PROJECT PORTFOLIO SELECTION MODEL DEVELOPMENT USING PROJECT PORTFOLIO MANAGEMENT (PPM) APPROACH

WITH SPECIAL REFERENCE TO DJENNA ENDOWMENT

By

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Abstract

The general objective of the thesis is to develop a model that assists companies' for the selection and management of an optimal project portfolio that maximizes the benefits using project portfolio management (PPM) approach.

In this thesis two models are developed. The first model is a general Project Portfolio Management (PPM) model that describes the whole process and steps of PPM. In this model the PPM process is divided in to six steps. The relationships between the steps, the processes and activities of each step are discussed in detail.

The second model developed in this thesis is the portfolio selection step of the PPM process. In the portfolio selection model project evaluation criteria and sub-criteria are identified, and projects that are screened in the individual project evaluation step are arranged in Analytical Hierarchy Process (AHP) structure to prioritize and give relative weights of each component against to the next higher level components. At the most lower level the candidate projects for portfolio selection are arranged. These projects are going to be prioritized and scored in accordance with their contribution to the total sub-criteria, which are placed on the next higher level in the structure. The score or weights of the projects are used as a coefficient of the optimization problem. A zero-one integer linear programming is proposed to find the solution of the optimization problem.

The developed model is tested and validated by considering one local multi-project owner corporate office. The corporate office vision, mission, objectives, criteria, sub-criteria, ongoing and candidate projects are considered and the objective function of the corporate office is formulated with an inclusion of the Endowment constraints and interdependence of projects. Then considering three probable demand scenarios and using a zero-one integer linear programming two portfolios of projects are generated. The portfolios' risk and objective function values are calculated thereafter. The selection of one out of the two portfolios by taking into account the trade-offs of the risk and objective function value is left unto management for their decision.

CHAPTER ONE

1. Introduction

1.1 Background

Strategic investment decisions involve a large sum of money and also determine the future success or failure of a company. Acceptance of a large strategic investment will involve a significant change in the company's expected benefits and in the risks to which these benefits will subject to.

Business organizations and public sectors are continually faced with the problem of deciding whether the commitments of resources, time or money are worthwhile in terms of the expected benefits. This situation is likely to lead stockholders and creditors to worry about the evaluation methods of investments during the selection process of new investments and re-evaluation process of ongoing investments. Hence, important investment decisions are approved by chief executive office (CEO) or board of directors of the organizations'. In spite of this fact, the procedures used by organizations are inadequate to achieve an effective and efficient decision. This is because the management can not organize the information without the aid of an appropriate system which can handle and analyze several information and data for better decision making [Bierman & Smidt, 1994; Levy & Sarnat, 1994].

This fundamental project evaluation task during the initial stage of investment selection and in the monitoring of ongoing projects/investments becomes more serious and tedious when a company undertakes many investments to achieve the overall company's objective with limited resources. Therefore, when a company wants to undertake many projects the value maximization effort would have different nature from the single investment value maximization effort.

In the case of multiple investment selection and management the interrelated nature of investments, resource sharing, etc, will require additional effort in the investment evaluation, prioritization, selection and monitoring process. In order to improve the investment evaluation, prioritization, selection and monitoring process, companies are required to have better approach than the conventional one-to-one investment evaluation method. In this respect project portfolio management (PPM) can address the issue by taking into consideration all the necessary information and evaluate, prioritize, select and monitor projects with systematic approach.

A portfolio is a set of managed assets allocated to investment strategies via an optimized mix based up on assumptions with forecasted performance to maximize value/risk trade-offs.

Project Portfolio Management (PPM) is a particular form of portfolio management that is engaged in selecting, prioritizing and managing the optimum mix of projects or investments to achieve maximum business value. In this decision making process, management can focus their scarce resource on investment that is achievable and strategically aligned with business goals. The resulting portfolio drives to a balancing of what is possible and what is needed [Pieter Meyer-COO-UMTSA, 2006].

In this thesis the term investment or project are used interchangeably to refer to commitments of resource made in the hope of realizing benefits that are expected to occur over a reasonably long period of time in the future.

1.2 Statement of the Problem

As mentioned above the conventional one-to-one investment evaluation, prioritization selection and monitoring method is inadequate to process information systematically and enable the management to make decision on multiple projects selection and management in order to achieve the overall objectives of the company. The investments selected in the conventional one-to-one evaluation method lacks to provide an appropriate fit to the strategy of the company, the value expected from the investments and balance between high and low risk, short and long period of return, etc. Because in one-to-one evaluation technique project interdependence, the link between the strategy of the company with the projects, resource sharing problems, balancing the project's return vs. risk, etc can not be dealt with a structured and dynamic decision process.

In the conventional one-to-one project evaluation method projects are identified and prioritized independently on certain criteria and ranked in the descending value order. Selection of investments is mainly done based on the result of this rank order. The number of projects that will be selected in this process is determined by the amount of resources available. Since this process does not consider the interrelation of the projects like the interdependence of projects, mutually exclusiveness, etc the result of project portfolio is not expected to give the most optimal project portfolio that maximizes the company's overall objective. In the selection and decision process two or more mutually exclusive investments and/or substitute investments might be included in the project portfolio. On the other hand if two or more investments are compliments to each other there might be a chance one or more compliment investments are included and the other might be excluded in the investment portfolio.

In general the selection of projects and formation of project portfolio without integrating all information such as, new investment opportunities, ongoing investments, constraints, interdependence between projects, tangible and intangible benefits, risk, etc of the company does not yield an optimum portfolio of projects. Hence it is desirable to develop a technique (model) that assists the management and enables to create the best possible project combination (project portfolio) in the selection process of projects.

1.3 Objective of the Thesis

The general objective of the thesis is to develop a model that assists companies' for the selection of an optimal project portfolio that maximizes the benefits using project portfolio management (PPM) approach.

The specific objectives are:

- To develop a general project portfolio management (PPM) process that describes the whole process of PPM starting from the investment identification stage up to portfolio monitoring stage.
- To formulate a model for portfolio selection that maximizes the benefits of the companies' within the given resource constraints, project interdependence, risk, etc.
- To lay down the basic concepts of PPM for Ethiopian professionals and students for further studies and research, and to the project management practitioners to apply in investment selection and management areas.

1.4 Methodology

The methods employed to achieve the objectives of the research are:

1.4.1 Literature Survey

An extensive review of different literatures from different sources has been done on the research topic. To investigate historical, theoretical and empirical aspects of project selection techniques, academic and professional journals, international publications, books, international and domestic research works, thesis, etc, have been tapped from web-sites, library and other sources. The state of the art of capital project selection techniques and recent works on the subject matter have been also summarized and incorporated in the thesis.

1.4.2 Data collection

Data, information, manuals, working procedures and working practices on project selection processes from governmental and non-governmental local multi-project owner companies are collected. A visit in different companies and face-to-face interview with different company managers, senior project engineers and experts are conducted. For testing of the model different data and information are collected from The Corporate Office of Dejenna Endowment. The Endowment ongoing, on-progress and conceived projects, objectives, the criteria and sub-criteria that are used for project evaluation are identified. Since the relative weight of the criteria, sub-criteria and projects are not determined by the endowment, for the purpose of this thesis the determination has been done in collaboration with the endowment's Senior Project Experts.

1.4.3 Data Analysis and Model Formulation

Basically the research problem of this thesis is a universal problem that challenges many multi-project owner corporations. Hence, literatures are the main sources of the research problem. The model has also been developed mainly from the knowledge tapped from literatures in the field by using different optimization techniques and tools. Different literatures have been collected and analyzed. In order to validate this universal problem at national level interview surveys are conducted in governmental and nongovernmental organizations.

After investigating and understanding the depth of the problem, and being convinced about the need for a better project portfolio selection technique, an overall project portfolio management process model is developed and project portfolio selection model is formulated. The model addresses the tangible and intangible objectives, all project options, constraints, interdependence between projects and generates a portfolio of projects that can optimize the objectives of the company better than the conventional method.

1.4.4 Testing the optimization model

The application of the model is verified on The Corporate Office of Dejenna Endowment. The vision, mission, objectives and criteria of the Endowment that is used for project evaluation are identified. The projects that the Endowment undertakes and data related to the projects are identified and an optimal portfolio of projects are generated.

1.5 Conclusions and recommendations

Finally conclusion and recommendation are forwarded and future research directions are indicated.

1.6 Limitation of the thesis

In the research process different problems that could have an adverse effect on the quality of the thesis are encountered. The major problems were:

i) Shortage of books on the subject in the university and in all local libraries.

ii) Shortage of literatures on the area at national level.

iii) Unwillingness of local companies' especially private companies to give data and information on the project issues.

Measures taken to alleviate the limitation:

- To solve the problem of books and literatures efforts have been made to contact different people from abroad through internet and certain responses and materials are found.
- To get data the doors of different governmental and nongovernmental organizations have been knocked repeatedly and some have opened slightly.

1.7 Expected outcomes

The model would help managers in making optimal decisions to achieve the company's objectives in the project portfolio selection and monitoring process.

Specific outcomes:

- Use for profit and social welfare maximization
- Use for enhancement of customer satisfaction
- Use to improve the reputation of a company
- Use as an input for further research
- Adds knowledge in the field
- Enriches academic advancements and applications of knowledge to solve real world problems, etc.

1.8 Beneficiaries of the thesis

- Multi-project owner companies
- Government in the allocation of capital budget
- Researchers in the field
- The society at large through the output of the application.

CHAPTER TWO

2. Literature Survey

2.1 Introduction

Prior to undertaking research, it is important to view the topics of interest related to the study from existing academic perspectives and to identify where they fit into this study and how they are relevant. Accomplishing this is also fundamentally important to ensuring that the thesis study is original and makes a contribution to the existing practice and body of knowledge in the field. Another use of this literature survey is to acquaint the reader about the existing practice and knowledge of the field, so that it will be easier to understand the main objective of the thesis, the developed model and its contribution.

The survey is not expected to comprehend all the literatures in the field; rather it summarizes the relevant literature to justify the validity of the main ideas of the study in practice. Therefore, the challenge in this chapter is to synthesize the totality of the current literature to the point where only the most relevant aspects from the existing body of knowledge that directly apply to the study are reported on. In this literature different reference materials are used. Some of the literatures are taken directly from the authors but in most cases the original authors' materials are not found. Hence the findings and concepts of some authors are collected from the secondary sources like journals, web-sites, and other doctoral and master's thesis.

As it is mentioned in the previous chapter strategic investment decision may involve a large sum of money and also determine the future success or failure of the company. Acceptance of a large strategic investment will involve a significant change in the company's expected benefits and in the risks to which these benefits will subject to. These situations are likely to lead stockholder and creditors to worry about the evaluation methods of investments during the selection process.

Business organizations and public sectors are continually faced with the problem of deciding whether the commitments of resources, time or money are worthwhile in terms of the expected benefits. If the benefits are likely to accrue reasonably soon after the expenditure is made, and if both the expenditure and the benefits can be measured in dollars, the solution to such problem is relatively simple. If the expected benefits are likely to accrue over a long time period and the measurements are in non-tangible factors, the solution becomes more complex [Bierman & Smidt, 1994].

Due to various limitations such as budget constraint and/or capacity of the company, frequently it is not possible to undertake all the projects that have passed a certain evaluation criteria. Hence the selection of best composition of investment portfolio within the above limitations need a systematic approach that considers the ***strategic objectives of the company, constraints, investment interdependence, risk, etc***. In the selection process many companies assess and evaluate investment opportunities on individual basis using different evaluation criteria. Based on the evaluation result investments are ranked. In most cases the decision of the investments and budget allocation are based on the result of the rank-order with the inclusion of the subjective judgment and experience of managers. But the set of investments combined on the basis of one-to-one evaluation and selection do not yield the best combination of investments.

To improve an investment evaluation, prioritization, portfolio selection and management of projects, companies need a better way of approach. In this respect project portfolio management (PPM) can address the issue by taking into consideration all the necessary information, and evaluate, prioritize, select and monitor projects in a systematic approach.

2.2 What is Project Portfolio Management (PPM)?

The term has a number of commonly accepted definitions. The different definitions on what portfolio management is depend on to whom you are talking or the field to which you are dealing. Perhaps this has contributed to some of the confusion surrounding the terminology. Originally it is coined in the financial and investment community as portfolio management, the term spoke to the process of managing the assets of a mutual fund; including choosing and monitoring appropriate investments and allocating funds accordingly. The adoption of the terminology into other industries such as real estate resulted in a tweaking of the term to reflect industry specific purposes. Similarly, within the technology sector, the term now applies to a set of projects or programs grouped and monitored collectively. For example, Giga Information

Group defines portfolio management as "the manifestation of the alignment of the corporate and IT strategic plans, viewing the portfolio as a suite of complementary investments that collectively provide the best possible allocation of resources to meet the business needs of the corporation" [Business Engine Corporation, 2004; Geoghan & Snow, 2000; ITtoolbox, 1998-2005].

A portfolio is a set of managed assets allocated to investment strategies via an optimized mix based up on assumptions with forecasted performance to maximize value/risk trade-offs.

Project portfolio management (PPM) is a particular form of portfolio management that is engaged in selecting, prioritizing and managing the optimum mix of projects or investments to achieve maximum business value. In this decision making process, management can focus their scarce resource on investment that is achievable and strategically aligned with business goals. The resulting portfolio drives a balanced of what is possible and what is needed [Pieter Meyer-COO-UMTSA, 2006].

Project portfolio management is a particular form of portfolio management. It uses structured approach to make educated decision about a collection or "portfolio" of projects, their associated investment mix, and their contribution to the organization's business mission capabilities [Enterprise Solution Competency Center].

According to Cooper et al.2001b:3 definition project portfolio management is defined as follows:

"Project Portfolio Management (PPM) is a dynamic decision process, whereby a business list of active new product (and development) project is consistently updated and reviewed. In this process new projects are evaluated, selected and prioritized; existing projects may be accelerated, killed or de-prioritized; and resources are allocated and re-allocated to active projects. The portfolio decision process is characterized by uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations, interdependence among projects, and multiple decision makers and locations. The portfolio decision process encompasses or overlaps a number of decision-making processes within the business, including periodic review of the total portfolio of all projects (looking at all projects holistically, and against each other), making

Go/Kill decision on individual projects on an on-going basis, and developing a new product strategy for the business, complete with the strategic resource allocation decision" [de Klerk, 2005]

2.3 The Rationale for Effective Project Portfolio management

The specific reasons for the importance of effective PPM according to Cooper et al (2001b:3) are:

1. **Financial-** to maximize return; to maximize R&D productivity; to achieve financial goals.
2. **To maintain the competitive position of the business-** to increase sales and market share.
3. **To allocate scarce resource properly and effectively.**
4. **To forge the link between project selection and business strategy:** the portfolio is the expression of strategy; it must support the strategy.
5. **To achieve focus-** not doing to many projects for the limited resources available; and to resource the "great" projects.
6. **To achieve balance-** the right balance between long and short term projects, and high risk and low risk ones, consistent with the business's goal.
7. **To better communicate priorities with the organization,** both vertically and horizontally to prove better objectivity in project selection- to weed out bad projects [de Klerk, 2005].

2.4 The effects of lacking effective project portfolio management

Cooper et al (1998:4-5) indicates that without effective PPM, companies will face difficulties in achieving the above-mentioned benefits. The immediate and end results of selecting and implementing projects without effective PPM are indicated in the figure below.

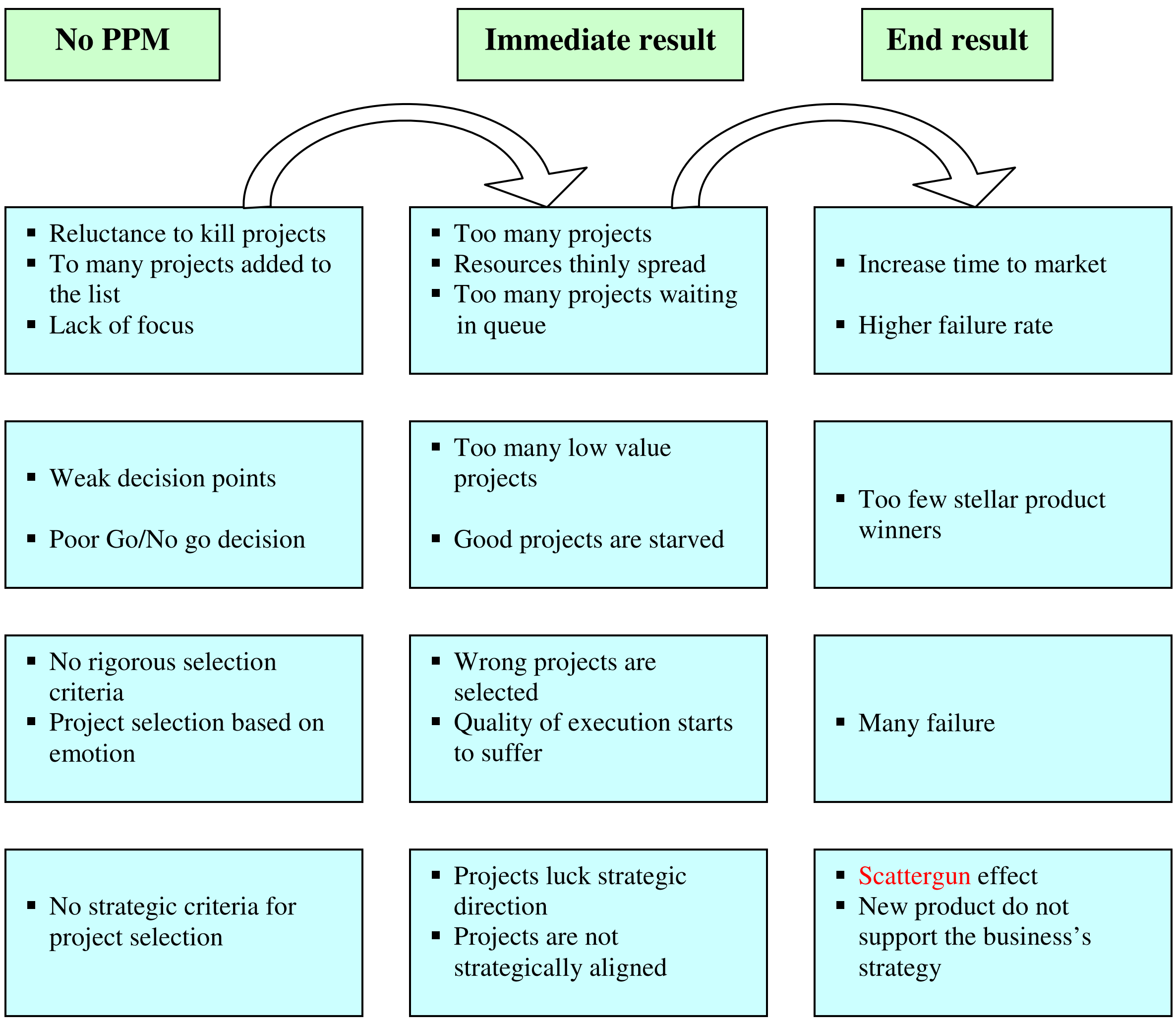

Figure 2. 1 What happens when you have no effective PPM

Indeed, many of the problems that beset product development initiative in business can be directly traced to lack of effective PPM. When the PPM is weak, first there will not have an effective Go/Kill criteria and no consistent mechanism for evaluating and, if necessary terminating weak projects. Projects seem to take a life of their won, running like express trains pass review point. Further, new projects simply get added to the "active list" with little appreciation for their resource needs or impact on other projects. Clark and wheelwright refer to this as the "canary cage approach". New canaries (projects) are thrown into the cage without any analysis of the effect of the other canaries already in the cage. The result is a total luck of focus: far too many projects for the available resources.

