the corporative market. Relying on the data provided by a telecom company base in Brazil, the study adopted the linear programming method so as to determine the best combination of quantities to be produced for a set of five products of that company which include: Private telephone network, Intranet network, Internet network, Low speed data network, and High speed data network, while taking into cognizance the several limitations of the resources to produce as well as looking to maximize the monthly revenue of the company. By applying the available data in the primary model, it was discovered on what number of monthly activations for each product that needs to be optimized so as to achieve the maximum revenue in the company.

Nyikal & Adhiambo (2008) in which they seek to find the appropriate method to finance small holder agriculture in Kenya, it was important for them to make documentation and analyses of the effective demand for credit of small holders. Their particular interest was comparing the existing production plans and the production plans which are under strict profit maximization. Linear programming model was adopted to validate the observed plan as well as also determine the ones that are under profit maximization. There was a comparison of the activities and the values of outputs

under different objectives. The study was carried out in identified zones of Muranga and Kisumu districts where the sample farmers were met and were administered structured questionnaires that covered farm events and physical resources of 1995 short rains and 1996 long rains. This served as the foundation for the formulation of the farm plans, and it was discovered that the objectives of the small holders have not changed as observed during the outreach program. The findings indicated the following (i) there were differences in the activities of the observed plans and those under strict profit maximization, (ii) the profit of the observed plans is significantly lower than the profit under profit maximization, and (iii) meeting constraints through credit can only be achieved when there is a profit maximization objective. Small holder agriculture which are described by survival production, do not show effective need for credit, thus financing it needs other ways apart from the competitive market.

Naifer, Al-Rawahy & Zekri (2010) focused on how farmers can achieve and withstand an economically and feasible agricultural production in salt affected areas in Oman. They separated a sample size of 112 farmers to different groups on the salinity level of the soil; low salinity, medium salinity and high salinity. They adopted linear programming technique to maximize the farm's gross margin underwater, land, and labor constraints. The financial losses that the farmers incurred were calculated by relating the profit of the medium and high salinity farms to the gross margin of the low salinity farm. It was discovered that and increase of salinity from low salinity to medium salinity level resulted to a damage of US\$ 1,604 ha⁻¹, and an increase from medium salinity level to a high salinity level resulted to a damage of US\$ 2,748 ha⁻¹. It was also shown that the introduction of salt-tolerant crops in the cropping systems leads to a substantial improvement in the gross margin, consequently making it attractive enough to farmers in the medium salinity category to adopt new crops as well as to moderate the effect of water salinity.

3. Conclusion

This study has captured the conceptual, theoretical and empirical literature on appraising investment using the linear programming. It has provided a detailed review of part of the vast literature on investment appraisal techniques and linear programming. It has however been observed that in appraising investment, many scholars adopts the traditional/non-discounted and the discounted method which include the payback period (PB), accounting rate of return (ARR), profitability index (PI), discounted payback (DPB), net present value (NPV), and internal rate of return (IRR), thus, ignoring the linear programming approach to appraise investments. This has formed the basis for this study so as to have an in-depth knowledge on linear programming, and how it can be used in making better investment decisions, as well as to find out whether it has an edge over the discounted and non-discounted investment appraisal technique.

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