

A decision framework for automatic teller
machine investment: An application to the
Nigerian banking sector

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ABSTRACT

The selection and adoption of an appropriate information technology projects is one of the most challenging business tasks of the last decade. IT projects often record the largest capital expenditure for most service oriented companies. Unfortunately, many IT projects have not met their expectation despite their huge expense.

Consequently, there is an urgent need to develop a framework that will assist in the analysis and selection of these IT projects. In this dissertation, classical financial theory coupled with Real Options analysis, namely a Mean-Variance (MV) model is used to provide new insights on project selection and analysis.

More specifically, this dissertation presents an easy-to-use framework that will assist managers to evaluate potential ATM deployment projects. In addition, a case study to demonstrate how to apply the framework in a typical bank of a growing economy is presented.

This dissertation contributes to IT management field by defining the risk dimensions of IT investments and providing insights based on interdisciplinary financial theories.

DEDICATION

I dedicate this dissertation to my loving mother, Late (Mrs.) Alice Olabisi Odewale who passed away during the pursuit of this programme.

ACKNOWLEDGEMENT

First of all, I give God all the glory for the wisdom bestowed on me during the course of this programme. To him alone be all the glory and honour.

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LIST OF ABBREVIATIONS

AHP	-	Analytic Hierarchy Process
ATM	-	Automatic Teller Machine
CBN	-	Central Bank of Nigeria
CSF	-	Critical Success Factor
DEA	-	Data Envelope Analysis
ERP	-	Enterprise Resource Planning
GSM	-	Global System for Mobile Telecommunication
ICT	-	Information and Communication Technology
IS	-	Information System
IT	-	Information Technology
ITU	-	International Telecommunications Union
MIS	-	Management Information System
MV	-	Mean Variance
NITDA	-	Nigeria Information Technology and Development Agency
NPD	-	New Product Development
NPV	-	Net Present Value
OAS	-	Office Automation Systems
OT	-	Options Theory
R&D	-	Research and Development
RO	-	Real Options
ROA	-	Return on Assets
ROE	-	Return on Equity
ROI	-	Return on Investment

CHAPTER ONE

1.0 INTRODUCTION

1.1 INVESTMENT IN INFORMATION TECHNOLOGY

The importance of Information Technology (IT) in today's business environment cannot be over-emphasized. Corporations invest immensely in IT in order to meet or maintain a competitive advantage (Sircar, 2000).

In 1996, it was estimated that the US companies spent about 43% of their capital budgets on hardware alone (Gibbs, 1997). Subsequently, in 1998, software development incurred an annual expenditure of 300-400 billion dollars with the employment of roughly 2 million software professionals (Boehm & Sullivan, 1999). Furthermore, it was estimated that IT investments in the US over the last decade reached 3 trillion dollars (Davenport, 1997).

In a recent summit sponsored by International Telecommunications Union (ITU) held in Rwanda (Oct. 2007) (International Telecommunications Union, ITU, 2007), Dr.Hartwig Schafer - the World Bank Director of operations - announced that World Bank is prepared to provide up to \$2 billion for ICT infrastructure development in Africa. In the same vein, the Governor of the Central Bank of Nigeria (CBN) Prof. Soludo recently said that "ICT is a major player in actualizing the country's 2020 vision, the target of which is to place Nigeria among the top 20 economies in the world by ensuring a 13% annual growth rate in the next 13 years" (African Central Banks, 2007). Prof. Cleopas Angaye - Director of Nigeria IT Development Agency (NITDA) - further reiterated in a recent Finance and IT summit held in Lagos, that "the success of e-payment solutions in Nigeria depends on the provision of adequate ICT infrastructure and reliable helpdesk services "(Finance and IT Summit, Lagos. Nigeria. 2007). With the advent of the electronic commerce era, it can only be expected that the spending on IT will continue to be on the increase. Afterall, Metcalfe's law says that "the value of networks equals the square of the number of the users (Gilder, 1993)"

1.2 ATM PERCEPTION

In particular, Automatic Teller Machines (ATMs) are defined as technology gadgets or devices that are used in public areas (Baber, Stanton, & Johnson, 1998). In most parts of the world, bank customers make use of ATMs. These machines are recognized as a basic banking tool saddled with the responsibility of dispensing cash and providing basic information about financial status (Angeli, Lynch, & Johnson, 2002).

This machine (ATM) is perceived as a box whose technology is hidden and mode of operation unthinkable.

However, acceptance of ATMs has been a major challenge as most bank customers are not willing to change from the traditional banking methods especially since this has to do with strictly private financial matters. Meanwhile, banks are continuously intensifying efforts in ATM campaign in order to encourage its wide acceptance and adoption. This has strictly been focused on reliability issues surrounding the ATM Technology (Little, Briggs, Coventry, & Knight, 2003), (Mead & Fisk, 1998) & (Pepermans, Verleye, & Van Cappellen, 1996).

1.3 ATM TECHNOLOGY IN NIGERIA

In Nigeria, the ATM was introduced in 1989 by the defunct Societe Generale Bank (Eshekels Limited, 2006). Since then, ATMs appear to have spread their tentacles across Nigeria. For the purpose of this dissertation, Ikorodu area of Lagos state of Nigeria will be chosen; housing in excess of 20 ATMs and being one of the newest centers of commercial activities in Lagos.

The Nigerian banking industry no doubt has witnessed advancement in technology just like any other sector. The use of the ATM is one of these as it affects banking operations entirely. With the adoption of Self Service technology by banks, ATMs have continued to service the populace by offering convenience to customers and providing banking services well beyond the traditional service period. It therefore encourages a cashless society. Thus, eliminating the risk of loss of cash through theft or fire as witnessed in the past, creating a win-win scenario for parties concerned.

At inception, the few banks that had these machines restricted customers to accessing the machines from their banks alone. This cannot be said today, as technology solutions have been made available to the banks to enable users make withdrawals from ATMs of other banks.

However, the usage of ATM in Nigeria is just advancing beyond withdrawals, checking of account balance and purchase of airtime, despite the craving for its multifunctional services (pay bills or make utility/tax payments, calls, stock transaction, purchasing tickets etc) these modern services are not popular among users.

This research aims to assist managers in making an informed decision in respect to investment in ATM technology in a developing country like Nigeria.

1.4 PROBLEM STATEMENT AND SUBSTANTIATION

With the huge amount being invested in ATM technology, issues that pertain to justifying these investments have continued to receive increased attention. The following questions normally arise:

- **What is the importance of ATM?**
- **Is ATM better than the traditional banking method of human tellering?**
- **How can investment decision in ATM be guided or justified?**

Financial institutions need answers to these questions since ATM is regarded as one of the keys to meeting expectations and succeeding in a highly competitive business environment. Precise answers to these questions will allow business managers to make a wise and informed ATM Investment decisions. Management will also be assisted in properly justifying their huge investment in ATM technology at present and in future.

Meanwhile, the business value of an IT investment can be derived using some financial indicators like Return on Equity (ROE), Return on Assets (ROA), Return on Investment (ROI), etc. However, it has been argued that they may not be valid metrics for IT value

assessment since IT provides both tangible and intangible benefits (Baber, Stanton, & Johnson, 1998), (Angeli, Lynch, & Johnson, 2002).

Therefore, it will be unfair to assess the impact of IT on organisations in monetary terms only. In view of this, there is thus a need for an assessment tool that will assist in properly justifying IT investments, which will also guide business managers in decision making.

In view of the above, this research **will be undertaken in order to develop a decision framework for ATM technology with specific application to the Nigerian banking sector.** The outcome of this research will benefit:

- Information Technology body of knowledge through the contributions of the outcome of this research.
- Management in banking sector, by improving the quality of decision making in respect of ATM projects.

1.5 RESEARCH AIMS AND OBJECTIVES

The aim of this research is to describe and formulate a framework which will assist business managers in making a qualitative ATM investment decision.

This research will also provide insights into the following:

- The awareness of ATM
- Reasons for using ATM
- Level of usage
- A decision framework for ATM investment.

In Chapter two, a review of the existing literatures as well as the evolution and history ATM will be dealt with extensively while the proposed framework is introduced in Chapter Three. In Chapter Four, a particular bank tagged 'Bank A' in Nigeria is used as a case study to demonstrate the applicability of the framework developed while Chapter Five closes with discussion, conclusion and recommendation.

CHAPTER TWO – LITERATURE REVIEW

2.1 WHAT IS AN AUTOMATIC TELLER MACHINE (ATM)?

Automatic Teller Machine, also referred to as ATM is a machine that gives out or receives cash deposits from account holders. A smart card is used to initiate and complete a transaction in a typical ATM.

The smart card or simply put, ATM card as widely called, has an electronic chip that identifies each customer with respect to corresponding accounts belonging to the customer.

Despite the slow adoption of ATM by the users, it is noteworthy that the strategic importance of ATM cannot be under-estimated. This is because ATM is an easy-to-use self service tool. ATM is fast becoming an essential commodity in the banking sector. The use of ATMs has also been extended to some non-banking outlets such as hospitals, recreation centers, supermarket, just to mention a few.

2.2 HISTORY OF ATM

The idea of having access to your account or cash – 365 days a year irrespective of wherever you are in the world came into being about 40 years ago by a man named **John Shepherd-Barron**. Born in Tain Ross, Scotland in 1925, he saw a need to have such a machine that will enable him access to his money anytime irrespective of his location. Thus, out of curiosity and strong desire he came up with the concept of a **self-service** machine that will dispense paper currency giving users 24-7 availability. His words and I quote:

“It struck me that there must be a way I could get my own money, anywhere in the world or the UK. I hit upon the idea of a chocolate bar dispenser, but replacing chocolate with cash”

(Lewis, 2007)

2.2.1 The benefits of ATM

- ATM machine generates more revenue volumes as it allows bank customers access to their account whenever and wherever they may be throughout the world.
- ATM provides more security to banks and their employees by reducing robbery attack and theft.
- 365 day availability of account information
- Transfer of funds between accounts
- Account balance verification
- Retrieval of accounts' statements
- Withdrawals, deposits, etc

2.3 REVOLUTION OF ATM

The adoption of ATM technology in the financial services industry closely parallels merchant adoption of Internet technology for electronic commerce. In both cases, however, the benefits of merchant adoption were not immediately realized because customers shied away from actually using technology because of concerns about security and benefits (Santos & Peffers, 1995).