The problems do not stop there. A lack of focus and too many active projects mean that resources and people are too thinly spread. As a result projects, end up in a queue- "pipeline gridlock" and cycle time starts to increase. Suddenly there are complaints about projects taking too long to get to market. But worse: with resources and people thinly spread, everyone starts to scramble too many balls in the air. The result is clearly predictable: the quality of execution starts to suffer. For example, the essential upfront isn't done and needed market studies designed to build in the voice of the customer are left out due to lack of time and people. Poor quality execution of this task and others such as required steps and stages in the new product process means an increase failure rates. Not only are projects then late to market, but their success rate also drops.

Additionally lacking effective PPM will result in too many unimportant projects in the pipeline; too many extension, minor modification and defensive products, which only yield marginal value to the company. Thereby many of the launches warrant and low and disappointing result and there is a noticeable lack of stellar new product winners. By far the most demanding results of the above is that the few really good projects are starved for resources so that they are either late to market or never achieve their full potential. Such wasted opportunities are not reflected in the company's financial statement.

Without a rigorous portfolio selection method, the wrong projects often get selected and for all the wrong reasons. Instead of decisions based on facts and objective criteria, decisions are based on politics and emotion. A great number of these ill-selected projects simply fail. The final consequence that needs mention is the result the on strategy. Without a PPM method, strategic criteria for project selection is missing and so there are no strategic direction to the projects selected. After all, new products are the leading edge of business strategy. They define tomorrow's vision of your company. But without a portfolio method, projects are not strategically aligned with the business's strategy and many strategically unimportant projects find themselves in the pipeline. The end result is a scattergun effort that does not support the business strategy direction [de Klerk, 2005; Revonta, 2004].

2.5 The Four goals of Project Portfolio Management

There are four macro or high level common goals across businesses when it comes to project portfolio management [Cooper & Edgett, 2006; de Klerk, 2005].

These four goals are:

1. **Maximize the Value of Your Portfolio**: Here the goal is to select new product projects so as to maximize sum of the values or commercial-worth's of all active projects in your pipeline in terms of some business objective. Tools used to assess "project value" include:
   - **a)** **NPV**: Determine the project's net present value and then rank projects by NPV divided by the key or constraining resource (for example, the R&D costs still left to be spent on the project; that is, by NPV/R&D). Projects are rank-ordered according to this index until out of resources, thus maximizing the value of the portfolio (the sum of the NPVs across all projects) for a given or limited resource expenditure.
   - **b)** **ECV**: The Expected Commercial Value method uses decision-tree analysis, breaking the project into decision stages. Define the various possible outcomes of the project along with probabilities of each occurring (for example probabilities of technical and commercial success). The resulting ECV is then divided by the constraining resource (as in the NPV method), and projects are rank-ordered according to this index in order to maximize the bang for buck. The projects on the top of the list are considered "Go" while the rest (beyond the total limits) are put on hold. This methodology insures that the ECV is maximized for a given budget.
   - **c)** **Productivity Index**: It is similar to ECV method illustrated above, although a probability adjusted NPV is employed as the ECV. This ECV values is multiplied by the probability of technical success and divided by remaining constraint costs.
   - **d)** **Scoring model**: Decision-makers rate projects on a number of questions that distinguish superior projects, typically on 1-5 or 0-10 scales. Add up these ratings to yield a quantified Project Attractiveness Score, which must clear a minimum hurdle. This Score is a proxy for the "value of the project" but incorporates strategic, leverage and other considerations beyond just financial measures. Projects are then rank-ordered according to this score until resources run out.

2) **Seek Balance in Your Portfolio**: Here the goal is to achieve a desired balance of projects in terms of a number of parameters; for example, long term projects versus short ones; or high risk versus lower risk projects; and across various markets, technologies, product categories, and project types (e.g., new products, improvements, cost reductions, maintenance and fixes, and fundamental research). Pictures portray balance much better than do numbers and lists, and so the techniques used here are largely graphical in nature. These include:

   a. **Bubble diagrams**: The bubble diagrams are two-dimensional representations that include all the investments considered. An example of the bubble diagram is shown in the figure 2.2. The size of the bubble indicates the resource amount the investment requires. The more the figure becomes an elliptical shape, the greater the uncertainty of the estimate. In the figure 2.2 the colored projects are the selected projects.

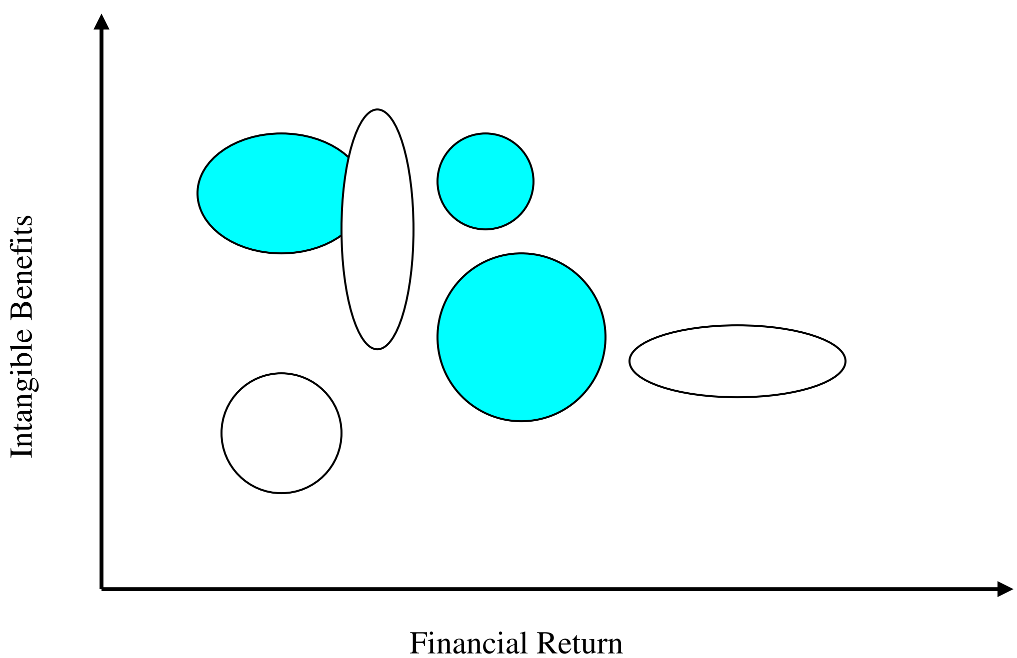

Figure 2. 2 An example of the bubble diagram

   b. **Pie charts**: Here show your spending breakdowns as slices of pies in a pie chart. Popular pie charts include a breakdown by project types, by resource allocation, by market or segment, and by product line or product category. The pie chart on figure 2.3 shows the distribution of resource to the projects.

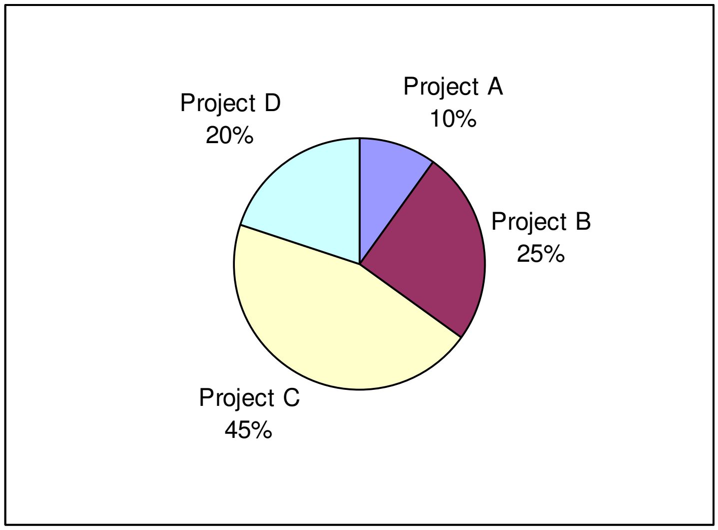

Figure 2. 3 The Pie chart that indicates the resource allocation on each project

C) **Histogram:** Figure 2.4 (adapted from Cooper et al., 1997a) indicates a histogram that illustrates the distribution of resource among the selected investment. This diagram can be used to detect the impact of resource constraints on the portfolio. Additionally the timing histogram represents how the portfolio is balanced considering short- and long-term investment. Other than resource utilization, the timing histogram can be used to represent expected yearly cash flows. Here the desire is to balance the investments in such away that cash inflows are reasonably balanced with cash outflows in the portfolio.

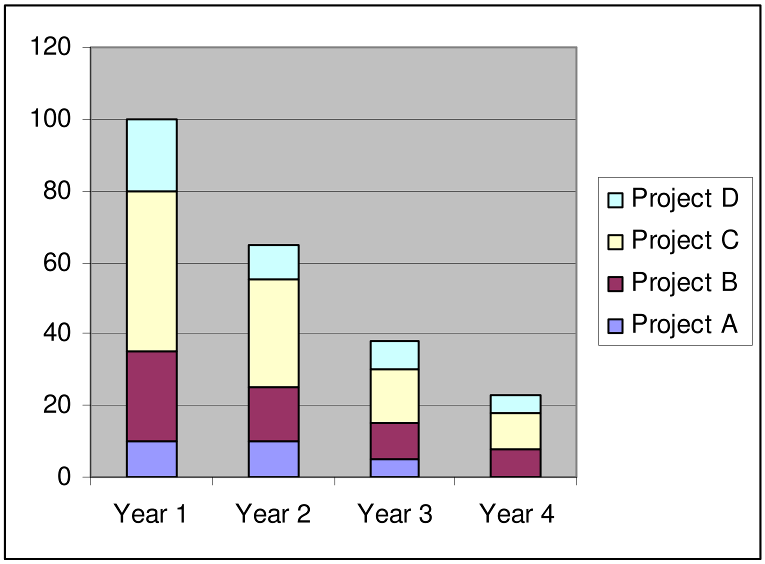

Figure 2. 4 The histogram shows the resource allocation on the projects in different years (The colors show the resource amount allocated to different projects)

Both bubble diagrams, pie charts and histograms, unlike the maximization of the main goal, are not decision-models, but rather aids in to display information: they depict the current portfolio and where the resources are going. These charts provide a viable beginning for the decision of "what should be?" How the resources should be allocated.

3) **Building the strategy into the portfolio.** This means that all your projects are "on strategy"; and that your breakdown of spending across projects, areas, markets, etc., must mirror your strategic priorities (your areas of focus and their respective priorities). Several portfolio methods are designed to achieve strategic alignment:

a) **Top-down, strategic buckets**: Begin at the top with your business's strategy and from that, the product innovation strategy for your business – its goals, and where and how to focus your new product efforts. Next, make splits in resources: "given your strategy, where should you spend your money?" These splits can be by project types, product lines, markets or industry sectors, and so on. Thus, you establish strategic buckets or envelopes of resources. Then, within each bucket or envelope, list all the projects – active, on-hold and new – and rank these until you run out of resources in that bucket. The result is multiple portfolios, one portfolio per bucket. Another result is that your spending at year-end will truly reflect the strategic priorities of your business.

b) **Top-down, product roadmap:** Once again, begin at the top, namely with your business and product innovation strategy. But here the question is: "given that you have selected several areas of strategic focus – markets, technologies or product types – what major initiatives must you undertake in order to be successful here?". It's analogous to the military general asking: given that I wish to succeed in this strategic arena, what major initiatives and assaults must I undertake in order to win here? The end result is a mapping of these major initiatives along a timeline.

c) **Bottom-up:** "Make good decisions on individual projects, and the portfolio will take care of itself" is a commonly accepted philosophy. That is, make sure that your project gating system is working well – that gates are accepting good projects, and killing the poor ones – and the resulting portfolio will be a solid one. Even better, to ensure strategic alignment, use a scoring model at your project reviews and gates, and include a number of strategic questions in this model. Strategic alignment is all but assured: your portfolio will indeed consist of all "on strategy" projects (although spending splits may not coincide with strategic priorities).

4) **Pick the Right Number of Projects:** Most companies have too many projects underway for the limited resources available. The result is pipeline gridlock: projects end up in a queue; they take too long to reach the market; and key activities – for example, doing the up-front homework – are omitted because of a lack of people and time. Thus an over-riding goal is to ensure a balance between resources required for the active projects and resources available. Here are the ways:

a) **Resource limits:** The value maximization methods (Goal #1) build in a resource limitation – rank your projects until out of resources. The same is true of histogram (Goal #2): The resource allocated in different color in each year indicates the resources devoted to each project. Adding one more project to the diagram requires that another would have to be deleted.

c) **Resource capacity analysis:** Determine your resource demand: prioritize your projects (best to worst) and add up the resources required by department for all Portfolio active projects (usually expressed in person-days per month). Project management software, such as MS-Project, enables this roll-up of resource requirements. Then determine the available resources (the supply) per department – how much time people have to work on these projects. A department-by-department and month-by month assessment usually reveals that there are too many projects; it suggests a project limit (the point beyond which projects in the prioritized list should be put On Hold); and it identifies which departments are the bottlenecks.

There is a danger that the four goals of PPM, as outlined above, can become in conflict one another. The value maximization goal (where the project with the highest NPV or IRR takes precedence) may be in conflict with the balancing goal (having the right mix of short and long term projects; high and low risk projects, etc). On the other hand, choosing a portfolio that is 100% aligned with strategy may lack the ability to generate profits in the short term [Copper & Edgett, 2006].

2.6 Project Management (single, multiple, enterprise)

The literature on project management is extensive and is growing at a rate proportionate to interest in the field, among both practitioners and academics. The literature more often focuses on the operational or individual task level and authors often try to distinguish between individual project management techniques and multiple project management techniques at the enterprise level.

Almost all literatures related to the effective management of projects focus on the success of on-time, on-budget or on-cost (often referred to as the triple constraint or iron triangle by practitioners) completion of projects. Articles or case studies that deal with the techniques of single or multiple project management, important to the profession, are of less relevance to this particular study than those which deal with a holistic and a strategic view of general project management processes. The general inters of this thesis are citations that include early stages related project selection, project portfolio adjustment and project portfolio monitoring techniques. And in particular this study focuses more on selecting strategic projects than managing them.

Recent studies indicate that, if an organization can locate a methodology to pick the right projects, there are ways of ensuring sufficient capability and maturity in the firm to actually execute the project itself. Therefore, the remaining concern would be to ensure the assigned practitioners are already experienced in effective single and multiple project management techniques. However, there is limited organizational capability on the selection of projects that are strategically aligned and in assuring the continuous alignment of projects to the company strategy.

2.7 The Hierarch of Project Management

In an enterprise level there are hierarchies of project management structure and activity which starts from managing a single project to project portfolio management. A picture that depicts the hierarchy of implementation of various aspects of accepted project management practice is shown in the figure below.

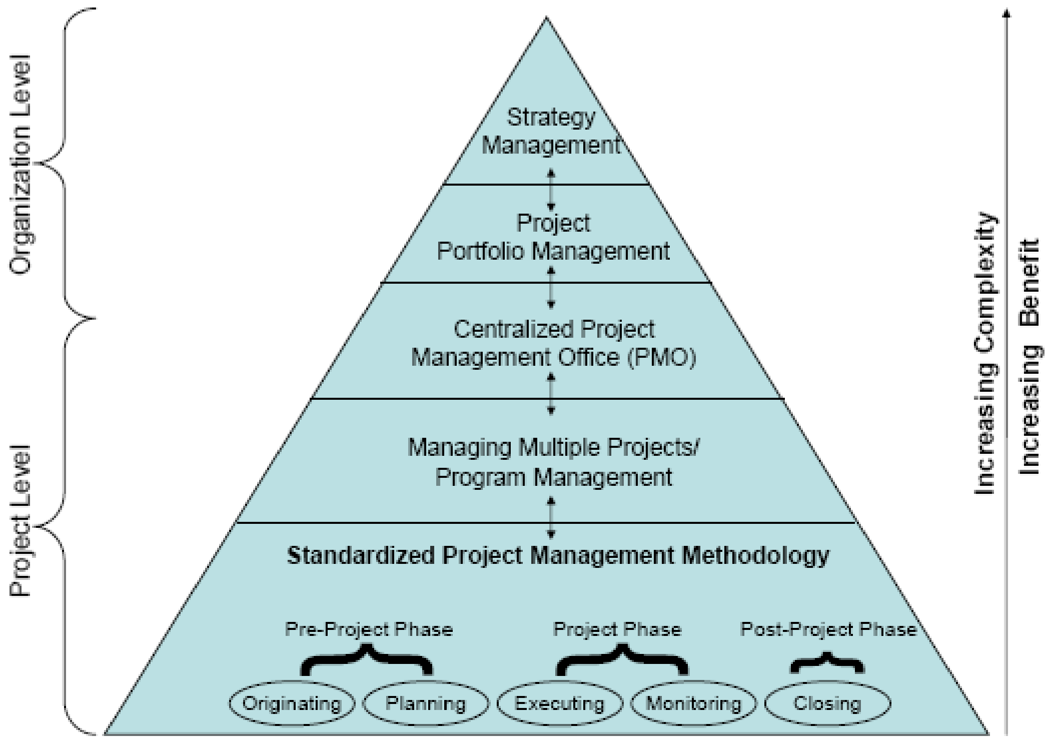

Figure 2. 5 Project management hierarchies

Most project management maturity models start with an organization's basic ability to have a standardized project management methodology for single projects covering pre-project, project and the post-project phases of the traditional PM process. In order of increasing complexity, we see the normal evolution of project management within an organization as it progresses through beginning to manage multiple projects, then eventually grouping projects (either thematically, divisionally or strategically) into programs. Concurrently, this often leads to the introduction of a centralized project management office (PMO). Of note is that there are two things moving in harmony in this diagram: as the complexity of tasks increases so too does the realization of business benefits. However, the responsibility for the proper execution of these capabilities can be thought of as being primarily at the project level, shared jointly with the organization's centralized processes, or residing exclusively at the organization level, as shown on the left had side of the diagram.

At the top of the diagram is the organization's strategy management process (formulation, communication and measurement of its progressive execution). Obviously, good strategy is central to success and must drive project conception and execution, thus its place is at the top of the hierarchy. However, it is also recognized as more amorphous and complex than the other tasks noted on the diagram – but getting it right drives the right results.

PPM is relatively resent methodology (introduced in the last 20 years). At first glance, to many practitioners it may seem like a natural extension of multiple project management methods as practiced in the centralized project management office. PPM is a central process that acts as the conduit between the organization's strategy formulation and its execution. Its objectives are project evaluation, prioritization and selection. Management uses the process to determine which projects to pursue and which to discontinue. This makes it an essential ingredient of the successful realization of strategy [Norrie, 2006].