As a consequence, 9 years after the first ATMs appeared in 1971, less than 20% of all banks had installed ATMs and 16 years elapsed before a majority of US banks had installed any ATMs. (American Bankers Association, 1972)

A technological innovation is socially visible and not adopting it places social system members at a disadvantage (Mahajan & Peterson, 1985). This was clearly the case with ATMs as reported in the figure 2.1 (Brian, Santos, & Peffers, 1998)

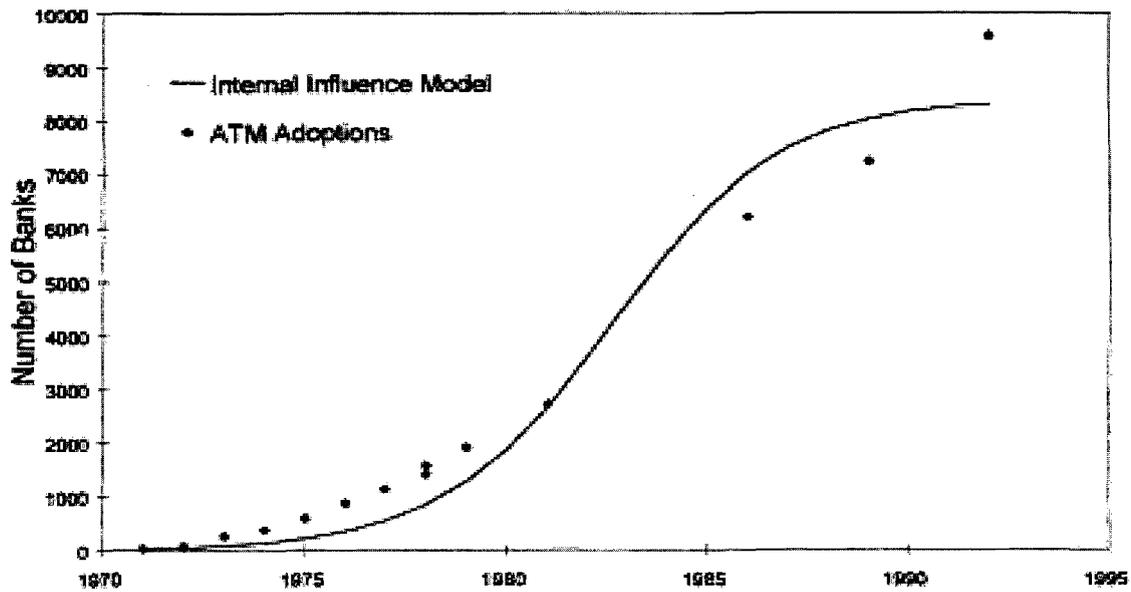


Figure 2.1: Fitted internal influence models on the cumulative number of US banks that had installed at least one ATM.

It is an indisputable fact that Nigeria has experienced a remarkable growth technologically in recent times. This is evident especially in the adoption of ATM and GSM technologies. (Matal, 2006)

The importance and continuous adoption of these machines cannot be under-estimated especially at this era of Banking reform and consolidation. More than 1000 ATMs are already in operation and being supported by InterSwitch network since 2004 needless to say that close to 6000 ATMs might be recorded by the end of 2008 given the current rate of adoption. (Matal, 2006)

According to a recent survey (Eshekels Limited, 2006), continuous deployment of ATMs is a key aftermath of the recent reform in the Nigerian Banking sector. This is clearly evident as most, if not all, banks make use of these machines as a way of enhancing their business productivity and at the same time using it to enhance their market share.

Meanwhile, experts in the field have started raising concerns about the effectiveness of the deployment of these ATMs by banks. The concern is that banks are not fully exploiting opportunities thrown by ATM technology in a way that would collaborate banking services and by so doing reducing cost.

As a result, the apex bank, Central Bank of Nigeria (CBN), has stepped into this evolution of ATM in Nigeria market by formulating policies that would allow third party firms and other non-financial institutions to seek financial support from banks for the purpose of encouraging local growth of ATM networks.

2.4 ATM LANDMARK IN NIGERIA

In spite of the growing enthusiasm of banks to promote a cashless society in Nigeria, about 1000 ATMs have so far been deployed by the participating banks as at October 2006 (Mordi, 2006)

Majority of the banks in Nigeria have adopted the use of ATM to enhance the provision of convenient banking services to customers. However, the extent of usage or awareness by the populace is still very low despite efforts by banks in terms of publicity. According to an eShekels survey (Eshekels Limited, 2006), several factors were attributed to non-widely acceptance of ATM usage in Nigeria. Some of these factors are diagrammatically represented in figure 2.3 as below.

2.4.1 Awareness of ATMs

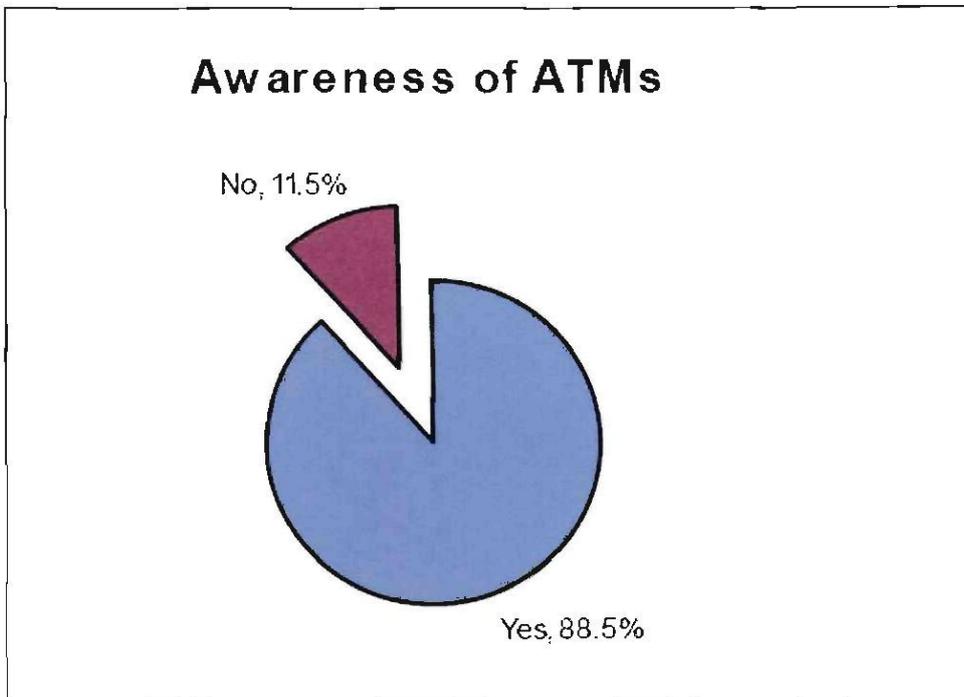


Figure 2.2

Figure 2.2 (Eshkels Limited, 2006) shows only about 11% of respondents not being aware of the presence of ATM within their environments. With Lagos Island being one of the most commercialized areas in Lagos one should expect a promising future in ATM usage as a whole. Going by this level of its awareness (88%), ATM seems to have a ready market. (Eshkels Limited, 2006)

2.4.2 Perception and willingness of ATM usage

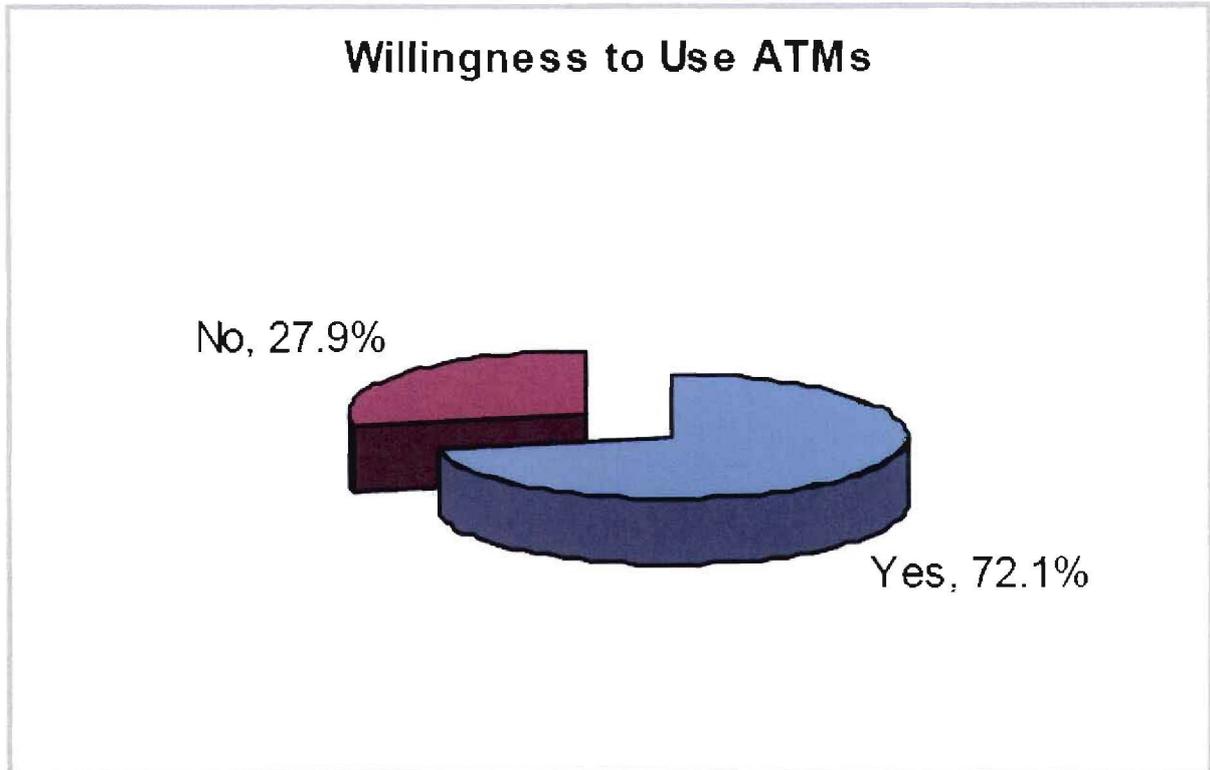


Figure 2.3

The majority of non users of this device show a willingness to use the ATM service, and this includes those that have never heard of it. There is, therefore, a ray of hope here as this shows that something can be done to incorporate the non users of ATMs into its usage; with an addressable market of over 72% (Figure 2.3) (Eshekels Limited, 2006).

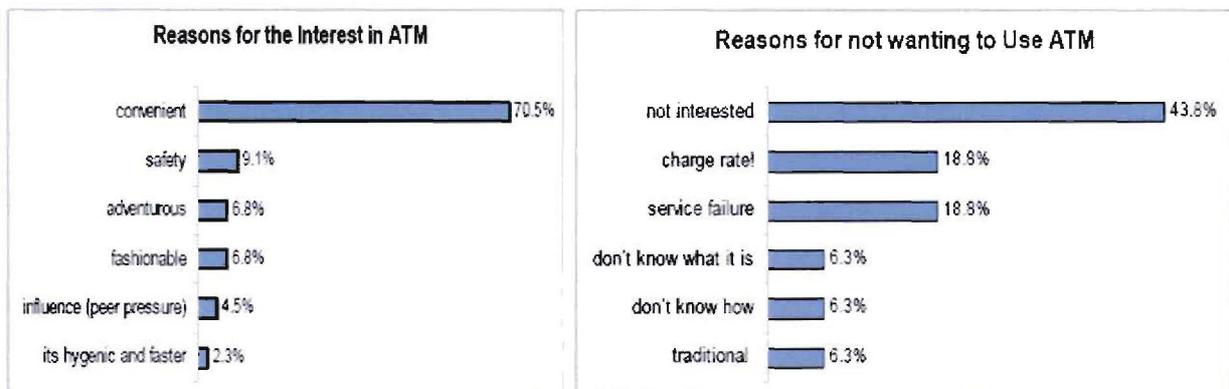


Figure 2.4

Over 70% of non users claim they would like to use ATM for its convenience. 9% see it as a safe way to carry money around. 6.8% find it adventurous while the same percentage says it's fashionable for use. While about 4% say they would only use it because their friends use it, only about 2% say it is hygienic and faster (Figure 2.4).

Of those not wanting to use ATM, about 43% said they were simply not interested while 6% are just traditionalistic and thus not readily open to change, while the opinion of the rest fell within; fear of service failure (18%), high bank tariff rates (18%), not trusting the quality of such a service, not knowing what it is all about (6%), not knowing how it works (6%).

As there appears to be different shades of opinion in the two graphs above, it is obvious that people are willing to use ATM the more if they can be convinced of the convenient nature of ATM and its cost effectiveness – which involve its service efficiency, what is all about and how it works.

2.4.3 Usage Pattern of ATM

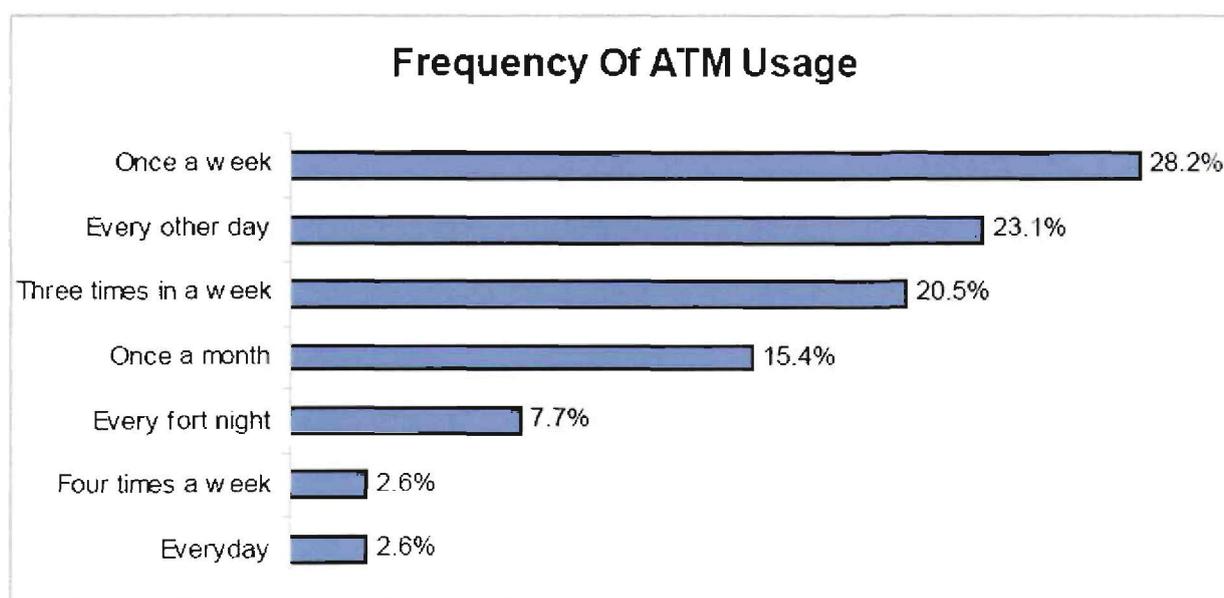


Figure 2.5

There seems to be no dull moment for the usage of ATM as consumers at various times engage the machine. Over 28% of users said they use it once a week while every-other-day users is above 23% and over 20% users engage the machine three times a week in that order (Figure 2.5) (Eshekels Limited, 2006).

2.5 INFORMATION TECHNOLOGY INVESTMENT

IT is an integral mechanism in the development and sustenance of competitive edge in today's global business environment. IT has the capability to change and improve the manner at which business is handled (Avison, 1999).

Researchers have reported extensively on various problems being faced when evaluating IT projects (Irani, 2002). Those problems can be derived from the difficulty of understanding the complex factors involved in IS decision making, such as scope and impact of the decision, the concept of value and its multi-dimensional facets, natures of IS benefits and costs, associated risks, strategy alignment, human and organizational mechanics or political issues.

Assessment of IT investment has been an interesting topic in research arena for quite some time. Already in the 1960s, researchers began working on IS related evaluation issues (Frielink, 1961). Since then, IS evaluation has become one of the most researched and written about topics in IS research, resulting in a large number of evaluation techniques available today.

Olson also reported on the way critical decision influences selection and pointed out various approaches with strong emphasis on implementation (Olsen, 1996).

Despite these efforts, organizational studies have shown that in practice business management fails to appreciate the portfolio of investment appraisal techniques available. Many companies are justifying there is expenditure on the basis of what could be called 'acts of faith' (Andresen, 2001).

Where formal evaluation takes place, it is predominantly based on conventional accountancy approaches such as methods implementing discounted cash flow analysis (Bernroider, 2001). The accountancy methods can be applied to any corporate investment proposal and are

widely understood by senior managers but they do not effectively cover or indicate the inherent benefits from an IT investment (Kumar, 2000).

2.5.1 TECHNOLOGY PROJECT SELECTION AND IT PROJECTS

The ranking and selection of technology projects is important; hence, a great deal has been written on the project. Most works focus on R&D project selection or the selection of generic manufacturing technologies (Csaszar, Nussbaum, & Sepulveda, 2006).

Many methods have been proposed for selecting R&D projects. Linton et al published a review of R&D project selection methods (Linton, Walsh, & Morabito, 2002). They divided R&D project selection into three categories. The first category is the traditional Net Present Value (NPV) method, which does not consider future uncertainties (Shehabuddeen, Probert, & Phaal, 2006). The second is the scoring method, which compares projects according to a number of criteria. The final category covers mathematical methods such as analytic hierarchy process (AHP) approach and the data envelopment analysis (DEA) (Chen, Lee, & Tong, 2006).

Although there are many studies on R&D project selection, information technology projects like ATM have a number of unique characteristics that must be considered. For example, the rewards gained from IT projects might be so intangible such that its monetary value might not be easily derived. In addition to being among the largest investments that organisations make, as well as the high failure rate and the potentially disastrous impact of such failures, IT projects differ from other technology projects in that they are intertwined with the organisational process and structure; thus they are also affected by organisational uncertainties.

Given the increasingly dynamic nature of the business environment, IT projects generate uncertainties, from both technological and organisational perspectives. Technological uncertainty results from the fact that IT changes rapidly, hence projects may become obsolete much faster than organisations expect. A cutting edge IT may be outdated by a competing IT, or even a potential IT rival that cannot be foreseen at the time of planning.

Furthermore, wrong decisions can cause the failure of projects. Therefore, selection of appropriate projects is becoming increasingly difficult.

Organisational uncertainty is even more risky because it is endogenous. Types of uncertainty range from unforeseen user resistance, the risk of commitment escalation, the cost of personnel turnover, to the maintenance costs incurred by the long implementation process. All of these dynamic factors make the selection of IT projects difficult.

Consequently, decisions regarding IT projects must be made with a great deal of caution because, unlike other projects, they involve a fundamental re-engineering process that results in major organisational changes.

2.6 FINANCIAL THEORY CONCEPT

The concepts of the two financial theories that will be adopted in this dissertation are now introduced and discussed below.

2.6.1 The Mean-Variance, MV Model

In the financial field, several studies have been devoted to establish portfolio criteria. For example, Markowitz proposed criteria for constructing an “Efficiency Frontier” in the MV model (Markowitz, 1952). His model assumes that investors pursue the highest estimated rate of return relative to a corresponding risk, or pursue the minimum risk relative to a corresponding estimated rate of return.

Thus, one can distinguish between two sets of stocks on the Efficiency Frontier, i.e., the efficient solution on the A-B curve(see Figure 2.6, (J & N, 2006)).

The criteria of the MV model are :

Stock k dominates stock m if

$$\mu_k \geq \mu_m \quad \text{and} \quad \sigma_k < \sigma_m$$

Where μ is expected rate of return and s is the volatility index.

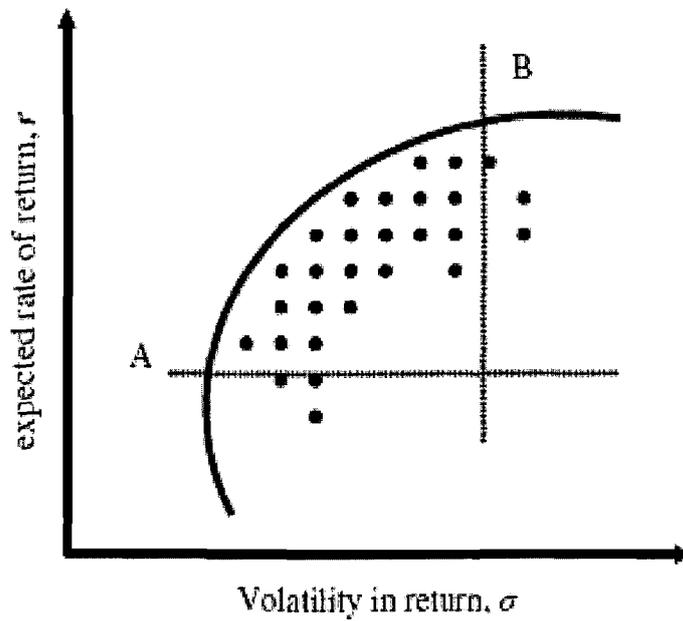


Figure 2.6

According to the criteria, the Efficiency Frontier should be quasi-concave. The MV model judges whether or not an asset is efficient, so it would appear that portfolios on the frontier are dominant and have a higher rate of return at the same risk level; or they have a lower risk with the same return.