Yet it is clear that in many organizations, in both the private and public sectors, they either have an under-developed PPM process or treat it as a simple extension of their program management or a centralized PMO capability. However, PPM is a distinct process from a PMO capability with its own objectives and should be treated as such within an organization's standardized project management processes and practices.

In general project management is concerned about the technical issues of projects, where as project portfolio management is concerned about the strategic issues of projects [Dye & Pennypacker, 2000]. Table 2.1 indicates the comparison of project management and project portfolio management.

Table 2. 1 Comparison of Project Portfolio Management and Project Management

	Project Management	Portfolio Project Management
Purpose	Resource allocation	Project selection and prioritization
Focus	Tactical	Strategic
Planning emphasis	Sort-term	Long & medium-term (annual/quarterly)
Responsibility	Project/resource managers	Executives/senior management

2.8 Risk Analysis

Risk is inherent in almost every business decision. More so in project investment decisions as they involve costs and benefits extending over a long period of time during which many things can change in unanticipated ways. Investment proposals have different magnitude of risk. A research and development project may be more risky than an expansion project. In view of such differences, variations in risk need to be evaluated explicitly in investment appraisal.

Risk analysis is one of the most complex and slippery aspects of project portfolio selection and management. Many different techniques have been suggested and no single technique can be deemed as best in all situations. The variety of techniques suggested to handle risk in project selection and management fall in to two broad categories: i) Techniques that considers the stand-alone risk of projects; ii) Techniques that consider the risk of a project in the context of the firm or in the context of the market. The techniques for risk analysis under the stand-alone and analysis of contextual risk have also different approaches. Under the two broad categories there are different approaches [Chandra, 2006].

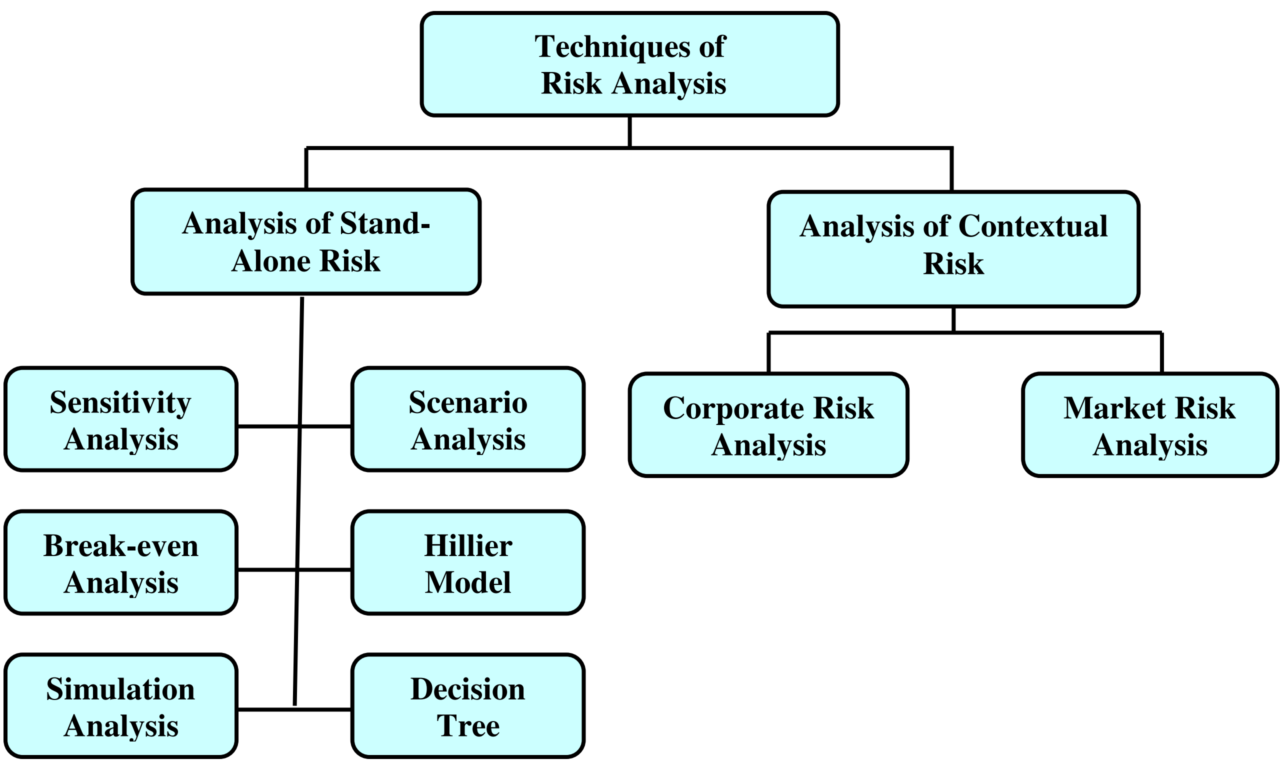

Figure 2. 6 Different approaches of risk analysis under the two broad categories.

2.8.1 Source, Measures and Perspective on Risk

Source of Risk: There are several source of risk in a project. The important ones are project-specific risk, competitive risk, industry-specific risk, and international risk.

- **Project-specific risk**: The earning and cash flows of the project may be lower than expected because of estimation error or due to some other factors specific to the project like the quality of management.
- **Competitive risk**: The earnings and cash flows of the project may be affected by unanticipated action of the competitors.
- **Industrial-specific risk**: Unexpected technology development and regulatory changes, that are specific to the industry to which the project belongs, will have an impact on the earning and cash flows of the project as well.
- **Market risk:** Unanticipated changes in macro economic factors like the GDP growth rate, interest rate, and inflation have an impact on all projects in varying degrees.
- **International Risk:** In the case of foreign projects, the earning and cash flows may be different than expected due to the exchange rate risk or political risk.

Measuring Risk: Risk refers to variability. It is complex and multi-faceted phenomenon. A variety of measures have been used to capture different facets of risk. The more important ones are range, standard deviation, coefficient of variation, and semi-variance.

Perspective on Risk: Regardless of the risk measurement employed, there are different perspectives on risk. You can view a project from at least three different perspectives. These are:
Stand-alone risk: This represents the risk of a project when it is viewed in isolation.
Firm risk: Also called corporate risk, this reflects the contribution of a project to the risk of the firm.
Systematic risk: This represents the risk of a project from the point view of a diversified investor. It is also called market risk [Chandra 2006].

2.8.2 Project Selection under Risk

Once information about expected return (measured as net present value or internal rate of return or some other criterion of merit) and variability of return measured in terms of range or standard deviation or other risk index has been gathered, the next question is, should the project be accepted or rejected. There are several ways of incorporating risk in the decision process: judgmental evaluation, payback period requirement, risk profile method, certainty equivalent method, and risk adjusted discount rate method.

Judgmental Evaluation: Often managers look at risk and return characteristics of a project and decide judgmentally whether the project should be accepted or rejected, without using any formal methods for incorporation risk in the decision making process. The decision may be based on the collective view of some group like investment appraisal team, or executive committee, or the board of directors.

Payback Period Requirement: In many situations companies use NPV or IRR as the principal selection criteria, but apply a payback period requirement to control risk. Typically if an investment is considered more risky a short payback period is required even if the NPV is positive or IRR exceeds the hurdle rate. This approach assumes the risk is a function of time.

Risk Adjusted Discount Rate Method: The risk adjusted discount rate method calls for adjusting the discount rate to reflect the project risk.

Certainty Equivalent Method: The certainty equivalent method is conceptually superior to the risk-adjusted discount rate method because it does not assume that risk increases with time at constant rate. Each year's certainty equivalent coefficient is based on the level of risk characterizing its cash flow. Despite its conceptual soundness it is not as popular as the risk-adjusted discount rate method. This is perhaps because it is inconvenient and difficult to specify a series of certainty equivalent coefficient but seemingly simple to adjust the discount rate. Notwithstanding this practical difficulty, the merit of the certainty equivalent method must not be ignored [Chandra, 2006].

2.8.3 Diversification of Risk in a Portfolio

We have so far seen the characteristics of return from a single investment proposal. It is not necessary that a firm should operate only in one business. A firm can opt to invest in more than one business in order to spread its risk. A firm that is currently engaged in some business activity may opt to diversify into some other line of business activity as a strategy. The proverb 'Don't put all your eggs in one basket' is worth practicing in the formulation of safe business strategy. When the actual performance of a business changes for the worst as compared to the estimates and forecasts a firm that has put all its resource in only one business activity is sure to suffer a huge loss [Nagarajian, 2001].

2.9 Finance, Capital Allocation and Portfolio Theory

The origins of PPM lie in the theoretical domain of finance – specifically capital allocation and investment portfolio theory. The basic notion of balancing a portfolio between risk and return is common knowledge and is understood as an overarching objective of sound financial management, both personally and corporately. This was first proposed by Markowitz (1959) and it is a notion for which he was later awarded the Nobel Prize in Economics [Norrie, 2006].

But when we move more deeply into a study of the mechanics of portfolio theory, we find in the associated literature in-depth discussions about how to assess, measure and relate risk, and return to assess the true value of a potential activity before assessing its value. As time goes on, manual calculations are replaced with more substantive mathematical models and model portfolio constructs that are often associated with the term "efficient frontier" as the place where return is maximized for any level of acceptable risk. The focus of the early writing in project portfolio management often requires a complete economic appraisal of the "fully loaded" costs of a project to compare its anticipated benefits with its costs and risks. Retrospectively, this seems to be an obvious recommendation but it was breakthrough thinking at the time. They suggest that companies prioritize those projects that offer the highest likelihood of a higher returns, measured capital consumption and a lower probability of risk (something we take as a given in project management methodologies today). In their book Connecting the Dots (2003), authors Benko and McFarlan provide a chart that summarizes the comparison between Financial Portfolio Management and Project Portfolio Management as follows:

Table 2. 2 Summary comparison of portfolio management paradigms

Comparison Points	Financial Portfolio	Project Portfolio
Assets	Various financial instruments with distinct characteristics	Various projects with distinct characteristics
Diversification	Employing multiple financial instruments can reduce risk	Monitoring project variables –scope, approach, vendors, project managers, etc. – can reduce risk
Goals	Income and capital gains	Profitability and growth
Asset Allocation	Invest according to individual investment goals	Invest according to overall organizational intentions
Connections	Correlation	Interdependency

Portfolio theory has its base in building up a portfolio of securities that offers maximum return for a given level of risk or minimum risk for an expected level of return. The unique feature of project is that it cannot be divided into sub units like securities for the formulation of a portfolio. Securities represent a proportionate share of the total capital of the company. Thus one can buy 1,000 shares of one company and combine the same with 2,000 shares of another company bought by him and from a portfolio of securities. This is not possible in respect of projects. One cannot have a portfolio consisting of 0.7 part of project-X and 0.3 part of project-Y. Hence, portfolio theory that was developed for building up an efficient portfolio of securities can not be straight away extended to projects unless the project exhibit essential feature of securities. For example, an entrepreneur may have plans to invest in transport service sector. He can invest in few passenger vehicles or in few goods carrier vehicles or a judicious combination of both. Such situations are to some extent amenable to the application of portfolio theory, since the total numbers of vehicles that are going to be purchased are more in numbers which are identifiable as separate sub units of the total project.

While interesting, these discussions are relevant to PPM only to establish that the a priori objective of creating and managing a portfolio is always to maximize financial return while minimizing risk. Thus, the optimal portfolio at the efficient frontier is assumed to generate the highest possible return for any given level of risk. In terms of investments, problems can arise because of the inherent risk in the financial instrument itself or as a relationship risk derived from how an instrument or portfolio of instruments relate to each other. Over time, this has led to the basic assumption that risk is minimized through a diversified portfolio. This is known as the assumption of collaborative risk and it assumes each financial instrument in the portfolio is not inter-dependent and that a choice to include or exclude it can be made without consequences [Norrie, 2006].

An oft-cited founding reference to PPM is Souder (1973) in the article "Utility and Perceived Acceptability of R&D Project Selection Methods" notes that the fundamental issue of project interdependency is distinct from the independent collaboration of financial instruments. Even this title allows the reader to see the early alignment with the financial and mathematical origins of portfolio theory being applied in project management settings. Souder proposes that a more structured model (including mathematical calculus to assess relative risk between projects) would enable corporations to make more informed decisions about which projects to continue and which to stop. Souder followed up in 1975 with a key article in Management Sciences entitled, "Achieving Organizational Consensus with Respect to R&D Project Selection Criteria". Therein, he advocates for the use of consistent criteria across both existing and proposed projects for the purposes of making relative comparisons between them. Thus we begin to see the emergence of PPM in its current incarnation. However, the approach was still considered to be too complex to be applied by many organizations at the time and so was not often used in practice because of the substantial amount of data and analytical processing required to reach conclusions. It is also clear that the theories on how to combine these disciplines more seamlessly (financial theory, the R&D process and project management) had not yet completely emerged.

Subsequently, Robert Cooper (a Professor of Marketing at McMaster University) began to evolve the process design combining "stage gates" with the interim assessment of potential risk and return at each stage of the new product development life cycle in order to recommend specific decisions at each stage of a company's project management life cycle. This was considered a practical breakthrough by many practitioners in terms of recommending a sound business process that applies seemingly complex theory in a precise, prescriptive and practical way which organizations could understand and adopt [Norrie, 2006].

2.10 Recent Masters and Doctoral Works on PPM

2.10.1 James L. Norrie (2006)

James L. Norri from RMIT University has done his doctoral thesis entitled, "Improving Results of PPM in the Public Sector using a Balanced Strategic Scoring Model." The focus of his thesis is about the application of PPM in the public sectors. According to his thesis the focus of the application of PPM is in the private sectors which have a main objective of maximizing their profit with a little attention to the other benefits that is very important in the public sectors. The negligence of other factors is felt as a deficiency in many practitioners. Hence the writer has tried to fill the gap by including other objectives in the evaluation of projects that have a special importance in the public sectors using a balanced strategic scoring model.

2.10.2 Schalk Willem de Klerk (2005)

De Klerk from University of Pretoria has done his masters thesis entitled, "Validating the Core Problems of Project Portfolio Management in a Multi Project Environment." In his work he tries to validate the postulated "release-problem" and to ascertain whether the effect-cause-effect pattern derived by Viljaen (2005:6-8) were in fact present in a specific organization (an electric equipment design and manufacturing operation, headquarter in Randburg, South Africa). The postulate he wants to validate describes that the release-problem causes a number of negative side effects and thereby jeopardizes the four desired outcomes of PPM.

It is assumed that work-in-progress (WIP) increases if more work is released in to the system and that increased WIP shows the system down and cause it to become unproductive as inputs into the system increases but the output do not. This is referred to as the release-problem. The seven undesired effects due to the release-problem are:

1) The portfolio management hierarchical level is overloaded,
2) Portfolio management does priority setting and resource re-allocation on daily bases,
3) An ongoing game of negotiation is played for key resources,
4. Management is primarily engaged in short term problem solving,
5. Priorities change often,
6. One project has negative effects on the other projects, and
7. Project managers keep a resource working on their projects unnecessarily in order not to lose them.

These seven underlined effect severely inhibit the performance of project portfolio delivery system and may ultimately jeopardize the four goals (value maximization, balancing, fit and having the right number of projects) of PPM. In his case study, he founds that the release-problem is in fact responsible for the problems of PPM.

2.10.3 Juhan Martikainen (2002)

J. Martikainen from Helsinki University of Technology has done his master's thesis entitled, "Portfolio Management of Strategic Investment in Metal Product Industry." His thesis is specific to the problems of strategic investment in metal product industries. He has developed a model for investment portfolio selection and tests it in a specific metal industry by considering twelve implemented and proposed investments.

2.10.4 Michael W. Dickison (1999)

W. Dickinson from Massachusetts Institute of Technology has done his masters thesis entitled, "Technology Portfolio Management: Optimizing Interdependent Projects over Multiple Time Period." The thesis presents an approach to account for and quantity the interdependence of technology projects and explains how it was integrated into a non-linear, integer program model at The Boing Company. The model evaluates if and when to start funding a project over four years period.

2.11 The Inputs of This Thesis and Model

In addition to the above recent works in the field of project portfolio management (PPM) there are plenty of portfolio selection models developed by researchers in the field. However, according to the researchers view in the field, none of them seems to be dominant and problem free. The specific contribution of this thesis that worth mentioning are the overall model constructed to show the whole process of project portfolio management and the application of analytical hierarchy process (AHP) with Simple Multi-Attribute Rating Technique (SMART) to find the coefficients of the maximization objective function in one problem. Merging these two techniques enable us to minimize the shortcomings of the techniques used separately. The portfolio selection model has also tries to identify the tangible and intangible criteria and sub-criteria that are used as a linkage between the company's objectives and the projects that are conceived. In most models the intangible factors (criteria) are not treated adequately. But in this model the intangible factors can be measured adequately with blend of AHP and SMART if the evaluators have sufficient know-how and experience on each criterion and their contribution to the success of the company, and the relative weights of the identified projects to each criterion. The model has also attempt to improve the portfolio selection deficiencies by compiling the constraints that companies could possibly encounter in the process.

The other specificity of this thesis is that, it is the first in its kind in Ethiopia as I have observed in my interview survey in different governmental and non-governmental companies. Hence I believe that this thesis could be considered as a pioneer in this field in the national context and helps practitioners and academicians to investigate further, adapt and use it.

CHAPTER THREE

3. Development of Project Portfolio Selection Model

3.1 Introduction

The objective of this chapter is to develop a model that enables to select an optimal set of projects (a portfolio of projects) from a large number of feasible proposals. The general project portfolio management (PPM) process model is also constructed and a detail discussion on each step of the PPM process is included. For project portfolio selection process evaluation criteria and sub-criteria are identified and discussed. The organization overall objective, criteria, sub-criteria and the feasible projects in the individual project evaluation process are arranged in analytical hierarchy process (AHP) structure. The criteria under the overall objective of the company are structured to be compared and weighed in accordance to their contribution to the overall objective of the company. The sub-criteria under the main criteria are also structured to be compared and weighed in accordance to their contribution to the main criterion. The projects screened in the feasibility study step are the candidate projects for the portfolio selection process. These projects are placed under the sub-criteria to be evaluated and weighed to each sub-criterion and to all sub-criteria. The determination of the score of the projects in accordance to their contribution to the overall sub-criteria is an essential task to formulate the optimization equation for the portfolio selection. The value of the projects score that is going to be determined through the above process is taken as the coefficient of the optimization equation. In the portfolio selection model besides to the formulation of the objective function different constraints and interdependence of projects are also considered and included in the optimization problem formulation. Finally a zero-one integer linear programming model is proposed to find the solution of the optimization equation.

3.2 Project portfolio Management Process

Once the basics of managing individual projects are mastered, an organization must provide a system for selection, prioritization and oversight of all the projects in which the enterprise engages. This level of project management differs as much from standard single-project management. As single-project management does from ordinary ongoing operational management. Making the conceptual leap from the tool-and-technique-focused variety of project management to portfolio management, with its broader focus on business strategy and enterprise-wide integration, is a special challenge and one that many organizations now face with little in the way of standards, best practices, or other generally accepted knowledge to guide them [Knutson, 2001].