An asset is efficient if it has a higher rate of return, given the same risk level. The advantage of the MV model is that it provides a theoretical framework for identifying uncertainty, reducing risk, and maximising value in IS portfolio management.

2.6.2 Options Theory, OT

The application of OT in the finance field is a fairly recent development. Researchers had long hoped to find a rigorous way to price derivatives, but it was not until the 1970s that the ground-breaking Nobel Prize winning works from Black, Scholes and Merton (Scholes & Black, 1973) and (Merton, 1973) achieved the goal. Based on Ito Calculus (J S. M., 2002) and the concept of dynamic portfolio hedging, the authors had a major research breakthrough by arriving at a differential equation that must satisfy the boundary conditions of the call option value. This resulted in the famous closed form Black-Scholes formula which led to the rapid development of OT.

OT is based on the concept that the even though an option holder has the right to choose an option, he is not obliged to do same (see figure 2.7); thus, the option's payoffs are asymmetrically distributed because of the restricted liability of the option.

By their nature, options create an asymmetrical payoff. In essence, they shift the possible distribution toward a more favourable pattern, which allows the option holder to take advantage of potential benefits when taking bounded risks (see Figure 2.7).

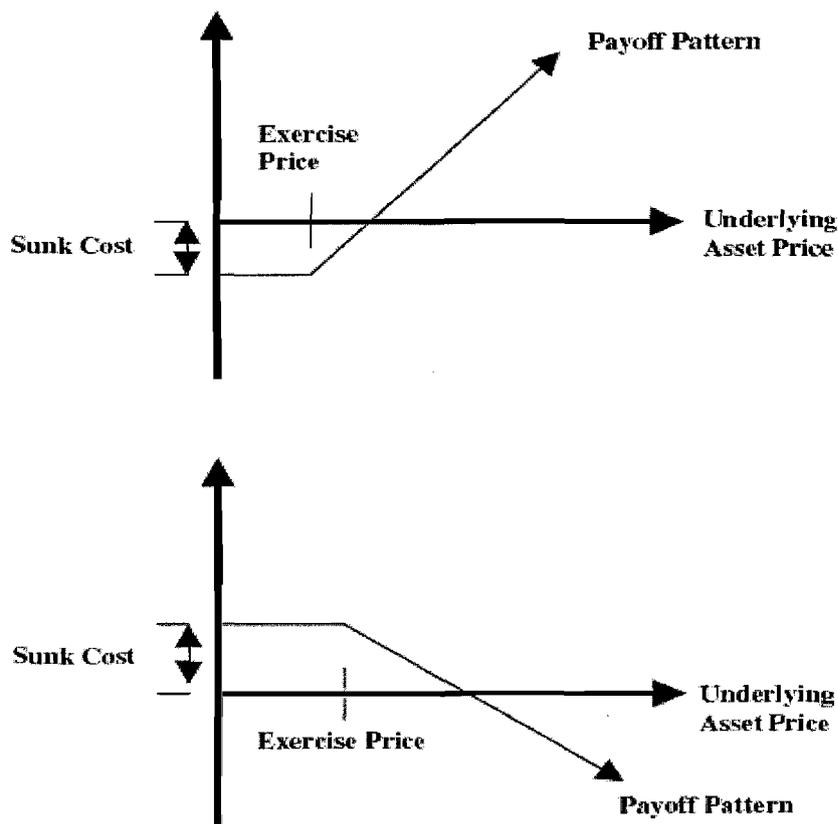


Figure 2.7: Payoff pattern

Myers was the first to report that option theory could also be applied to assets and non-financial portfolio. Because Options are derived from financial options theory, the initial phase of an investment project is implicitly equivalent to buying an option (Myers, 1974). Myers observed that discretionary investment opportunities , such as growth options, can capture a project's real value. Real Options have the capability to reduce risk and therefore managers use the method when evaluating projecting risks. In addition, managers will also be able to identify inherent opportunities embedded in each project option.

OT offers a new and more realistic means of evaluating strategic opportunities and risks that traditional models, such as the Net Present Value (NPV), do not consider. (Myers, 1974), (Kester, 1984) and (Dixit, Irreversible investment with uncertainty and scale economies, 1995) suggested using option-based approaches to assess the managerial responsiveness implicit in investment benefits. They pointed out the necessity that most investment decisions are not reversible especially when the environments under which the investments decisions are taken into consideration.

(Trigeorgis, 1988) used OT to deal with the features of , and the problems associated with, the valuation of projects. In addition, many useful OT valuation techniques have been used as alternative means of decision-making and valuation, as described by (Copeland & Antikarov, 2001).

2.7 THE NATURE OF IT INVESTMENTS

In this section, the two dimensions of IT projects, namely, their benefits and risks are discussed.

2.7.1 Risks – A forbidden part of benefits evaluation

The benefits of IT have long been the subject of extensive discussions (Balasubramanian, Kulatilaka, & Storck, 1999), (Chan, 2000), (Chang & king, 2005), (Pindyck, 1988) & (Santhanam & Hartono, 2003). Some works address the impact of IT investments on an organisation's performance, while others use a causal model to present the critical success factors (CSF) of such investments. However, the ex-post view of the impact of IT on organisations fails to capture the ex-ante view. Moreover, CSF does not describe how IT interacts with a changing environment in a dynamic manner.

Most studies have ignored the inherent value of managerial flexibility when assessing information technology investments, and used traditional evaluation methods, such as NPV, instead. However, the shortcomings of traditional project valuation tools are well documented. For example, NPV assumes that investments are irreversible and non-deferrable, but in the real world, IT investments are reversible, deferrable and undertaken in the conditions of uncertainty (Olafsson, 2003).

Furthermore, NPV ignores the strategic value embedded in IT investments (MacDougall & Pike, 2003). A number of researchers have applied OT to IT investments. Santos and Kumar suggested that the theory could be applied to IT investments to hedge project risks (Dos Santos, 1991) & (Kumar R. L., A note on project risk and option value of investments in information technologies, 1996).

Some researchers have employed specific OT formulas to guide IT investments. Benaroch and Kauffman used the Scholes Option pricing formula to assess the worth of deferring investments related to the expansion of electronic banking networks (Benaroch & Kauffman, 2000), (Scholes & Black, 1973). Taudes applied the Margrabe formula to assess the growth opportunities of a software platform implementation (Taudes, 1998) & (Margrabe, 1978). Subsequently, Kumar also used the Margrabe formula to decide whether to defer a CASE tool project. These studies stress that the value of managerial flexibility should be included in the value of IT investments. Real Options methods considers the value of managerial flexibility in the senses that some projects that are considered non-profitable in NPV might be profitable under real options.

2.7.2 A close-up of IT risks

Since IT investments involve uncertainties that must be carefully managed, the relative importance of various risks should be addressed. There are two kinds of uncertainty in the dynamic environment of IT investment. The first, “external uncertainty” comes from outside the organisation. Every company in the market faces external uncertainties, as opposed to internal uncertainties that occur within a company. According to Options Theory, the former affects the option value positively, while the latter reduces that value (Boer, 2000) & (Dixit, Irreversible investment with uncertainty and scale economies, 1995). For example, every company faces uncertainty about demand in the marketplace, i.e., the risk that demand will be low or high. Exogenous risks, which are analogous to the volatility of financial options create opportunities and increase the value of an option. Real Options approach is actually most relevant when investments involve a considerable level of risk combined with benefits opportunities to drive away that risk uncertainty as new information emerges (Copeland & Antikarov, 2001).

Since decisions made in the implementation of IT projects are contingent on unknown future states, OT is suitable for redefining decision-making behaviour via strategic business thinking. Although some studies recognise the use of these options in generating additional value in terms of managerial flexibility (Benaroch & Kauffman, 2000) & (Sumner, 2000), there is a however low volume of research into the application of Real Options to IT investments.

In the next chapter, a framework for evaluating IT portfolio investments in terms of their potential benefits and specific uncertainties is proposed. A case study , as mentioned in the topic of this dissertation will be discussed, analyzed and results validated against the proposed framework.

CHAPTER THREE – EMPIRICAL INVESTIGATION

3.10 A FRAMEWORK FOR THE ANALYSIS OF AN INFORMATION TECHNOLOGY INVESTMENT PORTFOLIO

In this chapter, a comprehensive framework is presented to help managers better understand how to apply Option Theory, OT and how to identify the opportunities and risks inherent in IT investments. Based on the discussion in Chapter two, section 2.0, Mean Variance, MV model and OT are combined and the benefits and risks of IT investments are highlighted.

3.1.1 An MV perspective of IT portfolio management

In the framework's matrix (see figure 3.1), the horizontal axis represents the degree of uncertainty that an information technology project involves, i.e. the risks; while the vertical axis represents the potential benefits that could accrue from such projects. In the 2 X 2 matrix, the projects are mapped into four generic parts.

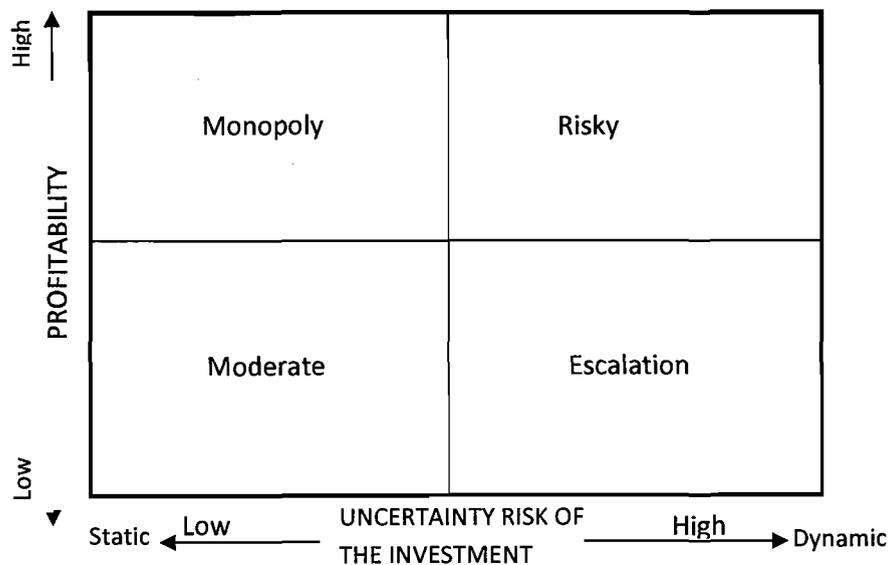


Figure 3.1: The matrix of the proposed framework

The top right-hand quadrant in the figure represents a “**Risky**” investment that has high potential benefits and a high degree of uncertainty. This type of IT investment is usually a strategic competency-driven project, such as an Enterprise Resource Planning, ERP system.

A “**Monopoly**” investment has high potential benefits and a low level of uncertainty. If a project falls in the top left-hand quadrant, it has low risks and high potential benefits. For example, a project that has first-mover advantages is a typical Monopoly investment. This type of IT investment gives companies a unique competitive advantage in the marketplace as there are no threats of any kind from a competitor for that moment. An example is the online reservations system first developed by American Airlines.

A “**Moderate**” project has low potential benefits and low uncertainty, and falls in the bottom left-hand quadrant. A typical example is a system used for daily processing of structured data. Such investments are necessary for running the day-to-day operations of a company.

The bottom right-hand quadrant indicates projects that undergo an “**Escalation of commitment**”. These projects have low potential and a high degree of uncertainty, and are usually unsuccessful. In fact, many IT projects that prove to be difficult, lengthy, and over budget should be terminated before completion. Instead, they undergo budget escalation, which negates any overall advantage to an enterprise, and may even threaten a company’s survival. To reduce losses, a firm should exercise the abandon option, i.e., stop further investment in unsuccessful projects.

In the next stage, I utilize the MV model to choose projects on the Efficiency Frontier, and remove those that are not efficient. A project is more efficient if it is more profitable than others with the same risk, or yields the same benefits with less risk. On the quasi-curve, IT projects are subjective at points A and B (see Figure 3.2); projects that fall on the frontier are the most efficient. Therefore, because resources are limited, organisations should choose IT projects on the Efficiency Frontier. The choice of these candidate portfolios has no absolute right or wrong answer, since the decision depends on the manager’s risk preference. In practice, both risk-averse and risk-seeking managers can set their goals according to their attitudes to risk.

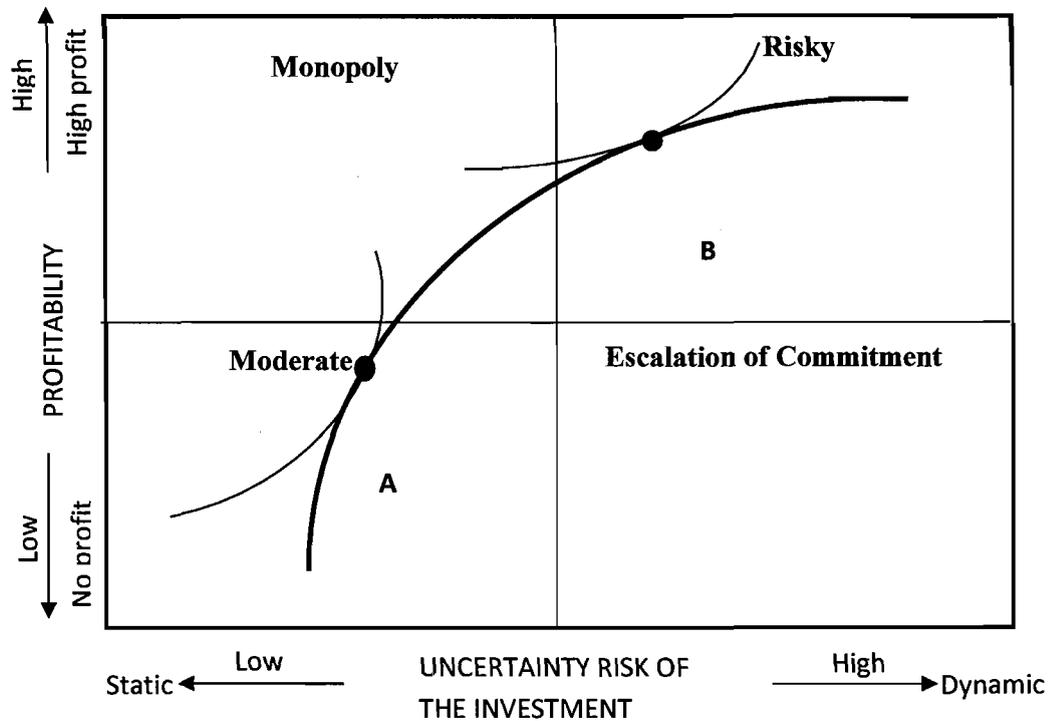


Figure 3.2: The proposed framework – an MV perspective

According to the MV criteria, if projects have the same risk level, managers first allocate resources to the portfolio that will yield higher returns. Therefore a company can only cope with IT risk that is within the tolerance of uncertainty involved.

A company can thus manage technology investment risks within the degree of uncertainty they can tolerate. Many large-scale technology projects, such as ERP, fail because of poor risk control (Markus, Axline, Petrie, & Tanis, 2000) & (Sircar, 2000). In the first step, the MV model helps managers allocate their portfolios.

3.1.2 The proposed framework combines with MV and Real Options perspectives

To ensure that the framework is practical and easy to use, I map the types of options in the matrix. The options are the growth option, the option to abandon, the option to switch to an input mix or an output mix, the option to alter operating scales, the option to defer, and the compound option (Taudes, 1998).

In the decision-making process, managers must carefully reconfigure different options when evaluating an IT portfolio. I now distinguish the options embedded in each of the four quadrants (see Figure 3.3). By determining where a project lies in the framework; managers can identify the options available to them. Projects in Portfolio “A” are characterized by low benefits and low risks, and are usually found in a highly competitive market. As competition reduces managerial flexibility (Dixit A. , 1995), the more intense the competition, the lower the value of options each company enjoys.

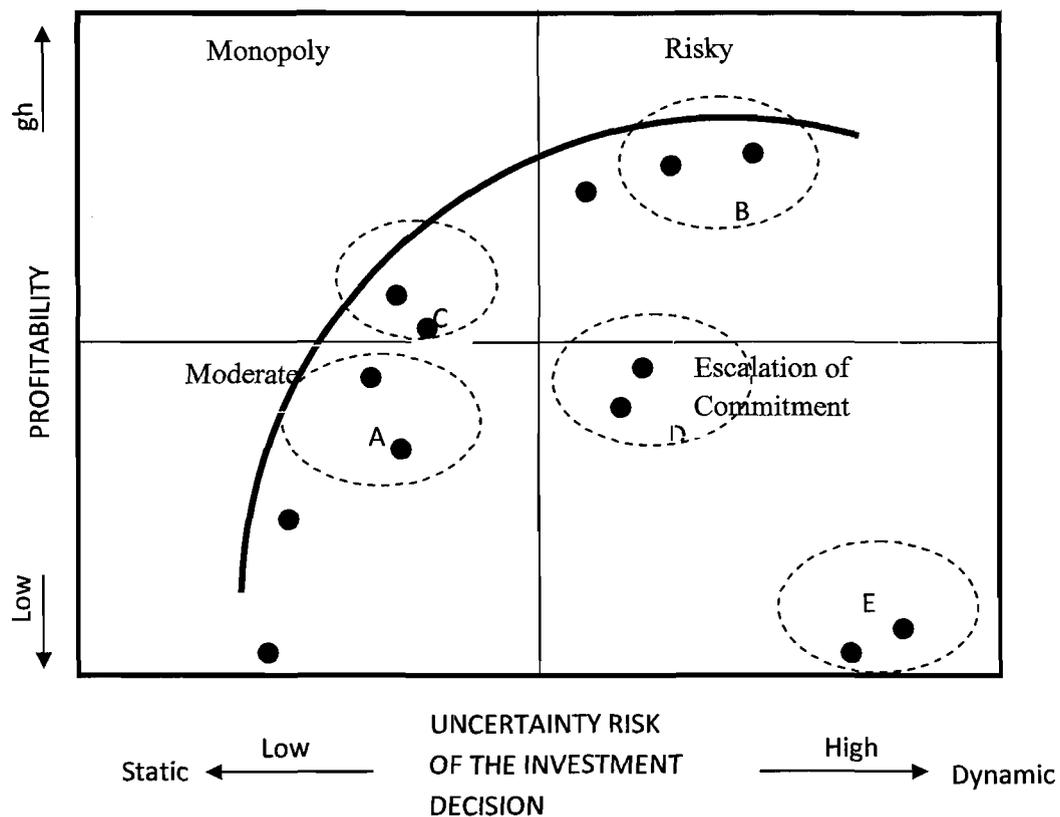


Figure 3.3: The framework of IT portfolio management

The IT systems in Portfolio “A” are often built to meet daily operational needs and provide managers with few options.

The IT projects in Portfolio “B” are strategy- driven. They have a high potential value and a high failure rate. If they are successful, they yield a distinct competitive advantage. For example, R&D investments are characterized by high costs and high potential value, but they also have a high failure rate.

To hedge the uncertainty inherent in such projects, managers can use the “learning option”, which calls for staged investments, i.e., a series of outlays that create the option for the next stage of the project. Each stage, therefore, can be viewed as an option following the value of corresponding stages which can influence future growth benefits. This occurs when a pilot investment is followed by further investments after uncertainties have been resolved.

When large technology projects are implemented, uncertainty may be resolved by the creation of preliminary modules or prototypes, or by the development of an infrastructure that enhances future competency. This is a limited-commitment investment with an uncertain payoff that conveys the right, but not the obligation, to make further investments should the payoff look attractive.

In Portfolio “C”, a technology project is protected, and the company is free to charge an excessive “economic rent” that stifles competition from other companies. This occurs when a new product development (NPD) creates a new market or legal protections allow a company this competitive advantage. In this context, the corresponding option is the option to expand. The firm can expand the scale of production when market conditions are favourable.