Evolution: From Project Management to Portfolio Management

On the individual project level of project management, the focus is on planning and controlling the various activities that go into the single project. In general project management is doing the projects right.

For many years, this focus sufficed organizations because the nature of most project endeavors was to be large-scale, long-duration, single projects: a bridge, an airplane, a legacy computer system. Recently, however, the world economy has made a dramatic shift to information-based wealth creation. With that shift, the projects that create value for companies have both proliferated and changed in nature. Software and hardware development and almost any kind of new product development projects necessitate short-cycle, rapid, and flexible project management.

This increased fluidity has occurred as an organic response to market conditions and has outpaced companies' development of methods for managing under these new conditions. As a result, there has been a disconnection between companies' ability to mange projects on the project level and their ability to manage them collectively on the organizational or enterprise level. The business of selecting which project to invest in, when to change priorities from one project to another, and how to align the projects a company does with one another and with organizational strategy and mission must be carried out at the executive level-at the level of *managing by projects, rather than of project management* [Knutson, 2001].

3.3 The Six Step Model of PPM Process

Project portfolio management seeks to answer the questions, *what should we take on? What should we drop?* It often requires determining what is possible and what is needed. Thus the analytical tasks involved in portfolio management are more related to higher-level business management than to the traditional planning and controlling functions of project management. Portfolio management is the way in which decision makers align projects with the organizational strategy, just as strategy is the way the organization aligns itself to the wider marketplace. While, most decision-making on the project level is concerned with tactical issues *(How can we do this thing right?)*, decision making on the portfolio level is concerned with strategic issues *(How can we be sure to do the right things?)* [Knutson, 2001].

For effective PPM process there is no universal method or generic model that serves to all types of businesses. To achieve the objectives of PPM by implementing it in a company it is required to develop a model that considers the company's internal and external environment. For the development of effective PPM process a few general assertion and guidelines can be made about its challenges.

- Portfolio management must consider all types of projects that compete for resources.
- Gate decisions for individual projects must be integrated with portfolio decisions.
- Information overload can be a problem in portfolio managements; continual focus must be maintained on improving the quality of information inputs.

In pursuit of the four main goals mentioned in the previous chapter, various approaches have been developed to address the issues of quality of information, integration of decision making, and so on. These approaches vary widely on a detail level, but share a general pattern of process. In this thesis six steps of PPM process model are developed. The process is represented in a diagrammatical ways and each process is explained in detail. In the PPM process a due attention is given to the portfolio selection step and it is formulated in such a way that it addresses the desired maximization of the company's overall objective through the project portfolio selection.

The steps of the PPM process are:

i) Strategic planning,

ii) Project identification,

iii) Individual project evaluation,

iv) Portfolio selection,

v) Adjustment and implementation and,

vi) Portfolio monitoring.

The process of the above steps consider four objectives of PPM: fit, utility, balance and right number of projects.

In general, fit is determined in the identification and subsequent stages; utility is assessed in individual project evaluation, but more thoroughly explored in selection process; and balance and determining the right number of projects are achieved in the portfolio selection and adjustment process. The six steps of portfolio management process developed to show the activities, responsibilities and relationship between the steps are indicated in figure 3.1.

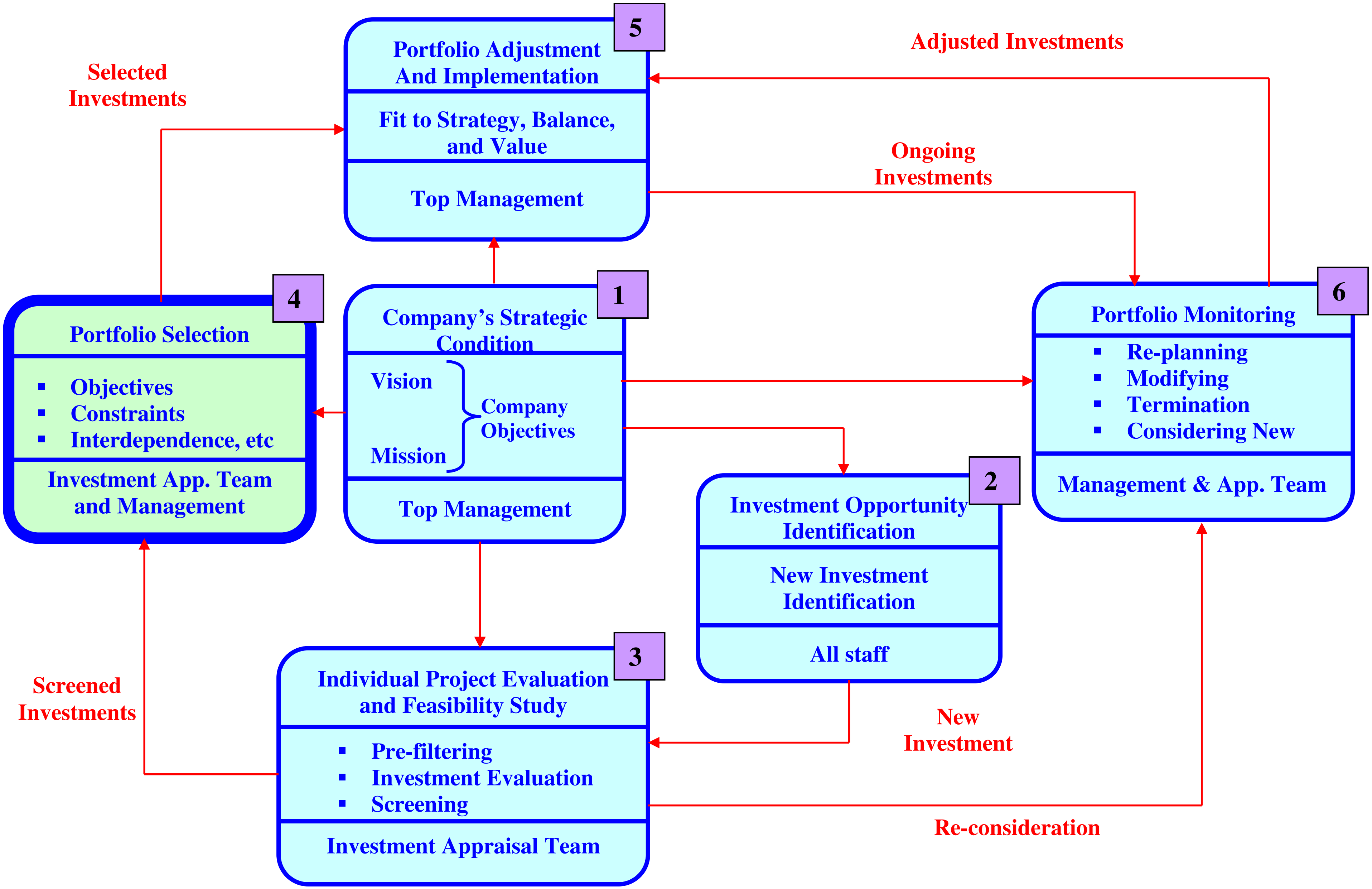

Figure 3. 1 Six steps in project portfolio management (PPM) process

Step 1: Strategic Planning

This is more of a pre-portfolio management step, and it may seem too obvious to be included here. However, many organizations still make project decisions without first having thought through their long-term goals. At this level, such activities as environmental scanning, market research and development of mission and vision statements must be carried out in order for an organization to express any rationality or coherence in its project selection process. Groups and individuals that conduct strategic planning are consistently more successful at achieving goals than those who don't utilize it.

Since strategic focus becomes the foundation for selecting projects, the strategic direction and business goals must be clearly established. These may be reflected in the vision statement, mission statement, statement of principles, organization objectives, and/or strategic plan(s). Even something as basic as traditional SWOT planning (strengths, weaknesses, opportunities, and threats) can provide an analytic framework for selecting and prioritizing projects.

Step 2: Investment Opportunity Identification

Where do projects come from? Two categories: strategic or top-down projects that are imposed on the organization by upper management and bottom-up projects, ideas that are generated by the people "in the trenches." There may be a third category, projects pressed on an organization by its customers. In any case, the step of opportunity identification is a critical one. Bridges offers a set of procedural tips for the identification process:

- ***Develop process to identify opportunities that is easy to follow.***
  Many people are averse to complex processes and bureaucratic paperwork. Establish an avenue for communicating ideas that is easy to use. Identify a team to review the opportunities and assess the fit within the strategic direction and business goals.
- ***Establish a template for project justification.*** The ideas must be supported by some substance; otherwise it will be difficult to screen the proposed initiatives. The template may include things such as the link to business goals and a top-level description of the project's costs, benefits and risks.

- ***Establish minimal acceptance criteria.*** Individuals submitting ideas and the review team should both understand the minimal acceptance criteria a project must meet before being considered for further analysis. Such requirements may include the link to strategic direction, business threshold minimums (e.g., return-investment or cost/benefit ratio minimums), compliance with organizational constraints (e.g., existing technology architecture), and completion of the project justification paperwork.
- ***Reward ideas and suggestion.*** People love recognition. Take the time and interest to acknowledge formally the ideas that meet the "fit" test and always give credit where credit is due [Knutson, 2001].

Steps 3: Individual Project Evaluation

In this step three distinct phases are included. These are pre-filtering, investment evaluation and screening.

Pre-filtering: This phase seems similar to the second step. But in this step more techniques and additional evaluation criteria might be considered and used in order to reduce the number of projects that will pass for evaluation and feasibility study. The pre filtering task is done by experts or investment appraisal team. Hence, there is a capability to consider more criteria and factors to filter and reduce investment opportunities that passes to the next step. The feasibility study of individual investment is very tiresome and time taking. Hence pre-filtering and reducing the investment opportunities that passes the second step and make ready for feasibility study will reduce the effort in the subsequent step. The purpose of pre-filtering phase is to insure that proposals are fitted strategically to the portfolio. It also checks that the proposals value has been carefully considered. That way no further efforts are given to any investment that would not be competitive or strategically right. In this phase it is imperative to clearly state the rules by which the filtering is conducted to bring forth innovations. Filtering mechanisms and rules have to be consistent and unambiguous.

In this phase certain information are required to pre-filter investment ideas. Among the information, relevance, risk, reasonableness, return, etc may be considered. Relevance addresses the degree to which the proposal supports the company's strategic objectives and mission. Risk addresses the level of different uncertainties associated with the investment. Reasonableness addresses the ability or resource held by the company to successfully complete the investment. Return addresses the value pursued by the proposal if the investment succeeds.

In the literature, the pre-filtering phase is not frequently conducted with any specific method. Usually the proposals are judged by the management using intuition to create consensus and see the fit to the strategy. However, this is contrary to the process requirements because of lack of consistency and transparency of decisions. Secondly, the management reviews are time consuming.

One method that has been seen suited for pre-filtering is checklist. It is a simple ad-hoc method that can be used to check that proposals satisfy the strategic requirements. The method simply asks Yes/No questions. Some questions are must-do where answering even one "No" will lead to rejection. The other questions are should-do in which having more than a certain amount of "No" answers will lead to rejection.

The second method has also represented numerical checklists, where each criterion is given a score (e.g. 1 to 3 or 1 to 5). The total score for each project is simply the sum of the scores. This is a more flexible method, but scoring can be quite difficult to do in such an early phase.

Checklists are simple, transparent and consistent. They work as guidelines for proposal makers and therefore direct innovations to strategically important investments. This can be seen as a way to communicate the strategy to lower hierarchical levels and it might increase the motivation to create new proposals. However, checklists can be abused by systematically overestimating the proposal possibilities. Thus, it would be advisable to demand a short explanation for each answer to check the underlying assumptions.

The biggest limitation of checklists is the assumption that every aspect can be formulated into a Yes/No question. Furthermore, the questions have to be thought very carefully so that everyone understands them unambiguously. Finally, since no weighting is used, all the questions have to bear roughly the same importance.

Investment Evaluation: Evaluating quite literally means determining the value or worth of things. It involves exploring, understanding and describing the consequences of the investment. The evaluation phase is conducted to investments that have passed the pre-filtering stage and are thus strategically viable. Usually this phase is the most time-consuming and can take manmonths to complete. Note that current investments, which have reached certain milestones, may also be re-evaluated at this time. To conduct investment evaluation different types of data is required. The purpose of evaluation phase is to make sure that there are no technical, commercial, financial, socio-economic, investment criteria, etc, pitfalls by collecting and analyzing the realistic information on those areas. Different alternatives and major risks are also assessed.

After the necessary information has been gathered, the individual investments will be evaluated in a suitable and relevant method. However not all information gathered is used in the investment evaluation. Factors that affect the portfolio or other investments such as investment interdependence, resource sharing, budget sufficiency and factors affecting portfolio balance are not used in this phase. This information are kept and used in the portfolio selection or decision steps. There is no single and dominant investment evaluation method. Some methods handle the cash flows as superior way, but cannot include many important qualitative factors in the model. Some methods consider all the possible subjective factors, but are inferior when evaluating accounting data. Therefore, using complimentary technique would seem to produce the most thorough results.

Three different methodologies are commonly proposed in the literature: 1) basic economic benefit methods, 2) scoring methods, and 3) decision analysis. The major benefits and disadvantages of them are represented in Table 3.1. There also exist dozens of other methodologies (e.g. different comparative and ad-hoc methods), but they will not be discussed here.

By looking at the benefits and disadvantages associated with each methodology, some notes are made. First, basic economic benefit methods and decision analysis methods are quite similar and can be seen as substitutes to each other. Basic benefit models provide simple and easier approach for investments with plenty of financial data and few uncertainties and decision points (usually short-term investments). Decision analysis on the other hand is more suitable for long-term investments with factors that are more uncertain and have more alternative decision points. Second, scoring methods seem to be complementary to other models since only they can include intangible factors in the evaluation. Figure 3.2 represents the positioning of the mentioned methodologies depending on the suitability to handle tangible and intangible factors and uncertainties.

Table 3.1 Benefits and disadvantages of various investment evaluation methods

Basic economic benefit methods	
Benefits	**Disadvantages**
Comparisons are in an easily understood language	Difficult to include non-tangible benefits
Good investments can be clearly identified	Detailed data is needed for cash flow estimates
Widely used in private areas of business	Do not consider multiple decisions
Allow some sensitivity analysis	Do not consider different timing options
	Only criteria is profitability
Scoring methods	
Benefits	**Disadvantages**
Easily adaptable to local circumstances	Risk is not explicitly considered
Can include financial and non-financial information	Weight may be difficult and cumbersome to evaluate
Easy to understand and use	Multiplicative and additive algorithms cannot model
Not impose an undue burden for management	Requires independence between used factors
Forces management to think about decision alternatives	Do not answer whether any investment really is good
Allow multiple (and weighted) criteria to be used	Do not consider multiple decisions
	Do not consider different timing options
Decision analysis methods	
Benefits	**Disadvantages**
Multiple stages and decisions can be considered	Detail data is needed
Good investments can be clearly identified	Difficult to include non-tangible benefits
Can include options for timing (to certain degree)	Probabilities can be difficult to determine
Include various different uncertainties	Only criteria is profitability
Forces management to think about decision alternatives	

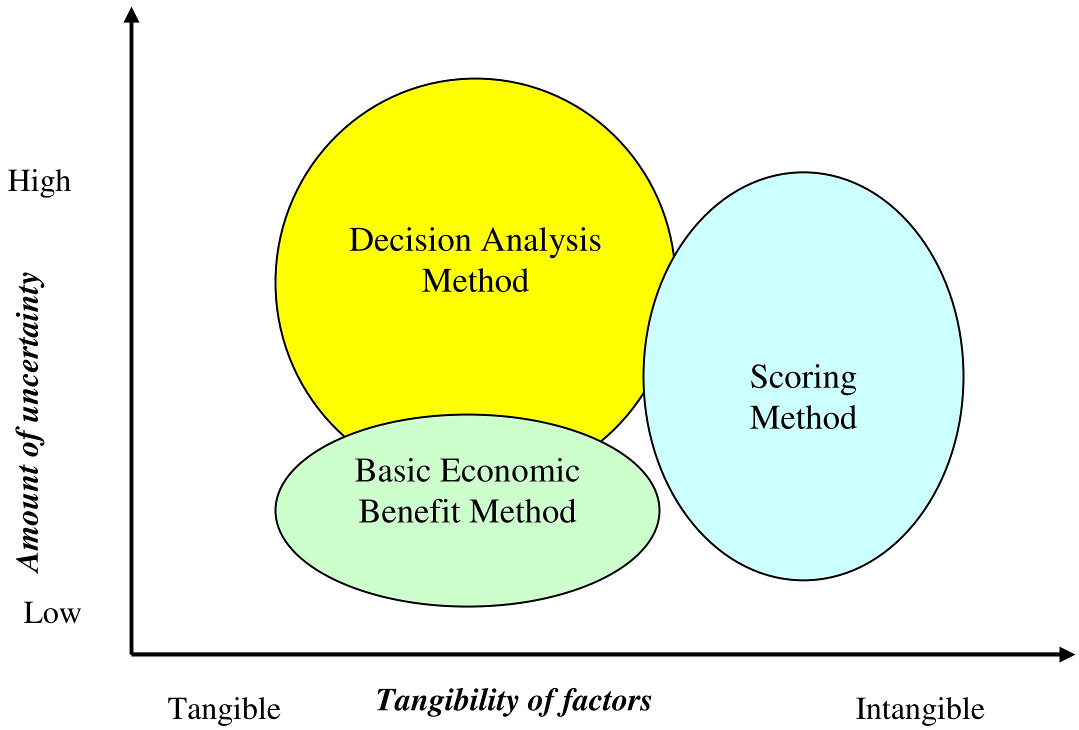

Figure 3. 2 The positioning of different methods depending on the amount of uncertainties and the intangibility of factors

Screening: Screening is the last stage before the portfolio selection. The criteria used in the previous stages, such as net present value can also be used in this phase. Screening is quite similar to pre-filtering. The only exception is that there is more information available with screening after feasibility studies. There are two reasons for applying screening:

1) *Too many projects in portfolio selection increase the complexity of the decision process and the amount of time required geometrically.*
2) *Interacting with investment evaluation in order to prevent making unnecessary assessments.*

The second reason originates from the observation that there should be a pre-defined order for information gathering. In order to make the process most efficient, factors should be divided into priority groups according to their importance in the evaluation. First, the factors essential for the investment to succeed, so-called "showstoppers", should be evaluated. Second, the important factors that are easily (with relatively little effort) gathered should be evaluated. Third, the important factors that are hard to gather should be evaluated. Finally, all the other relevant factors are evaluated.

Investment evaluation process should be iterative with screening methods to allow the rejection of investments in the middle of the assessments thus to minimize the unnecessary work. Depending on the investment type, various factors are seen as important. In Figure 3.3 factors are divided into priority groups for different investment types. Profit is a common method used for screening of projects. It is very simple and easy to use, but efficient. It is a crude form of scoring method, where limits are set for the various attribute level (thresholds) of the investment. If the investment fails to meet these limits, it will be eliminated.

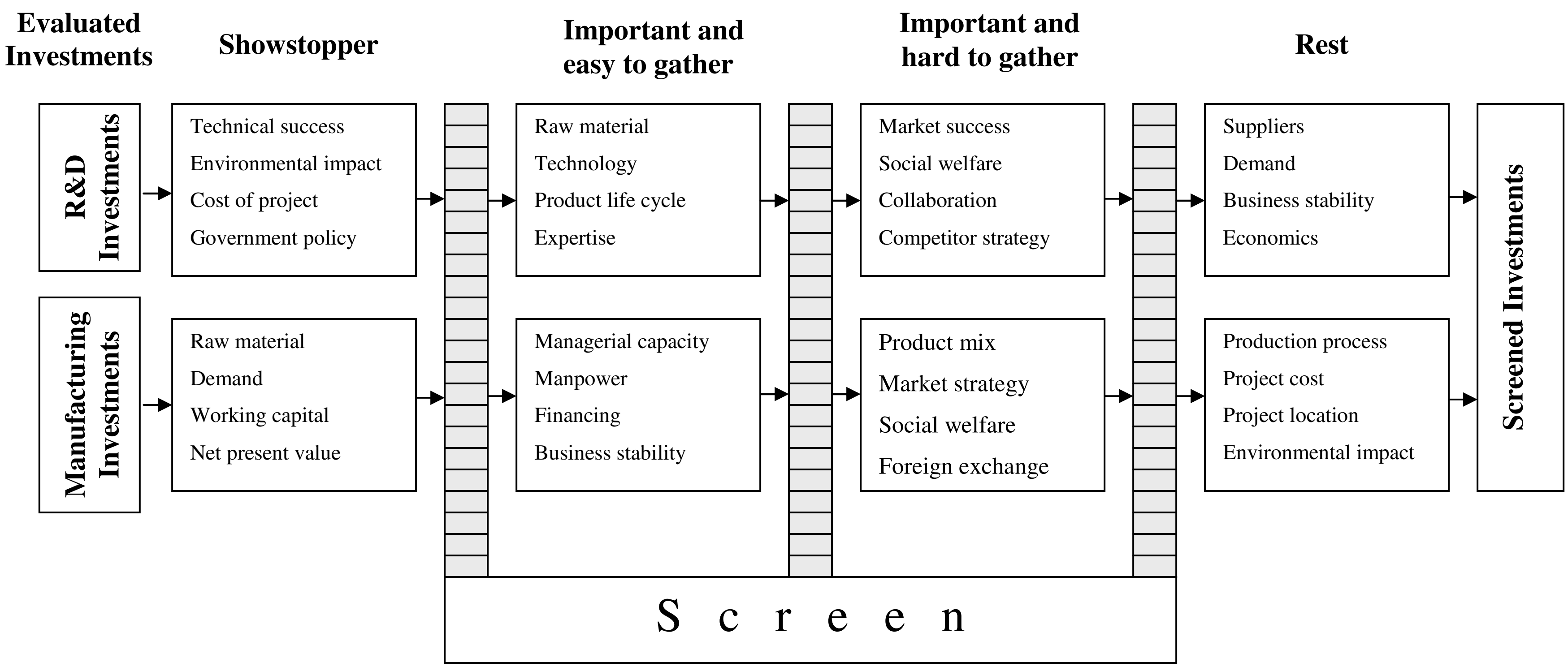

Figure 3. 3 Screening processes of investments

An example of profile for R&D investment is represented in figure 3.4.

The probability of technical success (rejection if under 40 percent) and the cost of projects (rejection if greater than $4 million) are used as profiling factors. In figure 3.4, investment 4, 5, 7 and 8 are rejected.

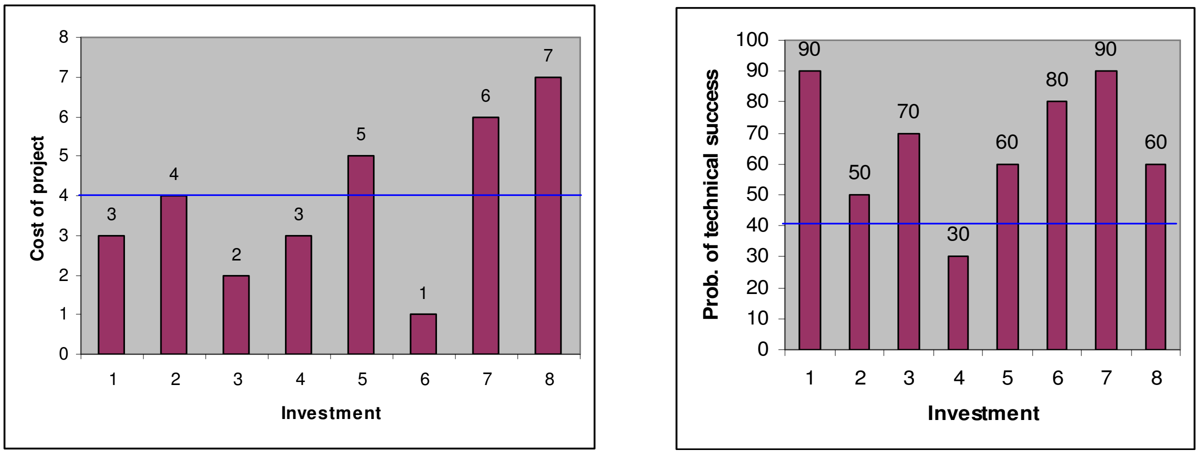

Figure 3. 4 Profiles of R&D investments

In this process determination of the limitation is not simple. Profiles are visually effective and can thus be used to represent the evaluation results to decision makers. By raising and lowering thresholds appropriately, a decent amount of investment can be selected to take part in the portfolio selection phase.

Step 4: Portfolio Selection

From the general six steps of PPM process portfolio selection is the main focus of this thesis. In this stage a portfolio of investments (new and already funded) that most optimally satisfies the given objectives of the company is identified using the model developed to optimize the company's objectives. Project prioritization and selection are the heart and soul of portfolio management. In the project prioritization and selection process an appropriate model is required that generates an optimal investment portfolio. The modeling of the investment portfolio selection is not easy task. There are many essential issues that have to be considered in the development of the model. Some of the criteria pooled from literature are indicated below. When a model is developed the following criteria have to be considered.

- **Easy to use:** A model that is not overlay complex will be more widely used and take less time to generate results, with obvious benefits.
- **Realistic:** It must take into account the realities of facilities, capital, resource, and risk.
- **Capable:** The model must be capable of dealing with multiple time periods and with situations both internal and external to the project. It should be an optimizing model, one that makes comparisons based on criteria important to management, considers risks, and then selects the best overall mix of projects.
- **Transparent:** Different decisions and assumptions behind the model should be traceable. This should prevent opinion leaders to obstinately get their will through without strong argument, Furthermore; this may increase the motivation to develop new innovations because the decision process would be more open. Finally, the effect of changes in assumptions behind the investment could be easily seen.
- **Extensive:** Models in the process should be able to present the real life as extensively as possible. For example, models should include resource constraints, investment interdependences and different uncertainties. This requirement is partly overlapping with the simplicity requirements because including more variables in to the model will evidently make them more complex.
- **Flexible**: The model must be able to take into account the rage of conditions that company might experience. It should be easily up-dated or modified with changing times.
- **Cost-effective:** The expense of data gathering and analysis must be kept low, relative to the cost of a project.
- **Consistent:** The model should be similar in two identical cases. This includes using the same methods (that should give same output) with same information even if different persons handle them. As ideal as that sounds, objectivity should be aimed whenever possible.
- **Iterative:** The model should allow for reviews, discussions and re-reviews in order to start with a simpler system and gradually add more complex items. Opinions from key individuals and records from a historical database provide information on how the

process should be developed. Therefore, a flexible, modular structure for the process is advisable.

- **Maximize the utility:** The main goal for the process is to maintain an investment portfolio that maximizes the utility for the company. Utility is the aggregate of strategic objectives. The objective function that maximizes the utility of the company will be discussed in the next sections.
- **Check for on-going investments:** A set of triggers for on-going investments in places where the utility might change substantially should be available. For example, investments could be checked when market conditions change, after an important milestone and after a resignation of a key employee.
- **Hierarchical objectives:** The model and its decision-aid models should take into account a multidivisional organization structure and hierarchical objectives. Usually there are strategic objectives from the corporation level (minimum return on investment, balance between business lines, etc.) and more specific divisional objectives (increase market share, increase R&D efforts, etc.) created by division managers. Further, the process should be able to cope with multiple decision makers. The hierarchical objectives /criteria/ that the company supposed to maximize or minimize is discussed in the next sections.
- **Minimal use of upper management's time:** The upper management usually has tight schedules, so the process should be so automated that their effort is minimized. Nevertheless, this does not mean that decision-making responsibilities would be transferred.
- **Commit the key personnel:** The process will not work and develop on its own. Therefore, responsibilities should be well defined and especially management has to be extensively involved into process.
- **Interaction with strategy:** The process should not just take the strategy for granted but also point out any deficiencies in it. For example, there can be some opportunities in related businesses appearing as investment proposals that have not been taken into consideration when planning the strategy. Therefore the process should be able to propose adjustments to the current corporate strategy.

- **Easily automated:** It should be easy to input, store, and work with the data in a standard computer program. The automation of the portfolio selection model will be discussed in the next sections.

Developing Procedures

In the model development process the following additional tips have to be considered.

- **Establish criteria:** Establish common decision criteria and measure each project against the criteria, since most decisions are based on multiple factors, weight each criterion to establish the relative importance of each item. This will be important in the prioritization step. The criteria that are supposed to be included are discussed in the next section.
- **Make sure accurate data is available:** Information from the accounting system (expenditures, revenues, and benefits) will be necessary to forecast project cost and benefits. The organization should have reliable, up-to-date market, technical, commercial, socio-economic, financial, etc, information. Since project portfolios include both new projects and ongoing projects, the company should have a system to track the status of on going project activities.
- **Establish a process to analyze the project information:** The purpose of this is to ensure data validity and consistent application of the decision criteria. It is important to go through this process before selecting the portfolio to eliminate any controversy over the data and key assumptions.
- **Uniformly apply the methodology across the company:** The criteria and weights should be completely documented. Different managers may have different definitions of an "excellent" rating. In order to ensure fairness. It is imperative that the company clearly defines all performance criteria so managers consistently interpret and apply them.
- **Optimize the portfolio, not just the individual projects:** Industry approaches for developing portfolios rang from simple ranking based on individual project financial returns to more complex methodologies that take into account the interrelationships

between projects. When developing and selection the portfolio, the organization needs to make relative comparisons between the projects.

- **Establish portfolio decision meetings:** Separate decision meetings and teams should be established to make portfolio decisions using the validated project information. Typically, senior leadership makes portfolio decisions.

Carrying Out the procedures

Five behaviors are suggested that support a good selection and prioritization process.

1. **Be explicit about what's important:** Selection criteria must be clearly defined. It's important not to get distracted by "the wealth of interesting possibilities" that confronts organizations. The selection criteria should capture organizational needs, and project selection occurs in accordance with those needs.
2. **Stick to explicit procedures for selection of projects:** Decisions become less arbitrary and more rational when there is rigid adherence to a defined approach.
3. **Challenge all assertions:** Statements about possible benefits or costs of a project must be subjected to detailed scrutiny. Neither champions nor critics of a project are objective, so the veracity of their statements should be validated by as much data as is available.
4. **Include a broad array of stakeholders on the project selection team:** The typical team should include members who reflect the varying perspectives of all the functional units of an organization. To this we would add those stakeholders associated with but perhaps not internal to an organization, such as, customers, key vendors or alliance partners, and so on.
5. **Involve key project personnel in the selection process:** Research indicates that few project managers have input into selection decisions. Without the input and buy-in of project personnel, it will be difficult to maintain continuity between the selection and execution phases.

Step 5: Portfolio Adjustment

Portfolio adjustment is the interacting stage in the nominal-interacting process. In this phase, the decision makers collaboratively check the results from the project selection models and decide whether the portfolio matches the set objectives. If they do not match, the decisions are made on how the model should be revised.

There are two important factors that influence how the decision process should be managed. 1) The amount of confidence the decision body has regarding the estimates of consequences of the options it is considering, and 2) the amount consensus on the decision objectives. The less confidence there is on the estimates, the more the experience and judgment is relied on. The less agreement there is over decision objectives, the more the decisions become negotiable. Literatures represented what the choice process will be depending on these factors. That is shown in Table 3.2 shows how decision is made in different circumstances.

Table 3. 2 Confidence and consensus in the choice process

		Consensus about decision criteria	
		Agreement	**Disagreement**
Confidence in the estimate of the consequences of decision model	**High**	Decisions by computation	Decision by negotiation
	Low	Decisions by judgment	Decisions by creative "inspiration"

If there is high confidence in estimates and high consensus about decision criteria, the project selection model can be given plenty of responsibility. Therefore, the role of the adjustment is to make sure that the model follows the criteria correctly. This is the most ideal situation, and it is called decision by computation.

If the members of the decision body disagree on the priorities of the criteria, the decision is made by negotiation. The adjustment is used to balance the portfolio so that all the parties are satisfied. On the other hand, if the consensus is high, but confidence on estimates is low, the decision calls for judgment. The selection model is only used as a guide, and the portfolio is formed using the judgment and experiment of the decision makers. The selection model in this process is used as a ground for the adjustment and decision making process of the portfolio. In a situation where there is no consensus about criteria and low confidence in the estimates, the decision is made by creative "inspiration". This means that the situation calls for strong leadership and reconsideration of the strategy, available investment options and used processes. The adjustment can be used as a tool to define the problem areas in the process.

Step 6: Portfolio Monitoring (Stage-Gate Process)

Once the investment is selected and the work is started, the project effort has to be monitored during its life cycle. Because the budgets and schedules are based on forecasts and estimates, numerous events and external forces may emerge to influence the outcome of the project. The projects may have to be re-planned or modified as a result. Even termination of an ongoing project may be necessary. A correct decision to terminate a project at the right time may save time, money and other resources. A wrong decision, on the other hand, may give a competitive edge to competitors. The objective of a stage-gate (or phase-review) process is to monitor ongoing projects. The project life cycle is divided into stages, and after each stage, there is a gate, where the project is reviewed before it is allowed to move to the next stage. The gates are points where the decision makers can interfere in the project.

Monitoring

The determination of gate points is an essential part of the stage-gate process. They should be placed at the major milestones in the project's life cycle; for example after creating a prototype, training the key personnel or testing the product in real environment. The pre-determinative nature of these milestones makes the monitoring passive. With passive monitoring, the re-evaluation is conducted because it is assumed that some additional information is available when certain milestones are reached. However, the changes in the environment are not monitored explicitly and they are only considered at the next gate.

Active monitoring is based on selecting certain factors that are monitored continuously. Values for the factors are given certain boundaries to lie in between. Crossing a boundary triggers re-evaluation of the project. Active monitoring is independent of the project's life cycle, and it provides a more dynamic approach to respond to the changes in the environment than passive monitoring.

The factors can be divided into critical and key variables. Significant changes in one of the critical factors should trigger re-evaluation event immediately. The key factors should not individually trigger re-evaluation and a significant deterioration in one of them does not crucially change the project outcome. However, if a substantial majority of the key factors change, the project should be re-evaluated. Factors can also be grouped according to their source. Endogenous factors can be either project related or organization related. Usually the endogenous factors are monitored by using accounting data and interviewing stakeholders. Some factors are exogenous and are independent of the company actions. Intelligence systems and market researches are the most common ways to monitor them. Table 3.3 pooled from different literatures, indicates factors that should be actively monitored. They are grouped according to their importance and source.

Table 3. 3 Monitoring factors divided by their importance and source

	Project Related	Organization Related	Exogenous
Critical Factors	- Probability of technical success - Change of any constraints - Project outcome deviation from forecast	- Change in company's strategy - Stakeholders priority change - Organizational level financial constraint	- Change in industry - Market change - Change in legislation
Key factors	- Probability of commercial success - Support of top management - Schedule	- New opportunity identification - Company profitability - Internal competition	- Change in economy - Competition and substitute - Change in demand

The factors mentioned as critical or key in the above table do not strictly represent the specified position of their columns and/or rows. Some of the factors mentioned as critical factor might be a key factor and vise versa depending on the organization internal or external situation. The classification of the factors as critical or key is determined by the company in order to monitor the conditions and take an action when required.

The major drawback with implementing active monitoring is that there may be some factors that are not monitored but that affect the project outcome. Additionally, the determination of boundaries can be difficult. The advantage of active monitoring is when an expected change on critical or on some of the key factors occur in the execution period, the company may conduct a stage-gate process and take an action or make an adjustment on projects or resources.

Actions

Depending on the nature of the changes and their impact on the project, different actions may be taken on projects. Some of them have little or no impact on the investment portfolio; others may require dramatic changes in the portfolio. Souder, 1984 have grouped some possible readjustment actions. They are represented in Figure 3.5 depending on the extent of the impact. Re-planning and rescheduling efforts are applicable to minor changes and only concern the investment in question. If there is considerable deterioration in the factors, re-prioritizing the portfolio and reallocating resources may be a necessity. If the changes are significant enough, the project may have to be suspended or even terminated.

Cooper et al. (1997b) have encountered two different philosophies in companies. In some firms the resource commitments are not firm, and resources can be easily stripped from existing project to a new, better project. This is especially true for firms with short-term projects and dynamic markets. Companies with longer-term perspective seem to embrace a more stable approach where resource commitments are quite firm. Because of motivational issues and high start-up and shutdown costs, the threshold to suspend or terminate a project is quite high.

The problem with suspending projects is that it is too convenient. Instead of terminating a project, it is easier to just put in on hold and wish that someday there would be enough resources to continue it. When a project is not clearly terminated, it is possible that project personnel will continue working on it concurrently with their new assignments. This leads to decreased productivity.

Cooper et al. have suggested that projects should stay suspended no longer than three months. The readjustment actions during the stage gate process may vary from re-planning of projects to termination of projects. The figure below indicates the actions that could be taken during stage gate process [Martikainen, 2002].