Portfolio “D” projects are not as efficient as those in Portfolio “B” because they have lower expected benefits, but the same level of risk. However, according to OT, opportunities can be judged by their uncertainties, which indicate zones of potential value. Such uncertainties imply the possibility of good outcomes, so managers are not advised to reject projects in Portfolio “D” immediately. Instead, they can wait and see how the situation unfolds; thus, they hold two options in this context (see figure 3.4).

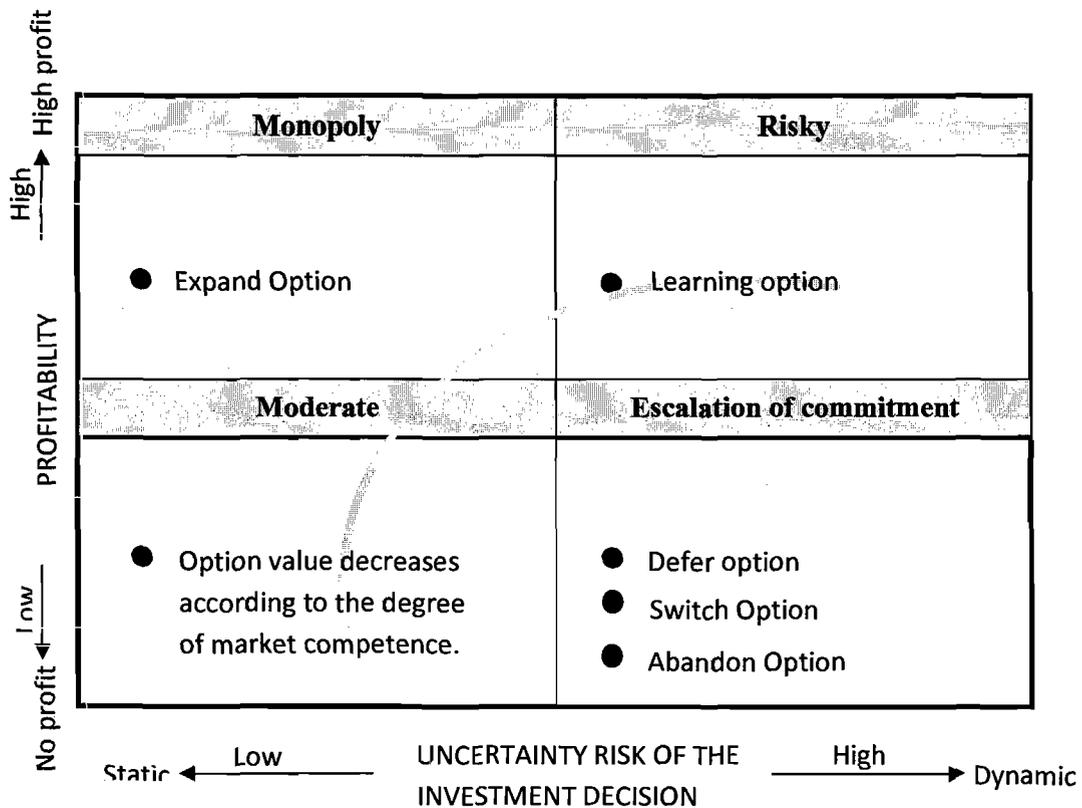


Figure 3.4: Options embedded in the framework

The first is the “**defer option**”, whereby managers can delay an investment decision. They can wait to see if the environment justifies investing in the IT project. The second option signifies a switch in the input or output mix of the project. For example, in a flexible manufacturing system, the product can be adjusted if prices or demand change.

The difference between Portfolios “D” and “E” is that projects in “E” are precarious because projected returns do not meet the cost of implementing the project. Therefore, such portfolios are characterized by high risks but low potential, which correspond to the option to abandon. This implies that if conditions in the market worsen, management can discontinue with current process in order to gain the resale value of capital equipments and other assets. Abandon options include decisions to liquidate assets, exit the market, or halt investments midway.

The option to abandon allows a company to predefine a maximum downside loss based on the “stop-loss” concept if the environment changes radically. The conditions in Portfolio “E” have other effects. Based on OT, too much uncertainty raises the particular level at which a company will enter a market (Dixit A. , 1995).

For a company trying to undertake such an uncertain project, it is clearly unprofitable and unwise to engage the project when viewed “escalation of commitment” and the high cost threshold of entering into a quest that may not yield future benefits.

I have explained how, within the dimensions of profitability and risk, the proposed framework divides technology projects into four types and maps the corresponding options. For example, the switch option and the defer option are available when implementing a project that falls in Portfolio “D”. Since the portfolio describes a situation with vague uncertainties and benefits, a company can defer an investment and wait to see how the business environment unfolds. Though uncertain, the potential benefits may influence the company to adopt the Portfolio “D” project; that is, the company can defer the investment to see how the situation unfolds.

Instead of using the NPV “Invest if $V > K$ ” rule, we can use the following OT rule: “Invest if $V > V^*$ ”, where V^* is the critical value threshold for investment. When a project involves a high degree of uncertainty, the “**Hysteresis Effect**” comes into play, so the company will delay implementing the project (Dixit A. , 1992).

Compared with Portfolio “B”, the uncertainty makes the wait options viable when they are viewed as opportunities. Compared with Portfolio “E”, the potential benefits of “D” projects should not be rejected immediately. A full list of portfolios and their corresponding options is given in Table 3.1 below.

Table 3.1: IT investments and corresponding options

Quadrant	Characteristics	Description	Corresponding options
Portfolio "A"	Low potential/low risk	Intense competition reduces option value. The more intense the competition, the lower the options value for the company due to sharing the market with competitors. Systems like daily accounting systems fall into this category, as they perform a standard task similar to many other off-the-shelf products.	Reduction in option value
Portfolio "B"	High potential/high risk	Unknown environments, such as uncertainties about the technology and the payoff, make projects very risky. This occurs when IT investments opens up future growth opportunities and can be used as a weapon against future competition. This type of investment is usually characterised by high costs and a high failure rate, as shown by ERP investments.	Learning option (opens up growth in compound stages)
Portfolio "C"	High potential/low risk	The company enjoys excess economic rent in the form of a monopoly. This usually occurs when an advance in technology receives a patent or other legal protection that prevents competition. The firm can expand the scale of investment in the IT project because market conditions are more favourable than initially expected.	Expand option
Portfolio "D"	Both potential and risks uncertain	The company should postpone further investment until better conditions arise. An interminable situation in which the hysteresis (lag) effect occurs because of the uncertainty about	Switch option/defer option

		opportunities that arises when investing in IT projects. The degree of uncertainty is dependent on the likelihood of a profit. This usually occurs when critical IT success factors are extremely uncertain (e.g., waiting until a brand-new IT project can be developed).	
Portfolio "E"	Low potential/high risk	Significantly lower potential and higher risks make such IT projects too expensive	Abandon option

The full detailed analysis of this case-study constitutes my experimental work and this is covered extensively in Chapter four of this dissertation.

CHAPTER FOUR – CASE STUDY AND ANALYSIS OF RESULTS

4.1.0 CASE STUDY

In this section, I describe how a financial institution in Nigeria, hereafter referred to as “Bank A” is used as a case-study applying this framework as a decision making tool in the management of its ATM investment portfolio.

4.2.0 The background

Bank A was founded in 1961. During the consolidation process in Nigeria, Bank A merged with one of the prominent banks in the country, and therefore making it a leading bank in the country.

The new Bank A evolved as a result of the recent reform in the Nigerian banking sector. The goal of Bank A is to be a role-model in the provision of superlative banking services in Nigeria market and beyond. The new Bank A is presently one of the largest banks in West Africa recording a balanced sheet weight in excess of One Trillion Naira and about seven million (7M) customer accounts.

Bank A has close to six hundred and fifty (650) retail outlets across Nigeria being its main operational base.

4.2.1 The challenge

As part of its efforts to bring simple, affordable and convenient banking solutions to its numerous customers, Bank A is considering incorporating ATMs into its business activities. This will allow customers access to their funds anytime the need arises.

This will be beneficial to customers who need to make some emergency or urgent withdrawals. In addition, the introduction of ATMs into the existing system will not only reduce endless queue

being witnessed in their retail outlets, but will also reduce, if not eliminate, the waiting time for customers.

Meanwhile, this ATM investment will, no doubt, attract huge cost. There is, therefore, the need to properly evaluate and justify the high cost attached to this project.

In my proposed framework, a detailed analysis of this ATM investment will be done and the results of the analysis will properly guide managers in their decision-making. The existing traditional banking methods (Human tellering) will also be comparatively analysed and recognised as an option or alternative which managers are equally considering.

The full detailed analysis of this case-study constitutes my experimental work and this is covered extensively in Chapter four of this dissertation.

4.3 Stage 1: MV analysis

The first step for Bank A was to prioritize the two projects and conduct an MV return and risk analysis of each candidate. The process of estimating the return is similar to traditional, widely used NPV (Net Present Value) calculations (Kumar R. L., A framework for assessing the business value of information technology infrastructures, 2004). Out of the two projects, ATM investment or deployment could help Bank A streamline its business processes by creating a fast-delivery transaction structure that integrates the key banking functions. Therefore, the management of Bank A considered the ATM investment project to be more promising because it had the most potential to develop and sustain a competitive advantage in the market. It was also recognised that the ATM project had the potential to help Bank A improve customer satisfaction and its relationship with its suppliers. **These factors would improve the company's competitiveness and thereby increase profits.**

Human tellering project, a traditional and alternative means to ATM, was deemed less risky because implementing it would involve little ambiguity or uncertainty about users' requirements. However, since almost all the banks in the industry have similar system or approach, the return on implementing this project would be limited. The return of the two projects was estimated based on the combined direct savings and the indirect annual savings due to a shorter payback

period, savings on labour costs, and improvements in productivity. The rankings of the two projects based on estimated return data are shown in the figure 4.1.