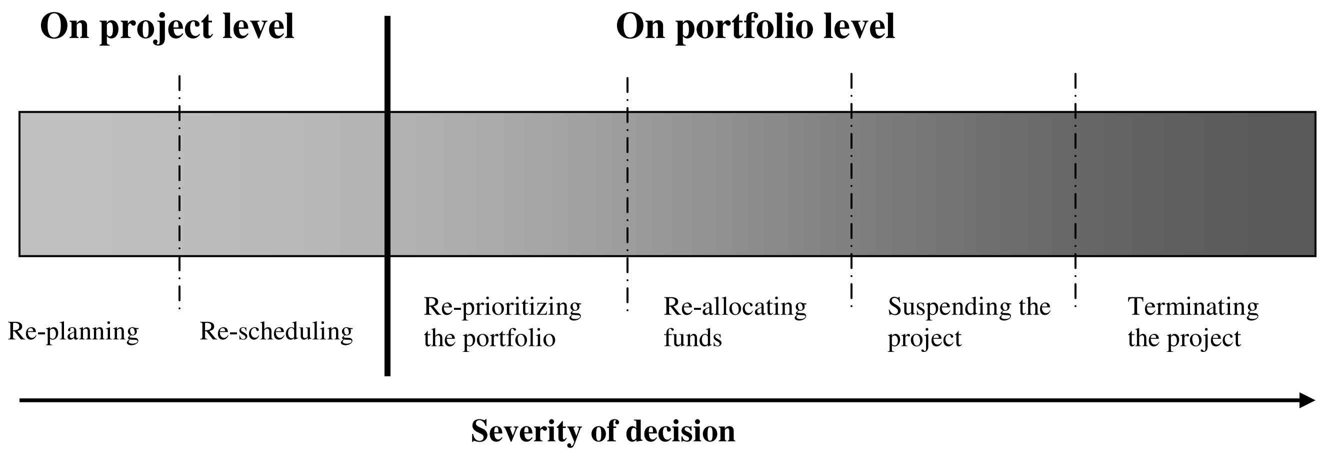

Figure 3. 5 Actions that could be taken in the portfolio monitoring stage

Implementation Issues

The re-evaluations process is almost similar to the investment proposal evaluations. The only difference is that the forecasts and estimates have already been made and furthermore, there usually exist some real information on how they have been fulfilled. The estimates should be updated to the present situation. If there have been some serious defects in certain estimates, the underlying reasons should be pinned down. It may result as changing the source of the information, underlying assumptions or estimating techniques. When the estimates have been updated, the aggregate utility of the investment is calculated. It should be noted, that because the project has been initiated, the shutdown costs should be included in the evaluation. In addition, the sunk costs should be removed from the calculations, since they cannot be salvaged anymore.

The boundaries for the critical and key factors should be derived from the latest portfolio analysis. The boundaries are monitored continuously, and if the value of a critical factor or the values of several key factors fall below their boundaries, the re-evaluation of the investment is performed. Depending on the re-evaluation results, the management may interfere with the project or even revise the whole portfolio.

Chief executives should have the responsibility for monitoring the projects, because it is unlikely that the project staff will eagerly report any negative issues. Levine (1999) has represented an idea of a portfolio team. It is led by a Portfolio Manager (PM), who takes care of the portfolio review process, and no project should be added to or removed from the portfolio without his review. A Chief Risk Officer (CRO) is responsible for checking the estimates and the risks of each investment and monitoring them. Resource availability and utilization and the human resource factors of the investments are handled by a Chief Human Resource Officer (CHRO). Additionally, Chief Financial Officer (CFO) and Chief Project Officer (CPO) are used as support for monitoring and evaluating the financial and scheduling aspects of the investments [Martikainen, 2002].

3.4 Evaluation Criteria Identification and Project Scoring

3.4.1 Evaluation Criteria Identification

In the evaluation of projects different criteria are identified and the projects are scored and weighed on the basis of the same. Identification of the proper criteria for project evaluation is one of the important and primary activities in the selection process of projects. The success or failure of projects is strongly related with the evaluation criteria and the accuracy of our evaluation by the identified criteria. The linkage between the strategy and objectives of the company with the project portfolio is established through the evaluation criteria. If the evaluation criteria is identified and prioritized in a consistent manner with the strategy and objectives of the company the chance of success of the company is very high. In this research different evaluation criteria are identified. All companies may not use all the criteria identified in this thesis for all projects. The evaluation criteria considered by the companies may depend on the mission, objectives and nature of the company, and nature of the projects the company undertake. In most cases private companies are established for profit, whereas, public enterprises are established mainly to improve social welfare. Hence in most cases private companies consider quantitative factors that are related to cost and return in financial terms, but public enterprises consider qualitative factors that are related to social welfare and environmental issues. The main criteria are sub-divided in to many sub-criteria. The criteria and sub-criteria are discussed below [adapted from Chandra 2006; Nagarajan, 2004; Berehanu 2006; Ministry of Finance and Economic Development, 2004; Heiskanen, 2005].

1. Technical Criteria

The analysis of technical and engineering aspects is one issue that should be examined when an investment idea is being considered. Other types of analyses are closely intertwined with technical analysis. The broader purpose of technical analysis is (a) to insure that the project is technically feasible in the sense that all the inputs required to set up the project are available, and (b) to facilitate the most optimal formation of the project in terms of technology, size, location, and so on. The main factors that have to be considered in the technical analysis are the following.

1.1 Production Process/Technology (PPT): Industries usually use more than one process/technology to produce a product. An appropriate process/technology which is economical, suitable to the local, social and environmental phenomena has to be selected. The selection of production process/technology has to be evaluated by the following points.

i) Its feasibility to the quality and quantity of product/service.
ii) Utilization of available labor.
iii) Utilization of available raw material.
iv) Its effect on ecological balance.
v) Its acceptance to the social and cultural condition, etc.

1.2 Scale of Operation (SO): Scale of operation is signified by the size of the plant. The economic size of the plant varies from project to project. The economic size of the given project can be determined by the analysis of capital and operating costs as a function of plant size. The final decision of the scale of operation is influenced by the following factors.

i) Availability of inputs,
ii) Investment cost.
iii) Market availability, etc.

1.3 **Raw Material (RM):** The evaluator of the project should assess the availability and alternatives of raw materials for the project that is going to be implemented. The location, amount and quality of raw material have also been carefully investigated. The delivery of raw material at the right time to the right place has also a significant impact on the production process.

1.4 **Technical Know-how (TK)**: The knowledge and experience of people have to be assessed on the technology or project that is going to be selected. The supplier or the consultant of the project has to be ascertained whether he has an experience of carrying out similar projects. The supplier or the consultant should also give training for the local people during the commissioning time.

1.5 **Collaboration agreement (CA):** The project supplier or agent has to be entered in to an agreement that ascertains the proper functioning of the project. The agreement should include conditions like commissioning, knowledge transfer, warranty for malfunctioning, etc.

1.6 **Product Mix (PM):** Customers differ in their needs and preferences. Thus variation in size and quality of products is necessary to satisfy the varying needs and preferences of customers. In order to enable the project to produce goods of varying size, nature and quality as per the requirements of customers, the production facilities should be planed with an element of flexibility.

1.7 **Machinery and Equipment (ME):** The requirement of machinery and equipment is dependant on production technology, plant capacity and type of projects. The machinery and equipment should be evaluated for:

i) Its capability to the production technology, plant capacity, and type of projects.

ii) Availability of skilled labour, etc.

1.8 **Location of Project (LP):** Location of the project is evaluated by the regional and site factors. Regional factors are evaluated for the accessibility of raw materials, proximity to market, availability of labour, availability of supplying industries, availability of infrastructures like power, water, transport facilities, climate factors, etc. Site factors are evaluated for cost of land, suitability of land, availability of ground water, facilities for effluent disposals, etc.

1.9 **Needs for Considering Alternatives (NCA):** As part of technical analysis, using the project for alternative uses could be considered as a merit for the project. The alternative use of the project may the capacity of the same to produce different varieties of products, in using different production processes, different product quality, scale of production, etc.

2. Commercial Criteria

The commercial appraisal is concerned with the marketing issues of product/service. The very idea of promoting a project is to produce product/service and to market the same to the customer and earning a profit thereby. Hence market appraisal occupies a prime place in project appraisal. In fact in the modern management concept, marketing management service gets more attention than in earlier years. This is because of the reason that the very survival and success of any project dependence on the questions as to whether the product/service offered by the project is successful commercially. Commercial appraisal (market appraisal) of a project is done by studying the commercial successfulness of the product/service offered by project from the following angles.

2.1 **Demand (DD):** Economists defined demand for commodity as the desire backed by the necessary purchasing power. One of the most important determinants of a firm's profitability is the demand for its products. In spite of an efficient and technologically advanced production process, efficient financial management, cordial inter-personal relationship between the employees and the management, the firm will find it difficult to earn profit if its products are not demanded by the customers.

The demand of the product/service should be evaluated for:

i) The availability of customer for the product/service,

ii) The total demand of the product/service in a particular period of time and in the life time of the product/service.

2.2 **Supply Position of the Product [SPP]:** It is necessary to know the existing source of supply and whether they are foreign or domestic. The supply of the product/service should be evaluated for:

i) Availability of the product,

ii) Local production level,

iii) Import,

iv) The export level of the product or service,

v) Availability of substitute and near-suitability, etc.

2.3 Market Strategy (MS): It is the strategy of a market penetration and/or market share expansion. The evaluator should assess the following marketing strategies.

i) The distribution channels

ii) Promotional strategy

iii) Pricing and positioning of the product/service, etc.

2.4 Government Policy [GP]: The role of the government in influencing the demand and market for the product/service may be significant. Government plans, policies and legislations, which have a bearing on the market and demand of the product under consideration, should be examined.

This could be reflected in,

i) production target in the national plan,

ii) import and export trade controls,

iii) import duties,

iv) export incentives,

v) excise duties,

vi) state tax, etc.

2.5 Stability of the Business Sector [SBS]: The business environment of some business sectors is turbulent. In unstable and turbulent business, risk is high. Therefore environment of the project that is under consideration has to be assessed carefully.

3. Socio-Economic Appraisal

The main objective of an individual, a firm or a company in investing on a project is to earn the maximum possible returns from the investment. But still there are also special projects that are undertaken by governments and social sectors which have social implications with no attractive returns as far as commercial profitability is concerned. Such projects are like road, bridge, irrigation, power, etc., for which socio-economic considerations play a significant part rather than mere commercial profitability. Such projects are analyzed for their net socio-economic benefits.

The sub-criteria of socio-economic analysis include the following.

3.1 **Employment Effect (EE):** While assessing the impact of a project on employment, unskilled and skilled labors have to be taken in to account. The employment opportunity is not limited to the project that the company has undertaken. The employment opportunity can also be created in the forward and backward linkages of the project. The evaluation of the employment opportunity has to be done in a wider perspective to cover all the above opportunities.

3.2 **Net Foreign Exchange Effect (NFEE):** A project under consideration might have a plan to export or produce goods/services for import substitution. In such cases analysis of the effects of the project on the balance of payment and foreign exchange effect is necessary. The assessment of the project on the county's foreign exchange is done in two ways. First balance of payment effects of the project and second, import substitution effect of the project.

3.3 GDP Contribution (GDP):

When the socio-economic criterion is assessed, the GDP contribution of the project has to be considered and evaluated.

3.4 **Improvement of the Social Welfare (ISW):** The evaluation of sociological aspect of the project should consider the following main factors.

i) The socio-cultural and demographics of the local beneficiaries.

ii) The social organization of productive activities of the population in the project area.

iii) The acceptability of the project and its compatibility with the behavior and perceived needs of the intended beneficiaries.

iv) The social strategy for product implementation and operation needed to elicit and sustain beneficiaries' participation, etc.

3.5 **Environmental Impact (EI):** A project may cause environmental pollution in various ways. Projects that produce physical goods like cement, steel, paper, and chemicals by converting natural resource endowments in to salable products are likely to cause more environmental damage. Hence the environmental aspect of the project has to be properly examined. The key issues that needs to be considered in this respect are,

i) the existing environmental base line condition,

ii) potential environmental impact both on negative and positive sides,

iii) positive and negative compensation measures,

iv) monitory costs to protect the environmental damage, etc.

4. Financial Criteria

Financial appraisal of projects consists of two major areas. These are the cost of projects and means of financing. In this respect the following issues have to be evaluated.

4.1 Cost of Project (CP): The cost of project represents the total of all items of outlay associated with a project which are supported by long-term fund. It is the sum of the outlay of the following.

i) Land and site development,

ii) Building and civil work.

ii) Plant and machinery.

iii) Expertise and engineering fees.

iv) Miscellaneous fixed assets.

v) Preliminary and capital investment, etc.

4.2 Working Capital requirement and financing (WCRF): In estimating the working capital requirement and planning for financing, the following points have to be born in mind.

i) The working capital amount required for raw materials, goods-in-process, stock of finished goods, operating expense, consumable stocks, etc.

ii) The source of financing for the working capital, etc.

4.3 Means of Finance at Initial (MFI): To meat the cost of project at initial stage different sources have to be assessed. The source may be,

i) share capital, ii) term loans, iii) debenture capital, iv) different credits,

v) incentive sources and, vi) miscellaneous sources.

5. Investment Criteria

There are several criteria that have been suggested by economists, accountants and others to judge the feasibility of capital projects. The important investment criteria are divided in to two categories. These are discounting and non discounting criteria.

Under discounting cash flow criteria the following are included.

5.1 **Net Present Value (NPV):** It is the sum of the project present value of all negative and positive cash flow that are expected to occur over the life of the project.

5.2 **Internal Rate of Return (IRR):** The internal rate of return of a project is the discount rate that makes its NPV equal to zero. Put differently, it is the discount rate that equates the present value of the future cash flows with the initial investment.

5.3 **Profitability Index (PI):** It is the value calculated by dividing the present value of cash inflows in to initial value of investment.

Under non-discounting cash flow criteria the following are included.

5.4 **Pay Back Period (PBP):** It is the length of the time required to cover the initial cash outlay on the project.

5.5 **Accounting Rate of Return (ARR):** Accounting rate of return is referred to the average rate of return on investment. It is calculated as profit after tax divided by the book value of investment.

5.6 **Urgency (UR):** According to these criteria projects that are demand to be more urgent gets priority over projects that are regarded as less urgent.

6. Institutional Appraisal

During project preparation and analysis, the suitability of the organization, the competence of the management, skilled and unskilled manpower availability and performance should be examined. In this respect the following points have to be examined.

6.1 **Managerial Capability (MC):** Management is the most important aspect that causes a project to succeed or to fail. The management has to be evaluated by all functions of the management. Knowledge of the business and experience, financial management, management ability to cope with changing environment, etc., has to be evaluated.

6.2 **Manpower Appraisal (MA):** The institutional manpower capability to undertake the intended project has to be evaluated.

The summary of the evaluation criteria and the sub-criteria, and their relation with the rank value are indicated in the table 3.4.

Table 3. 4 The summary of criteria and sub-criteria and their relation with the rank value

NO.	Criteria and Sub-criteria	Symb.	Criteria and Ranking Relation
1	**Technical Criteria**	**TC**	
1.1	Production Process/Technology	PPT	The greater the feasibility of production process, the higher the rank
1.2	Scale of Operation	SO	The higher the flexibility of scale of operation, the grater the rank
1.3	Raw Material	RM	The more the availability of raw material, the higher the rank
1.4	Technical Know-how	TK	The higher the technical know-how, the greater the rank
1.5	Collaboration agreement	CA	The greater reliability of the agreement, the higher the rank
1.6	Product Mix	PM	The higher the feasibility of the product mix, the greater the rank
1.7	Machinery and Equipment	ME	The higher the availability of proper machinery and equipment, the greater the rank
1.8	Location of Project	LP	The greater location and site conformability, the higher the rank
1.9	Needs for Considering Alternatives	NCA	The higher the alternative use of the project, the grater the rank
2	**Commercial Criteria**	**CC**	
2.1	Demand	DD	The higher the demand of the product, the greater the rank
2.2	Supply Position of the Product	SPP	The less the supply, the higher the rank
2.3	Market Strategy	MS	The higher the feasibility of market strategy, the greater the rank
2.4	Government Policy	GP	The higher the alignment of the project to the government policy, the higher the rank
2.5	Stability of the Business Sector	SBS	The higher the stability, the greater the rank
3	**Socio-Economic Appraisal**	**SEA**	
3.1	Employment Effect	EE	The higher the employment opportunity, the greater the rank
3.2	Net Foreign Exchange Effect	NFEE	The higher the gain of foreign exchange, the greater the rank
3.3	GDP Contribution	GDP	The higher the contribution to the GDP, the greater the rank
3.4	Improvement of the Social Welfare	ISW	The higher the improvement to the social welfare, the greater the rank
3.5	Environmental Impact	EI	The less/higher the environmental negative/positive impact, the greater the rank
4	**Financial Criteria**	**FC**	
4.1	Cost of Project	CP	The less the cost of project, the greater the rank
4.2	Working Capital requirement and financing	WCRF	The less the working capital and the feasible the financing resource, the greater the rank
4.3	Means of finance at initial	MFI	The feasible the initial finance resource, the higher the rank
5	Investment Criteria	**IC**	
5.1	Net Present Value	NPV	The higher the NPV, the greater the rank
5.2	Internal Rate of Return	IRR	The feasibility the IRR, the greater the rank
5.3	Profitability Index	PI	The higher the PI, the greater the rank
5.4	Pay Back Period	PBP	The shorter the PBP, the greater the rank
5.5	Accounting Rate of Return	ARR	The higher the ARR, the greater the rank
5.6	Urgency	UR	The higher the UR, the greater the rank
6	**Institutional Appraisal**	**IA**	
6.1	Managerial Capability	MC	The higher the managerial capability, the greater the rank
6.2	Manpower Appraisal	MA	The higher the availability of manpower, the greater the rank

3.4.2 Prioritizing the Criteria and Scoring Projects

After the identification of projects' evaluation criteria, establishing priorities and assigning relative weights to each criterion are a crucial task. The relative importance of projects to the identified and prioritized criteria and sub-criteria should be determined and transformed in to a single weight/coefficient/ by combining the relative values through an appropriate weighing and scoring methods. A number of techniques are available to prioritize the criteria and assign relative weights of the project with respect to each criterion. The techniques can also integrate the weights of each project on every subjective and objective criterion, and give an overall relative score of the project on the whole criteria.

Out of many different methods that can be applied to score the criteria, sub-criteria and projects, the Analytical Hierarchy Process (AHP) has received wide application in the variety of users, and has voluminous body of literature. Besides to its wider application the score results are more consistent and accurate than other methods if the size of matrix is limited. But AHP is not applied without problems like other techniques. Some of the problems are: i) it is time consuming especially when the criteria or factors that are considered are more than six. ii) AHP cannot be used for more than ten criteria or factors to get reliable relative weights due to the deterioration of the consistency factor [Saaty, 1990; Chandra, Kodali & Kumr, 2000].

Therefore in this literature it is found to be appropriate to use AHP with the combination of other technique in order to handle more than ten projects in the relative weight determination process.

The other method applied in this literature is known as Simple Multi-Attribute Rating Technique (SMART). SMART is a commonly used and simpler method that can be applied in many managerial decision processes. The technique is less difficult and less time consuming than AHP. The other advantage of SMART is that we can prioritize and find scores of any number of factors or criteria without limitation. The disadvantage of SMART is that its priority and score result is not equally consistent with AHP. Therefore in this thesis both techniques are used depending on their merit in different stages of relative weight determination [Valiris & Chytas, 2005].

First qualitative and quantitative criteria and sub-criteria for selecting projects are identified and formulated in hierarchical structure. The relative contribution of each criterion to the overall objectives of the company is calculated using AHP. In the same manner the relative contribution of each sub-criterion to its higher-level criterion against other sub-criteria is calculated using AHP. Finally, the value contribution of each project to each criterion and the overall score of each project to the whole sub-criteria is determined using SMART. The relative weight determination of the criteria and sub-criteria is calculated using the pair-wise comparison technique. Using SMART the relative weight of projects to the overall sub-criteria will be determined. These relative weighs are used as a coefficient of the objective function formulation in the next step. The structure of AHP that indicates the overall objective of the company, criteria, sub-criteria, and the screened projects are shown in figure 3.6.

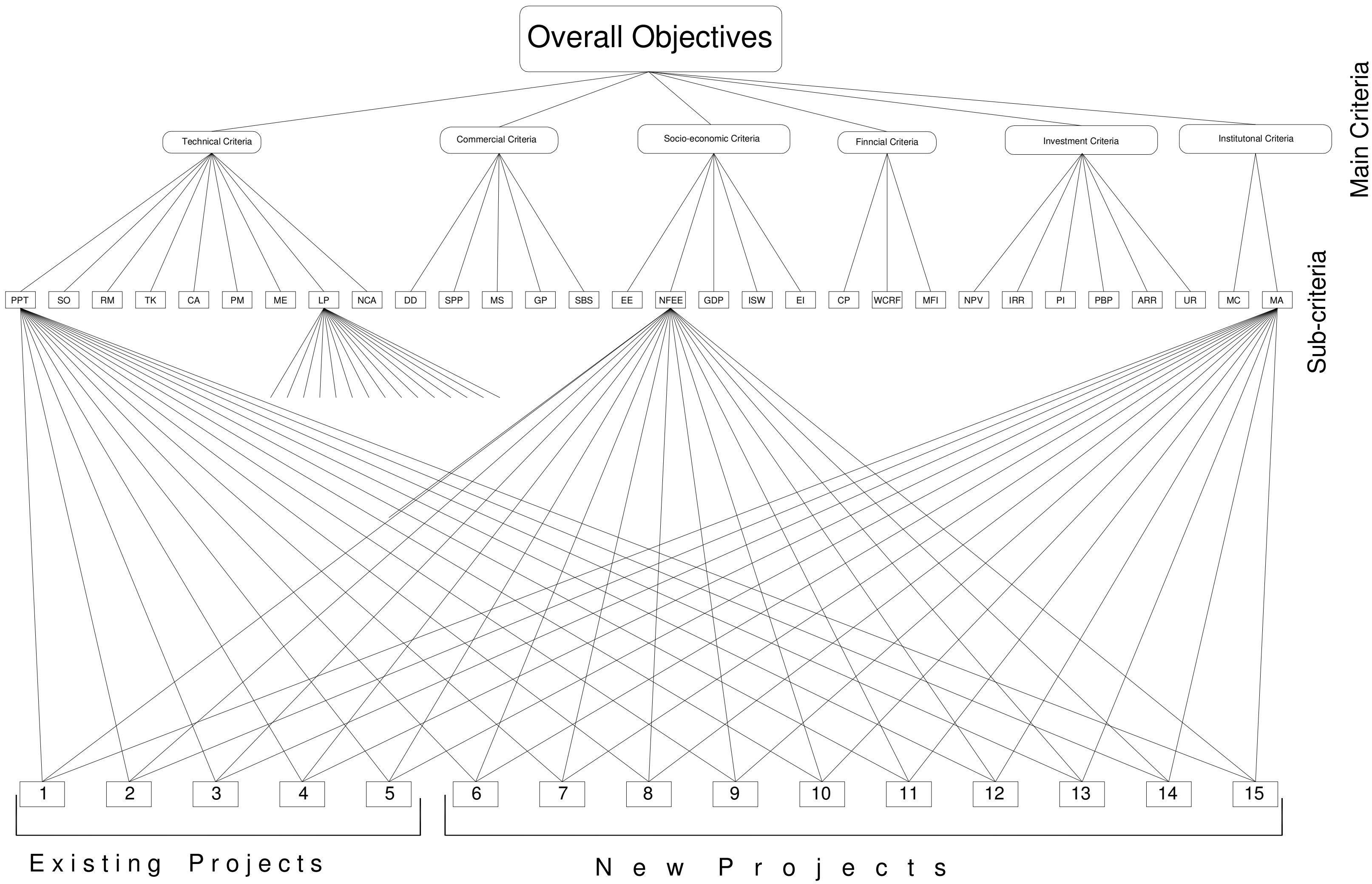

Figure 3. 6 AHP Frame that indicates overall objectives, criteria and screened projects

3.5 Risk Analysis

As it is discussed in the previous chapter, risk analysis is one of the most complex and slippery aspects of project portfolio selection and management. Many different techniques have been suggested and no single technique can be deemed as best in all situations. The variety of techniques suggested to handle risk in project selection and management fall in to two broad categories: i) Techniques that considers the stand-alone risk of projects; ii) Techniques that consider the risk of a project in the context of the firm or in the context of the market [Chandra, 2006; Linstrom, 2004].

3.5.1 Project Selection under Risk

Once information about expected return (measured as net present value or internal rate of return or some other criterion of merit) and variability of return measured in terms of range or standard deviation or other risk index has been gathered, the next question is, should the project be accepted or rejected. There are several ways of incorporating risk in the decision process.

In this model the assessment of risk and the evaluation of project's risk are supposed to be evaluated in the individual project feasibility study stage and in the portfolio adjustment stage. In an individual project feasibility study stage the company should specify its own risk threshold, which can be expressed as a maximum acceptable project risk. In its screening of new projects, the company can then determine each project's risk and can decline all those projects where the risk exceeds the risk threshold.

3.5.2 Risk Analysis in the Project Portfolio

In order to select an optimal portfolio of projects, risk could be considered in the portfolio selection stage and in portfolio adjustment stage. In the portfolio selection stage risk could be included as one-evaluation criteria of projects. Projects with a risk value below the company's risk threshold and that passes the screening will have different risk level within the threshold. Hence in regard to risk, projects in the project selection process could have different weights. Similar to other criteria risk could also be included in this stage. But in this thesis the inclusion of risk in the portfolio is ignored to reduce complications in the portfolio selection process.

The other stage that risk could be evaluated is in the portfolio adjustment stage. In this stage in order to select an optimal portfolio of projects, one must be able to calculate the risk of the portfolio as a whole, as it is important for the company to insure that the overall portfolio risk lies within the acceptable limits. If the portfolio risk is above the company acceptable limit, the management could take an adjustment measures on the portfolio.

3.5.3 Scenario Analysis in the Portfolio Adjustment Stage

There is always some uncertainty concerning most of the parameters used in project portfolio problems. This uncertainty may arise due to inexperience with similar projects, an inability to determine the availability of certain recourses in advance, and unpredictability of the project environment (including compotators activities, weather, labor strife, etc). Consequently, decision makers may want to evaluate the impact of certain parameters change on the portfolio.

In this model different scenarios can be considered on each project. But due to the quantity of projects that are evaluated in the portfolio analysis, the investment team and the management may focus on a specific project and on critical factors or criteria that are subjected to a large source of uncertainty for success. In this thesis demand is considered to be treated in different scenarios. Under high, medium and low demand scenarios of the product of an investment will be treated and different sets of project portfolios are generated. The management and the investment team will compare and contrast the generated portfolios with certain critical factors, such as, risk, objective function value, NPV, etc, and select the best portfolio out of them.

3.6 Portfolio Selection Model formulation

Selecting certain projects from many projects that are usually possible and feasible is a curtail decision in many organizations, where efforts must be made to estimate, evaluate, and choose optimal sets of projects to be implemented. Some of the criteria that have to be addressed in the process of project portfolio selection are the organization's objectives and priorities, financial benefits, intangible benefits, availability of resources, and risk level of the project portfolio, etc.

The major difficulties associated with project portfolio selection are:

1. There may be multiple and often conflicting objectives;

2. Some of the objectives are qualitative, as opposed to quantitative, in nature;
3. There is usually uncertainty associated with the project parameters such as risk and cost;
4. Some projects are highly interdependent in nature;
5. Constraints such as finance, workforce, and technology must be considered in the decision making process;
6. A portfolio should be balanced in terms certain factors, such as risk, time to marketing, etc. that are of importance to decision makers; and
7. The number of feasible portfolios is often enormous [Ghasemzadeh, Archer & Iyogum, 1999].

To overcome these difficulties an optimization model for the selection of an optimal portfolio is developed.

3.6.1 An Integer linear Programming Model for Project Portfolio Selection

Project portfolio selection is usually a multiple criteria problem, where tradeoffs must be made among potentially conflicting tangible and intangible criteria, such as risk, socio-economic requirements, investment requirements, financial feasibility and technical feasibility, etc. These criteria are often in different categories and incommensurable units. When there is uncertainty, expected values will be assumed in the derivation of approximate value functions. Risk in this thesis is considered explicitly as a constraint during individual project evaluation step and during post-optimization stages as an explicit decision variable for portfolio balancing.

Because of its discrete 'select or not select' nature, choosing a project portfolio is inherently a 'zero-one' problem. There are normally a number of resource constraints (financial, manpower, equipment, etc) in this problem, and different projects may exhibit interdependence. Most of the techniques developed for continuous solution cannot be used in this problem because assumptions made in the continuous case does not hold true in discrete case. In this thesis a 0-1 integer linear programming is used to solve the optimization problem.

3.6.2 Model Formulation

1. Decision Variables

The decision variables are defined by:

$$X_i = \begin{cases} 1, \text{ if project } i \text{ is included in the portfolio} \\ 0, \text{ otherwise, for } i = 1, 2, \ldots, n, \text{ where } n \text{ is the total number of projects being considered.} \end{cases}$$

2. Objective Functions

The objective function is given by:

$$\text{Max: } Z = \sum_{i=1}^{n} a_i X_i \text{ ----------- } (1)$$

Where, Z is the value function to be maximized, and a_i is the score of project i as formulated in the previous steps.

3. Resource Constraint

It is important that the model's solution has to be realistic and that the company has to implement the model without violating the necessary constraints that critically affects the success. Hence the need to carefully specify the constraints in terms of various factors, such as, budget, raw materials, floor space, skilled labor, etc., has to be included.

Therefore when two or more projects compete for the same resource, the model will not select projects whose collective demand for certain resources exceed the availability of the resources.

The resource constraint function is given by:

$$\sum_{i=1}^{n} a_{ij} X_i \leq C_j \text{ ---------- } (2)$$

Where, a_{ij} is the amount of resource j allocated on project X_i,

C_j is the available amount of resource j.

4. Mandatory Projects

Mandatory projects may exist in the portfolio selection. There are projects that, based on certain considerations, are to be identified and included in the portfolio. More over at a periodic revision of the portfolio, it is normal for many or all of the ongoing projects to be continued, and therefore they must be included. It is important to address the issue of mandatory and ongoing projects in the model because such projects compete with the others for scarce resources.

The mandatory project constraint both for the new and existing one are given by:

$$X_i = 1 \ for \ i \ \varepsilon \ S_m ----------(3)$$

where S_m is the set of mandatory projects.

5. Project Interrelationship

There are always a number of conditions and relationships between projects that must apply and that must therefore be considered in the composition of the project portfolio. It is important to identify all such conditions and interrelationships between projects and clearly put them as a constraint in the model.

i) Mutual exclusiveness (one but not both):

A set of projects is considered to be mutually exclusive if including one project out of the set is sufficient for the formation of the portfolio. For example, in the case of infrastructure development projects joining two different regions, two mutually exclusive projects could be the construction of highway or railroad. Once one of these projects is selected the other should be excluded from the portfolio.

Mutually exclusiveness of projects is given by:

$$\sum_{i \varepsilon S_n} X_i \leq 1 ----------(4)$$

where S_n is a set of mutually exclusive projects.

ii) Contingent projects (Project k only if project j is included):

For the two projects j and k with the decision variables X_j and X_k, the following relationship will insure that project k will be considered for inclusion if project j has been included in the portfolio.

The relation is given by:

$$X_j \geq X_k \text{ ----------- (6)}$$

One project may also be contingent on two or more projects. If project k is contingent on projects h and j, it means that project k can be chosen only if both h and j are chosen.

This contingent relation is given by:

$$X_h + X_j \geq 2X_k \text{ ----------- (7)}$$

iii) One of, or both:

For the two projects j and k with the decision variables X_j and X_k (where X_j and/or X_k =1), the following relationship will insure that either at least one of the projects or both will be included in the portfolio.

The relation is given by:

$$X_j + X_k \geq 1 \text{ ----------- (8)}$$

iv) Both or neither:

For the two projects j and k with the decision variables X_j and X_k (where X_j and X_k = 1 or, X_j and X_k = 0), the following relationship will insure both or neither of the two projects will be included in the portfolio.

The relation is given by:

$$X_j = X_k \text{ ----------- (9)}$$

v) Limit on the number of projects:

The following constraints will insure that the number of projects, selected from m possible candidates, will not exceed a specified limit n.

The relation is given by:

$$\sum_{j=1}^{m} X_j \leq n ----------(10)$$

Many other types of constraints can also be considered in this model, depending on the situation at hand. One could specify the required relationships for different types of projects, for example, the amount of resources to be used for each category of projects should not exceed a certain amount, or the number of projects in a certain category should be at least twice the number of projects in another category, etc.

CHAPTER FOUR

4. Model Testing

4.1 Introduction

The objective of this chapter is to test the developed model in the previous chapter with a real data and information collected from the Corporate Office of Dejenna Endowment. The data required for testing of the model is supposed to be very detail and explicit. But the data available and ready to give for this research work by the Endowment is not sufficient enough. Besides to the insufficiency of the available data, some data are kept secrete by the Endowment for confidentiality.

To fill the gap for the data that are not available at all in the Endowment project evaluation process efforts have been made to estimates and give values cooperating with the Senior Project Experts of the Endowment. For the data available but is not disclosed for this thesis work, the writer has estimated the values independently.

The corporate office vision, mission, objectives, criteria, sub-criteria, and candidate projects are considered and the objective function of the corporate office is formulated with an inclusion of the office constraints and interdependence of projects. Then considering three demand scenarios and using a zero-one integer linear programming two portfolios of projects are generated and the portfolios' risk and objective function values are calculated. The selection of one out of the two portfolios by taking into consideration the trade-offs of the risk and objective function value is left for the management.

4.2 Background of Dejenna Endowment

Dejenna Endowment is a corporate business organization engaged in broad Agro-industrial development ventures to bring about sustainable socio-economic development in the nation. The Corporate Office is situated in Addis Ababa aimed at offering strategic leadership through planning, coordinating and appraising the work of its companies and projects.

A Chief Executive Officer who is responsible for the overall activities across the Endowment heads the Office. There are also four Executive Officers heading the departments of Business Development, Finance and Treasury, Operation and Human Resources Development. To realize its vision and strategic objectives the Endowment has established several business groups under its umbrella, which are currently found under company and project stages.

Vision

To be technological pioneers in the agricultural development and agro processing industries of the country that can consistently and successfully competes in the national and global market. To accomplish its vision, the endowment has envisaged to establish projects that have significant effect on the development of the agricultural and agro-processing sectors, mechanized farming, natural resource conservation as well as livestock marketing.

Mission

The mission of the endowment is to alleviate poverty in the country through modern agricultural practices and create backward and forward integration with the industrial sector.

Objectives

- To eradicate poverty in the country through fundamental changes in the prevailing agricultural and related practices.
- To be a key player in the development endeavors of the country.
- To play a considerable role in the conservation of natural resources and environmental rehabilitation.
- To tap the huge agricultural potential of the country for commercial purpose.
- To engage in lucrative and resource based ventures.

With a view to realizing its strategic objectives, the endowment has established the following business groups.

1. **Alage Forestry development and utilization PLC**

The PLC plants and markets different specious of trees from the commercial viability angle and also gives emphasis on the impact of the environmental rehabilitation.

2. **Biruh-Tesfa Plastic Products PLC**

Bruh-Tesfa Plastic Products PLC become operational in January 2005 with the main objective of producing different pipelines, fittings and drippers for application of drip irrigation and hi-tech technologies to transform agricultural sector.

3. **Dimma Beekeeping & Honey Processing PLC**

It has been legally established as a private limited company starting from January 2005 to produce honey and queen ranching as profit oriented.

4. **National Geo-textile Technology PLC**

The PLC produces a protective structure in Gabion and mattress forms for terracing, check dams, retaining wall of side roads and river basins.

Taking many factors into consideration including the existing and potential demand for these products, the factory was established with a capacity of 2700 tons per year.

5. **Abergelle International Livestock Development PLC**

The PLC is structured to utilize the existing huge potential of cattle and sheep in the country for socio-economic development of the inhabitants through proper fattening for the supply of quality animals to the export oriented slaughterhouse.

The Endowment has also many feasible projects that are under different stages. See project list on table 4.10.

4.3 Data, Data Analysis and Portfolio decision

4.3.1 Calculation of Criteria and Sub-criteria Weights

In this section different data of the Endowment's are given. Weights of the criteria, sub-criteria, and projects under different demand scenarios are calculated. The objective function in different scenarios is formulated including the constraints of the Endowment and interdependence of projects. Finally an optimal portfolio is generated using 0-1 integer linear programming.