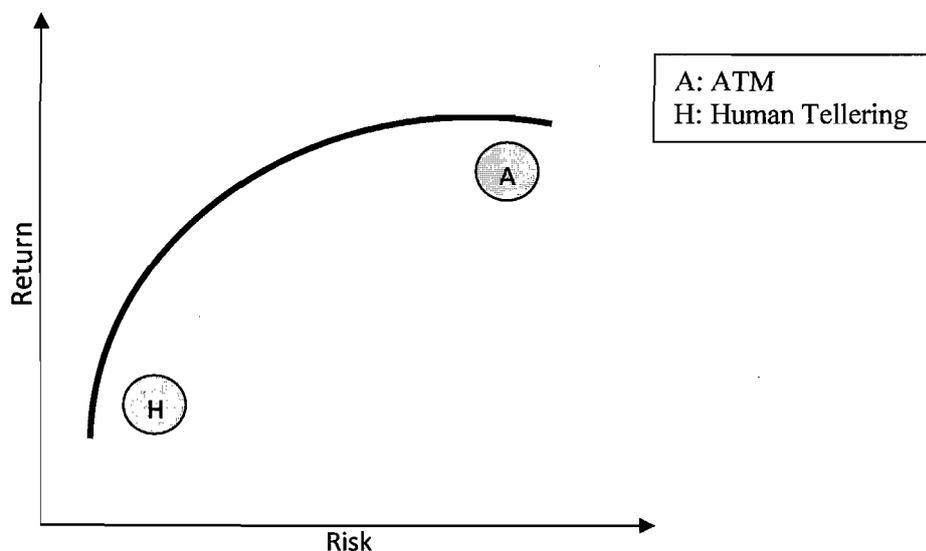


Figure 4.1: Application of the MV model to Bank A

The other parameter of MV analysis which is the risk posed by the two projects was also considered. A number of methods can be used to calculate such risks. One approach determines risk based on public market data, such as listed companies involved in similar projects (Campbell, 2002). Management expertise is another widely used method (Campbell, 2002). Benaroch, (Benaroch, 2002) proposed a method that breaks risk down into risk factors, which are measured separately using the above-mentioned methods. Moreover, Bardhan, (Bardhan, Bagchi, & Sougstad, 2004) developed a method that estimates a project's risk based on different project scenarios, without resorting to historical data or the need to make ad hoc project-specific assumptions.

Bank A ranked the risks of the two projects based on their expertise and knowledge of the industry. Out of the two projects, ATM project was ranked as most risky because of possible cost/schedule overruns during the lengthy and costly implementation process.

On the other hand, human tellering, which is the second project was also evaluated. Since the user requirements and specification for the project were well defined, Bank A had sufficient experience and resources to implement it. It was assessed having a lower risk compared to the ATM project. The risk ranking of each project is also shown in figure 4.1.

Because projects on the Efficiency Frontier are superior in terms of return and risks, the two projects appeared to be good choices for Bank A.

4.4 Stage 2: Options Analysis

Options analysis was conducted in the second stage to reinforce the MV perspective, which does not consider uncertainty. In this stage, the management ranked the projects by comparing the options values embedded in them. The ATM project was deemed more promising in terms of options values.

The first option embedded in the ATM project related to learning options, which would allow Bank A to avoid the enormous risks of a one-time implementation. ATM project implementation is an ongoing business re-engineering process, rather than a one-off installation of a software program. The requirements evolve over time, and many ATM adopters rely on vendors for extensible technical assistance, emergency maintenance, updates, and special modifications. Through such learning, additional knowledge about the uncertainties can be gained through the initial implementation of the ATM project. Following the basic ATM deployment, follow-up investments may be made to enhance the value of ATM technology. Additional modules or components can be added depending on how the environment evolves.

The second option embedded in the ATM project for Bank A was the option to abandon. The bank could abandon the project if the implementation evolved unfavourably. The advantage of this approach is that the management can pre-define the maximum sustainable losses and prevent over-commitment of resources. ATM projects that go over time and budget can be controlled or

abandoned, preventing an unlimited commitment of resources that would eventually exhaust the organisation's resources.

On the other hand, the options value for the Human Tellinging project was limited because of its non-strategic role and well-defined user requirements. Most rivals of Bank A had similar approach. As noted in section 3.1.2, competition reduces managerial flexibility while there is little option benefits in the project.

This 2-stage analysis, which combined the MV analysis and the Options perspective, suggested that Bank A should implement the ATM project. Although suggested with little options value, the Human Tellinging project was suggested by the MV analysis. Eventually, the management of Bank A approved the ATM project being the first choice suggested by both stages. In addition, it was decided that the Human Tellinging project should be implemented, since the budget was sufficient and the goals of the two projects did not really conflict.

4.5 Validation of the ATM decision framework

This decision framework was validated using a case study of Bank A as described above. A team of 10 members was inaugurated with representatives from Information systems, Operations, Finance and logistics departments of the bank. The chairman of the team is from the IS department while I acted as a consultant to the team.

It became extremely necessary to set up this committee in order to properly introduce, apply and co-ordinate the implementation of this framework. The framework was first introduced to the committee by way of a three-hour seminar during which theories adopted in the framework were discussed. Subsequently, various questions and concerns were raised but a logical point was reached at which the application of the framework was based on.

Various meetings were also held to discuss the progress of the implementation till a final decision was made as regards the two projects the bank was considering.

The detailed report from this committee is presented in Appendix A of this dissertation.

CHAPTER FIVE – DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 DISCUSSION

Real Options combines the values of NPV and the value of inherent future benefits (Trigeorgis, 1996), such that it does not necessarily add value to every single type of IT investment. For some projects, Real Options add little value in terms of future opportunities; therefore, the options value can be measured by the traditional NPV directly. Uncertainty is the key to determine which investments the Real Options approach can be applied to. It does not play a key role in every information technology investment decision. This is particularly true of small-scale applications.

Simple well-defined applications, such as daily accounting systems and office automation systems (OAS) are designed to replace workers who perform repetitive tasks, e.g., payroll clerks. These applications are well suited to NPV analysis because their costs and benefits can be determined relatively easily and users' requirements are clear (Martinsons, 1999) ,(Stefanou, 2004); therefore, they offer few options.

Real Options are also useful for evaluating information technology projects that take a long time to implement. This is another source of uncertainty because of the dynamic nature of the business environment. When a technology evolves over several years, the potential revolution in standards can produce an entirely new paradigm, leading to an unbridgeable gap between the old and the new. Doubling the implementation time more than doubles the uncertainty.

5.2 CONCLUSION

This dissertation has considered information technology investments from a different perspective by using insights gained from financial theory, namely Real Options to enhance the understanding of technology investment portfolio management. This has important implications for researchers and practitioners.

For researchers, in contrast to a large body of the literature, this dissertation does not focus on pricing issues. On the normative side, it first provides a practical way to realize the nature of the OT and MV. Secondly, it contributes to the literature by incorporating a risk dimension parameter in the framework. It provides how to incorporate financial theories in order to broaden and deepen interdisciplinary discussion in the technology management field.

For practitioners, this study provides guidelines for managing information technology investment projects especially the deployment of ATM in the Nigerian banking sector. This framework is mostly suited in the Nigerian banking sector because ATM usage and adoption is still in the elementary stage. This is clearly evident as most banks in the country now engage in massive ATM deployments and awareness campaigns to their customers. These managers face the difficulty that most technology investments are inherently risky, especially in a rapidly changing technological and deregulated economy.

This framework therefore provides a simple and comprehensive investment management tool. Managers can easily understand how to use the proposed framework to assess their technology portfolio requirements. More importantly, as the framework maps different kinds of options, so managers can easily identify appropriate decisions about different kinds of technology investments.

Using the case study carried out in this dissertation, the value and importance of ATM in the Nigerian banking sector are highlighted as against using the alternative approach of human tellering. As a matter of fact, this framework is a valuable tool that could assist in answering the three most important questions as regards ATM investment as earlier described in section 1.3;

- **What is the importance of ATM?**
 - **Is ATM better than the traditional banking method of human tellering?**
 - **How can investment decision in ATM be guided or justified?**
-

5.3 RECOMMENDATION

Having derived this framework as a great tool in making an informed decision as regards ATM investment, managers and other decision makers especially in the banking sector are encouraged to apply this framework to assist them in their investment decisions.

Since the application of OT in the technology management field is still in the early stages, future researchers could include studies of different technology project selection problems, e.g., in non-information technology projects. Future researchers should also assess and verify the use of this framework in other parts of the world especially countries where ATM usage and adoption is in the elementary stage. This will suggest a global acceptance and applicability of this framework project and by so doing will also generate interesting issues and concerns within the research community.

Finally, by identifying the unique features of different technology projects, researchers can study the applicability of the proposed framework to those projects, and it is hoped that the ideas, issues and discussions in this dissertation will attract and inspire further studies.

APPENDIX A

FEEDBACK FROM THE MIS DIRECTOR OF BANK A

As part of the experimental work carried out during the course of this research dissertation, I consulted with the Management Information Systems, MIS team of Bank A in order to demonstrate the applicability of the proposed framework. The focus was to assist Bank A in their decision to invest in ATM technology. Several meetings were held with the MIS team to ensure the successful implementation of this framework.

However, in subsequent feedback, the MIS Director made the following observations:

The framework improved communications

Firstly, he noted that the framework improves communications within the project committee. “The way we evaluate a project begins from the proposal of a project by our General Manager, and we are responsible for providing suggestions. In most circumstances, the decision processes were fast, mostly based on subjective judgements. Although we were somehow aware of the return and the risk aspects of our projects, the two aspects were still an implicit concept to be put into analysis.” He added: “The framework is an easy-to-understand tool for choosing projects. It simplified the features of the different projects and it was easy to explain the ranking procedure to our top managers. We were able to present the differences of each project to the top management.”

Feedback on investments

Secondly, in his opinion, the more substantial the investments, the more valuable the dynamic project review process can be. “Selecting ATM parameters is a long-term trial and error process. We are still trying the numerous parameters provided by the ATM system and it takes time to see the effects of making adjustments. We cannot make an immediate judgement about whether the ATM project is successful or not. Many banks do not admit their IT projects have failed until after a period of adjustment. Therefore, the ATM project may be in a quite different place in the framework in later evaluations.”

Challenges/unresolved issues

He also highlighted certain challenges in using the framework. The first is how to quantify the issues. “We used to report the technical feasibility of projects and our suggestions to top managers. Sometimes we made our decisions based on intuition. The required quantity estimation generated additional work especially for our MIS department.” “What interested the top managers most were the numbers, thus, this seems to be unavoidable for us.” He also noted that determining the risks is another challenge. “There was no problem in determining that the Human Telling is less risky for us. However, different opinions arose on the risk ranking of the ATM project.” He concluded that agreement on the risk ranking of the projects is important in using the framework and “Expertise and quantitative methods may help in this situation.”

Miscellaneous

Finally, he mentioned that when determining the risks of projects, there may be a tendency to weight projects that involve huge investments with more risk. Therefore, the potential bias in overweighting the risks of such projects may be worth noting if the risk assessment is based on purely subjective judgements.

REFERENCES

- African Central Banks. (2007, October). *Three-day International Conference*. Retrieved November 3, 2007, from ACB: <http://allafrica.com/stories/200710250407.html>
- American Bankers Association. (1972). *Results of the 1972 National Automation Survey*. Washington, DC.
- Andresen, J. L. (2001). A framework for selecting an IT evaluation method - in the context of construction. *BYG-DTU*.
- Angeli, D., Lynch, A., & Johnson, G. (2002). Pleasure versus efficiency in user interfaces: towards an involvement framework. (W. S. Green, & P. W. Jordan, Eds.) *Taylor & Francis*, pp. 97-111.
- Avison, D. E. (1999). The paradox of information systems: Strategic value and low status. *Journal of Strategic Information systems*, 8, 419-445.
- Baber, C., Stanton, N., & Johnson, G. (1998). From public technology to ubiquitous computing: Implications for ergonomics. *Ergonomics*, 41, 921-926.
- Balasubramanian, P., Kulatilaka, N., & Storck, J. (1999). Managing information technology investments using a real options approach. *Journal of Strategic Information Systems*, 9 (1), 39-62.
- Bardhan, I., Bagchi, S., & Sougstad, R. (2004). Prioritizing a portfolio of information technology investment projects. *Journal of Management Information Systems*, 21 (2), 33-60.
- Benaroch, M. (2002). Managing information technology investment risk: a Real Options perspective. *Journal of Management Information Systems*, 19 (2), 43-84.
- Benaroch, M., & Kauffman, R. J. (2000). Justifying electronic banking network expansion using Real Options analysis. *MIS Quarterly*, 24 (2), 197-225.
- Bernroider, E. W. (2001). ERP selection process in midsize and large organisations. *Business process management Journal*, 7 (3), 251-257.
- Boehm, B., & Sullivan, K. (1999). Software economics: status and prospect. *Information and software technology* (41), 937-946.
- Boer, F. P. (2000). Valuation of technology using "Real Options". *Research-Technology Management*, 43 (4), 26-30.
-

- Brian, L., Santos, D., & Peffers, K. (1998). Competitor and vendor influence on the adoption of innovative applications in electronic commerce. *Information & Management* , 34, 175-184.
- Campbell, J. A. (2002). Real Options analysis of the timing of IS investment decisions. *Information and Management* , 39 (5), 337-344.
- Carey, J. M. (1998). Creating global software: a conspectus and review. *Interracting with Computers* , 9, 449-465.
- Carey, J. M. (1998). i am gopign to joburg.
- Chan, Y. E. (2000). IT Value: The great divide between qualitative and quantitative and individual and organisational measures. *Journal of Management Information Systems* , 16 (4), 225-261.
- Chang, J. C., & King, W. R. (2005). Measuring the performance of information systems: a functional scorecard. *Journal of Management Information Systems* , 22 (1), 85-115.
- Chen, H. H., Lee, A., & Tong, Y. (2006). Analysis of new product mix selection at TFT-LCD technological conglomerate network under uncertainty. *Technovation* , 26 (11), 1210-1221.
- Copeland, T., & Antikarov, V. (2001). Real Options - A Practitioner's Guide.
- Csaszar, F., Nussbaum, M., & Sepulveda, M. (2006). Strategic and cognitive criteria for the selection of startups. 151-161.
- Davenport, T. (1997). *Information Ecology*. New York: Oxford University Press.
- Dixit, A. (1992). Investment and hysteresis. *Journal of Economic Perspectives* , 6 (1), 107-132.
- Dixit, A. (1995). Irreversible investment with uncertainty and scale economies. *Journal of Economics Dynamics and Control* , 19 (1-2), 327-350.
- Dos Santos, B. L. (1991). Justifying investment in new information technologies. *Journal of Management Information Systems* , 7 (4), 71-89.
- Eshekels Limited. (2006). *Automated Teller Machine (ATM) user perception*. Mini-survey report.
- Finance and IT Summit, Lagos, Nigeria. (2007, October). Retrieved November 2, 2007, from <http://allafrica.com/stories/200708020015.html>
- Frielink, A. B. (1961). Auditing automatic data processing.
- Gibbs, W. (1997, July). Taking computers to task . *Scientific American* , pp. 82-89.
- Gilder, G. (1993, September 13). Metcalfe's Law and Legacy. *Forbes ASAP* .
-

- International Telecommunications Union, ITU. (2007, October). *Marshal Plan for ICT infrastructure development in Africa, Rwanda*. Retrieved November 2, 2007, from <http://rep.pt/geeklog/article.php?story=20070713152010364>
- Irani, Z. (2002). Information systems evaluation: Navigating through the problem domain. *Information and Management* , 40, 11-24.
- James, B., John, G., & Dele, T. (2007). Her movement for today. *Holiday* , 35 (3), 54-56.
- Kester, W. C. (1984). Today's options for tomorrow's growth. *Harvard Business Review* , 62 (2), 153-160.
- Kulatilaka, N., & Marks, S. G. (1988). The strategic value of flexibility - reducing the ability to compromise. *American Economic Review* , 78 (3), 574-580.
- Kumar, R. L. (2004). A framework for assessing the business value of information technology infrastructures. *Journal of Management Information Systems* , 21 (2), 11-32.
- Kumar, R. L. (1996). A note on project risk and option value of investments in information technologies. *Journal of Management Information Systems* , 13 (1), 187-193.
- Kumar, R. L. (2002). Managing risks in IT projects: an options perspectives. *Information and Management* , 40 (1), 63-74.
- Kumar, R. (2000). Understanding the value of information technology enabled responsiveness. *Electronic Journal of Information System Evaluation* .
- Lewis, O. (2007, September 5). *Automatic Teller Machine*. Retrieved January 13, 2008, from More Action Less Talk (MALT): <http://www.olanrewajulewis.com/05/09/2007/automatic-teller-machines-atms-1>
- Linton, J. D., Walsh, S. T., & Morabito, J. (2002). Analysis, ranking and selection of R&D projects in a portfolio. *R and D Management* , 139-148.
- Little, L., Briggs, P., Coventry, L., & Knight, D. (2003). Attitudes towards technology use in public areas: the influence of external factors on ATM use. (C. Stephanidis, & J. Jacko, Eds.) *Human-Computer interaction* .
- MacDougall, S. L., & Pike, R. H. (2003). Consider your options: changes to strategic value during implementation of advanced manufacturing technology. *Omega - International Journal of Management science* , 31 (1), 1-15.
- Mahajan, V., & Peterson, R. (1985). Models for innovation diffusion. *SAGE* .
- Margrabe, W. (1978). Value of an option to exchange one asset for another. *Journal of Finance* , 13 (1), 177-186.
-

- Markowitz, H. (1952). Portfolio selection. *Journal of Finance* , 7, 77-91.
- Markus, M. L., Axline, S., Petrie, D., & Tanis, C. (2000). Learning from adopters' experiences with ERP: problems encountered and success achieved. *Journal of Information Technology* , 15 (4), 245-265.
- Martinsons, M. (1999). The balanced scorecard: a foundation for the strategic management of information systems. *Decision Support Systems* , 25 (1), 71-88.
- Matal, B. (2006, September 19). *NIGERIA'S ATM MARKET IS THE FASTEST GROWING IN AFRICA*. Retrieved February 13, 2008, from Ghana Community Online: <http://www.ghanacommunity.com/forums/index.php?s=fd770d4b046d006d61a56f77594b621f&showtopic=6275&pid=115950&st=0&#entry115950>
- Mead, S., & Fisk, A. (1998). Measuring skill acquisition and retention with an ATM simulator: the need for age specific training. *Human factors* , 40 (3), 516-523.
- Merton, R. C. (1973). Theory of rational option pricing. *Bell Journal of Economics* , 4 (1), 141-183.
- Mordi, C. (2006, November 29). ATMs deployed in Nigeria. *The Nigeria Business.com - Banking & Finance* .
- Myers, S. C. (1974). Interactions of corporate finance and investment decisions - implications for capital budgeting. *Journal of Finance* , 29 (1), 1-25.
- Olafsson, S. (2003). Making decisions under uncertainty - implications for high technology investments. *BT Technology Journal* , 21 (2), 170-183.
- Olsen, D. L. (1996). Decision aids for selection problems, Series in operations research.
- Pepermans, R., Verleye, G., & Van Cappellen, S. (1996). Wallbanking, innovativeness and computer attitudes: 25-40-year old ATM-users on the spot. *Journal of Economic Psychology* , 17, 731-748.
- PesaPoint Network. (2006, August 16). *National Bank Joins PesaPoint ATM Network*. Retrieved February 13, 2008, from <http://www.pesapoint.co.ke/docs/standard.pdf>
- Pindyck, R. C. (1988). Irreversible investment, capacity choice, and the value of the firm. *American Economic Review* , 78 (5), 969-985.
- Santhanam, R., & Hartono, E. (2003). Issues in linking information technology capability to firm performance. *MIS Quarterly* , 27 (1), 125-153.
- Santos, D., & Peffers, K. (1995). Rewards to Investors in innovative information technology applications: First movers and early followers in ATMs. *Organisation Science* , 6 (3), 241-259.
-

Scholes, M., & Black, F. (1973). Pricing of options and corporate liabilities. *Journal of Political Economy*, 81 (3), 637-654.

Shehabuddeen, N., Probert, D., & Phaal, R. (2006). From theory to practice: challenges in operationalising a technology selection framework. *Technovation*, 26 (3), 324-335.

Sircar, S. T. (2000). A framework for accessing the relationship between information technology investments and firm performance. *Journal of Management Information Systems*, 16 (4), 69-98.

Stefanou, C. J. (2004). A framework for the ex-ante evaluation of the ERP software. *European Journal of Information Systems*, 10 (4), 204-215.

Sumner, M. (2000). Risk factors in enterprise-wide/ERP projects. *Journal of Information Technology*, 15 (4), 317-327.

Taudes, A. (1998). Software growth options. *Journal of Management Information Systems*, 15 (1), 165-185.

Trigeorgis, L. (1988). A conceptual options framework for capital budgeting. *Advances in Futures and Options Research* (3), 145-167.

Trigeorgis, L. (1996). Evaluating leases with complex operating options. *European Journal of Operational Research*, 91 (2), 315-329.