Table 4. 1 The summery of criteria and sub-criteria used by Dejenna Endowment for project evaluation

NO.	Criteria and Sub-criteria	Symb.	Criteria and Ranking Relation
1	Technical Criteria	TC	
1.1	Production Process/Technology	PPT	The greater the feasibility of production process, the higher the rank
1.2	Scale of Operation	SO	The higher the flexibility of scale of operation, the grater the rank
1.3	Raw Material	RM	The more the availability of raw material, the higher the rank
1.4	Technical Know-how	TK	The higher the technical know-how, the greater the rank
2	**Commercial Criteria**	**CC**	
2.1	Demand	DD	The higher the demand of the product, the greater the rank
2.2	Supply Position of the Product	SPP	The less the supply, the higher the rank
3	**Socio-Economic Appraisal**	**SEA**	
3.2	Net Foreign Exchange Effect	NFEE	The higher the gain of foreign exchange, the greater the rank
3.3	GDP Contribution	GDP	The higher the contribution to the GDP, the greater the rank
3.4	Improvement of the Social Welfare	ISW	The higher the improvement to the social welfare, the greater the rank
3.5	Environmental Impact	EI	The less/higher the environmental negative/positive impact, the greater the rank
4	**Financial Criteria**	**FC**	
4.1	Cost of Project	CP	The less the cost of project, the greater the rank
4.2	Working Capital requirement and financing	WCRF	The less the working capital and the feasible the financing resource, the greater the rank
4.3	Means of finance at initial	MFI	The feasible the initial finance resource, the higher the rank
5	**Investment Criteria**	**IC**	
5.1	Net Present Value	NPV	The higher the NPV, the greater the rank
5.2	Internal Rate of Return	IRR	The feasibility the IRR, the greater the rank
5.3	Profitability Index	PI	The higher the PI, the greater the rank
5.4	Pay Back Period	PBP	The shorter the PBP, the greater the rank
6	**Institutional Appraisal**	**IA**	
6.1	Managerial Capability	MC	The higher the managerial capability, the greater the rank
6.2	Manpower Appraisal	MA	The higher the availability of manpower, the greater the rank

Table 4. 2 Main criteria pair-wise comparison and priority values

Main Criteria	TC	CC	SEA	FC	IC	IA	Priority Value
Technical Criteria (TC)	1	2/3	1/2	3/2	1/2	2	0.130
Commercial Criteria (CC)		1	3/4	9/4	3/4	3	0.196
Socio-Economic Appraisal (SEA)			1	3	1	4	0.261
Financial Criteria (FC)				1	1/3	4/3	0.087
Investment Criteria (IC)					1	4	0.261
Institutional Appraisal (IA)						1	0.065
Total							**1**

Table 4. 3 The sub-criteria under the technical criteria pair-wise comparison and priority values

No.	Technical Criteria (TC)	PPT	SO	RM	TK	Priority Value
1.1	Production Process/Technology (PPT)	1	3/2	1/2	2	0.240
1.2	Scale of Operation (SO)		1	1/3	4/3	0.160
1.3	Raw Material (RM)			1	4	0.480
1.4	Technical Know-how (TK)				1	0.120
Total						**1**

Table 4. 4 The pair-wise comparison of the sub-criteria under the commercial criterion and priority values

No.	Commercial Criteria (CC)	Symbol	Rank	Priority Value
2.1	Demand	DD	1	2/3=0.667
2.2	Supply Position of the Product	SPP	2	1/3=0.333
Total				**1**

Table 4. 5 The pair-wise comparison of the sub-criteria under the socio-economic appraisal and priority values

No.	Socio-Economic Appraisal (SEA)	NFEE	GDP	ISW	EI	Priority Value
3.2	Net Foreign Exchange Effect (NFEE)	1	3/2	1/2	3/2	0.231
3.3	GDP Contribution (GDP)		1	1/3	1	0.154
3.4	Improvement of the Social Welfare (ISW)			1	3	0.462
3.5	Environmental Impact (EI)				1	0.154
Total						**1**

Table 4. 6 The pair-wise comparison of the sub-criteria under the financial criterion and priority values

No.	Financial Criteria (FC)	CP	WCRF	MFI	Priority Value
4.1	Cost of Project (CP)	1	3	2	0.545
4.2	Working Capital Requirement and Financing (WCRF)		1	2/3	0.182
4.3	Means of Finance at Initial (MFI)			1	0.273
Total					**1**

Table 4. 7 The pair-wise comparison of the sub-criteria under the investment criterion and priority values

No.	Investment Criteria (TC)	NPV	IRR	PI	PBP	Priority Value
5.1	Net Present Value (NPV)	1	1	3/2	2	0.316
5.2	Internal Rate of Return (IRR)		1	3/2	2	0.316
5.3	Profitability Index (PI)			1	4/3	0.211
5.4	Pay Back Period (PBP)				1	0.158
Total						**1**

Table 4. 8 The pair-wise comparison of the sub-criteria under the institutional appraisal and priority values

No.	Description	Rank	Priority Value
6.1	Managerial Capability (MC)	2	1/3 = 0.333
6.2	Manpower Appraisal (MA)	1	2/3= 0.667
Total			**1**

Table 4. 9 Summary of the overall priority value of the sub-criteria

Main Criteria (MC)		Sub-Criteria (SC)		Overall Value (E) = (BXD)
Identification (A)	**Priority Value of Main Criteria (B)**	**Identification (C)**	**Priority Value of Sub-Criteria (D)**	
Technical Criteria	0.130	PPT	0.240	0.031
		SO	0.160	0.021
		RM	0.480	0.062
		TK	0.120	0.016
Commercial Criteria	0.196	**CC**	0.667	0.131
		DD	0.333	0.065
Socio-Economic Appraisal	0.261	NFEE	0.231	0.060
		GDP	0.154	0.040
		ISW	0.462	0.121
		EI	0.154	0.040
Financial Criteria	0.087	CP	0.545	0.047
		WCRF	0.182	0.016
		MFI	0.273	0.024
Investment Criteria	0.261	NPV	0.316	0.082
		IRR	0.316	0.082
		PI	0.211	0.055
		PBP	0.158	0.041
Institutional Appraisal	0.065	MC	0.333	0.022
		MA	0.667	0.043
Total	**1**			**1**

4.3.2 Calculation of Project Weights under Different Scenarios

Different scenarios on the demand of the project 10 (X_{10}) product are considered and different portfolios are generated that is used for the portfolio adjustment process.

Table 4. 10 List of projects that are implemented and passed the feasibility study

Ident.	Name of Projects	Stage	Sector	Budget Required (000.000)
X_1	Alage Forestry Development and Utilization	Implemented	Agriculture	28
X_2	Bruh-Tesfa Plastic Product	Implemented	Industry	35
X_3	Dimma Beekeeping & Haney Processing	Implemented	Agro-processing	25
X_4	National Geo-textile technology	Implemented	Industry	40
X_5	Abergelle International livestock Development	Implemented	Agriculture	50
X_6	Maichew Particleboard Project	Feasible	Industry	30
X_7	Abergelle Export Slaughter House Project	Feasible	Agro-processing	30
X_8	Selam Flower Project	Feasible	Agriculture	50
X_9	Plant Tissue Cultural Laboratory	Feasible	Agriculture	20
X_{10}	Modified Starch Project	Feasible	Agro-processing	120
X_{11}	Cement Bag Project	Feasible	Industry	70
X_{12}	~~~~~~~~~~~~~~~~~~	Feasible	Agriculture	100
X_{13}	~~~~~~~~~~~~~~~~~~	Feasible	Agriculture	100
X_{14}	~~~~~~~~~~~~~~~~~~	Feasible	Agro-processing	70
X_{15}	~~~~~~~~~~~~~~~~~~	Feasible	Industry	70

Three demand scenarios are considered:

Scenario 1: The demand for the product of project X_{10} is high

Scenario 2: The demand for the product of project X_{10} is medium

Scenario 1: The demand for the product of project X_{10} is low

In this scenario analysis certain factors or criteria and sub-criteria are supposed to have strong relation with demand and certain factors or criteria and sub-criteria are supposed to be constant in different scenarios.

The other consideration for different scenarios is that the demand variation in between each consecutive scenario is assumed to be 40%. This means the medium level demand will have 40% higher sales amount than the low demand, and the high level demand in will have 40% higher sales amount than the medium level.

In this model it is also assumed that the trend of other factors that have strong relations with demand will vary with equal proportion to the demand or to the sales amount. The relationship of the criteria and sub-criteria to demand is described in table 4.11.

Table 4. 11 The criteria and sub-criteria relationship to demand change of project X_{10} product

NO.	Criteria and Sub-criteria	Symbol	Relationship of other sub-criteria to the demand of X_{10} product
1	Technical Criteria	**TC**	**Constant**
1.1	Production Process/Technology	PPT	Constant
1.2	Scale of Operation	SO	Constant
1.3	Raw Material	RM	Constant
1.4	Technical Know-how	TK	Constant
2	**Commercial Criteria**	**CC**	
2.1	Demand	DD	The scenario Factor
2.2	Supply Position of the Product	SPP	Constant
3	**Socio-Economic Appraisal**	**SEA**	
3.2	Net Foreign Exchange Effect	NFEE	Constant
3.3	GDP Contribution	GDP	Vary in the same direction
3.4	Improvement of the Social Welfare	ISW	Vary in the same direction
3.5	Environmental Impact	EI	Constant
4	**Financial Criteria**	**FC**	**Constant**
4.1	Cost of Project	CP	Constant
4.2	Working Capital requirement and financing	WCRF	Constant
4.3	Means of finance at initial	MFI	Constant
5	Investment Criteria	**IC**	**Vary in the same direction**
5.1	Net Present Value	NPV	Vary in the same direction
5.2	Internal Rate of Return	IRR	Vary in the same direction
5.3	Profitability Index	PI	Vary in the same direction
5.4	Pay Back Period	PBP	Vary in the same direction
6	**Institutional Appraisal**	**IA**	**Constant**
6.1	Managerial Capability	MC	Constant
6.2	Manpower Appraisal	MA	Constant

Relationship between projects and budget constraint:

1) The available capital to be allocated in the first year is Birr 500 million
2) Project X_1, X_2, X_3, X_4 and X_5 are assumed to be mandatory projects, because the projects are already implemented and it is very difficult to terminate due to high shutdown cost.
3) Either project X_8 or X_{14}, but not both must be included in the portfolio.
4) Either both project X_{10} and X_{13}, or one of them must be included in the portfolio.

Table 4. 12 Calculation of project weight against the sub-criteria using SMART in high demand scenario

Sub-criteria		Project's SMART Score														
Description	**Weight (K_j)**	**X_1**	**X_2**	**X_3**	**X_4**	**X_5**	**X_6**	**X_7**	**X_8**	**X_9**	**X_{10}**	**X_{11}**	**X_{12}**	**X_{13}**	**X_{14}**	**X_{15}**
PPT	0.031	80	60	70	60	80	60	70	70	70	84	60	80	80	70	60
SO	0.021	70	80	70	80	70	70	70	70	90	100	90	70	70	80	90
MR	0.062	90	70	90	60	90	90	90	80	60	100	80	90	90	80	60
TK	0.016	100	70	80	60	80	70	80	60	40	98	70	90	90	60	50
DD	0.131	80	90	90	100	70	90	60	100	90	98	80	90	90	70	100
SPP	0.065	90	80	90	100	70	90	60	100	80	100	80	80	80	90	100
NFEE	0.06	30	30	70	80	60	40	80	100	30	100	30	60	60	80	40
GDP	0.04	70	70	70	70	70	70	70	70	70	98	70	70	70	70	70
ISW	0.121	100	60	80	60	80	60	100	70	60	84	60	90	90	70	60
EI	0.04	100	0	70	0	40	20	40	0	100	56	20	100	100	40	0
CP	0.047	90	90	90	90	70	90	90	70	90	0	60	30	30	50	50
WCRF	0.016	90	90	90	90	70	90	90	70	90	0	60	30	30	50	50
MFI	0.024	90	90	90	90	70	90	90	70	90	0	60	30	30	50	50
NPV	0.082	0	90	60	100	60	100	70	100	0	100	90	70	70	80	100
IRR	0.082	0	90	60	100	60	100	70	100	0	100	90	70	70	80	100
PI	0.055	0	90	60	100	60	100	70	100	0	100	90	70	70	80	100
PBP	0.041	0	100	70	100	90	70	90	70	70	98	90	60	50	70	100
MC	0.022	100	60	80	60	80	60	80	70	50	84	50	90	90	70	50
MA	0.043	100	70	80	70	80	70	80	60	20	84	60	90	90	70	50
$\sum_{j=1}^{m} K_j X_{ji}$		62.49	73.82	76.66	80.84	70.33	77.86	75.61	81.41	53.9	85.51	70.47	75.5	75.09	71.75	73.93
a_i		57	67	69	73	64	70	68	74	49	77	64	68	68	65	67

Table 4. 13 Calculation of project weight against the sub-criteria using SMART in medium demand scenario

Sub-criteria		Project's SMART Score														
Description	**Weight (K_j)**	**X_1**	**X_2**	**X_3**	**X_4**	**X_5**	**X_6**	**X_7**	**X_8**	**X_9**	**X_{10}**	**X_{11}**	**X_{12}**	**X_{13}**	**X_{14}**	**X_{15}**
PPT	0.031	80	60	70	60	80	60	70	70	70	60	60	80	80	70	60
SO	0.021	70	80	70	80	70	70	70	70	90	80	90	70	70	80	90
MR	0.062	90	70	90	60	90	90	90	80	60	80	80	90	90	80	60
TK	0.016	100	70	80	60	80	70	80	60	40	70	70	90	90	60	50
DD	0.131	80	90	90	100	70	90	60	100	90	70	80	90	90	70	100
SPP	0.065	90	80	90	100	70	90	60	100	80	80	80	80	80	90	100
NFEE	0.06	30	30	70	80	60	40	80	100	30	100	30	60	60	80	40
GDP	0.04	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
ISW	0.121	100	60	80	60	80	60	100	70	60	60	60	90	90	70	60
EI	0.04	100	0	70	0	40	20	40	0	100	40	20	100	100	40	0
CP	0.047	90	90	90	90	70	90	90	70	90	0	60	30	30	50	50
WCRF	0.016	90	90	90	90	70	90	90	70	90	0	60	30	30	50	50
MFI	0.024	90	90	90	90	70	90	90	70	90	0	60	30	30	50	50
NPV	0.082	0	90	60	100	60	100	70	100	0	80	90	70	70	80	100
IRR	0.082	0	90	60	100	60	100	70	100	0	80	90	70	70	80	100
PI	0.055	0	90	60	100	60	100	70	100	0	80	90	70	70	80	100
PBP	0.041	0	100	70	100	90	70	90	70	70	70	90	60	50	70	100
MC	0.022	100	60	80	60	80	60	80	70	50	60	50	90	90	70	50
MA	0.043	100	70	80	70	80	70	80	60	20	60	60	90	90	70	50
$\sum_{j=1}^{m} K_j X_{ji}$		62.49	73.82	76.66	80.84	70.33	77.86	75.61	81.41	53.9	65.94	70.47	75.5	75.09	71.75	73.93
a_i		58	68	71	74	65	72	70	75	50	61	65	70	69	66	68

Table 4. 14 Calculation of project weight against the sub-criteria using SMART in low demand scenario

Sub-criteria		Project's SMART Score														
Description	**Weight (K_j)**	**X_1**	**X_2**	**X_3**	**X_4**	**X_5**	**X_6**	**X_7**	**X_8**	**X_9**	**X_{10}**	**X_{11}**	**X_{12}**	**X_{13}**	**X_{14}**	**X_{15}**
PPT	0.031	80	60	70	60	80	60	70	70	70	36	60	80	80	70	60
SO	0.021	70	80	70	80	70	70	70	70	90	48	90	70	70	80	90
MR	0.062	90	70	90	60	90	90	90	80	60	48	80	90	90	80	60
TK	0.016	100	70	80	60	80	70	80	60	40	42	70	90	90	60	50
DD	0.131	80	90	90	100	70	90	60	100	90	42	80	90	90	70	100
SPP	0.065	90	80	90	100	70	90	60	100	80	48	80	80	80	90	100
NFEE	0.06	30	30	70	80	60	40	80	100	30	60	30	60	60	80	40
GDP	0.04	70	70	70	70	70	70	70	70	70	42	70	70	70	70	70
ISW	0.121	100	60	80	60	80	60	100	70	60	36	60	90	90	70	60
EI	0.04	100	0	70	0	40	20	40	0	100	24	20	100	100	40	0
CP	0.047	90	90	90	90	70	90	90	70	90	0	60	30	30	50	50
WCRF	0.016	90	90	90	90	70	90	90	70	90	0	60	30	30	50	50
MFI	0.024	90	90	90	90	70	90	90	70	90	0	60	30	30	50	50
NPV	0.082	0	90	60	100	60	100	70	100	0	48	90	70	70	80	100
IRR	0.082	0	90	60	100	60	100	70	100	0	48	90	70	70	80	100
PI	0.055	0	90	60	100	60	100	70	100	0	48	90	70	70	80	100
PBP	0.041	0	100	70	100	90	70	90	70	70	42	90	60	50	70	100
MC	0.022	100	60	80	60	80	60	80	70	50	36	50	90	90	70	50
MA	0.043	100	70	80	70	80	70	80	60	20	36	60	90	90	70	50
$\sum_{j=1}^{m} K_j X_{ji}$		62.49	73.82	76.66	80.84	70.33	77.86	75.61	81.41	53.9	39.56	70.47	75.5	75.09	71.75	73.93
a_i		59	70	72	76	66	74	71	77	51	37	67	71	71	68	70

$\sum_{j=1}^{m} K_j X_{ji}$ is weighted value for all projects, where K_j is the j Sub-criteria weight calculated using AHP.

X_{ji} is the value of project i given out of hundred on sub-criteria j.

$$a_i = \left[\sum_{j=1}^{m} K_j X_{ji} \Big/ \left[\sum_{i=1}^{n} \sum_{j=1}^{m} K_j X_{ji} \right] \right] \times 1000$$

Where a_i is the coefficient of the objective function X_i.

Table 4. 15 a_i Values of projects in different demand scenarios for project X_{10} product

Project	a_i Values in Different Demand Scenarios for Project X_{10}		
	High Demand	Medium Demand	Low Demand
X_1	57	58	59
X_2	67	68	70
X_3	69	71	72
X_4	73	74	76
X_5	64	65	66
X_6	70	72	74
X_7	68	70	71
X_8	74	75	77
X_9	49	50	51
X_{10}	77	61	37
X_{11}	64	65	67
X_{12}	68	70	71
X_{13}	68	69	71
X_{14}	65	69	68
X_{15}	67	68	70

4.3.3 The Optimization Problem Formulation and Optimal Solution

The decision variables are defined by:

$$X_i = \begin{cases} 1, \text{ if project i is included in the portfolio} \\ 0, \text{ otherwise, for i = 1, 2, . . ., n, where n = 15 in this case.} \end{cases}$$

The objective function in three scenarios is given by:

Scenario 1: *High demand for product of project X_{10}*

$$\text{Max. Z} = \sum_{i=1}^{n} a_i X_i = 57X_1+67X_2+69X_3+73X_4+64X_5+70X_6+68X_7+74X_8+49X_9+ 77X_{10}+ 64X_{11}+68X_{12}+68X_{13}+65X_{14}+67X_{15} \text{ ------- } 1$$

Scenario 2: *Medium demand for product of project X_{10}*

$$\text{Max. Z} = \sum_{i=1}^{n} a_i X_i = 58X_1+68X_2+71X_3+74X_4+65X_5+72X_6+70X_7+75X_8+50X_9+ 61X_{10}+ 65X_{11}+70X_{12}+69X_{13}+69X_{14}+68X_{15} \text{ ------- } 2$$

Scenario 3: *Low demand for product of project X_{10}*

$$\text{Max. Z} = \sum_{i=1}^{n} a_i X_i = 59X_1+70X_2+72X_3+76X_4+66X_5+74X_6+71X_7+77X_8+51X_9+ 37X_{10}+ 67X_{11}+71X_{12}+71X_{13}+68X_{14}+70X_{15} \text{ ------- } 3$$

Subject to,

$28X_1+35X_2+25X_3+40X_4+50X_5+30X_6+30X_7+50X_8+20X_9+120X_{10}+$

$70X_{11}+100X_{12}+100X_{13}+ 70X_{14}+70X_{15} \leq 500$ ---------- 4

$X_1, X_2, X_3, X_4, X_5 = 1$ ---------- 5

$X_8 + X_{14} = 1$ ---------- 6

$X_{10} + X_{13} \geq 1$ ---------- 7

$X_1, X_2, ..., X_{15} = 1 \text{ or } 0$ ---------- 8

The Solution of the optimization Problem is solved using 0-1 Linear Integer Programming and the output of the optimization problem is indicated below in table 4.16.

Table 4. 16 An optimal solution of 0-1 Linear Integer Programming in different scenarios

Project	X_i Values in Different Demand Scenarios for Project X_{10} Product		
	High Demand	Medium Demand	Low Demand
X_1	1.0	1.0	1.0
X_2	1.0	1.0	1.0
X_3	1.0	1.0	1.0
X_4	1.0	1.0	1.0
X_5	1.0	1.0	1.0
X_6	1.0	1.0	1.0
X_7	1.0	1.0	1.0
X_8	1.0	1.0	1.0
X_9	1.0	1.0	1.0
X_{10}	1.0	0.0	0.0
X_{11}	0.0	0.0	0.0
X_{12}	0.0	0.0	0.0
X_{13}	0.0	1.0	1.0
X_{14}	0.0	0.0	0.0
X_{15}	1.0	1.0	1.0
Objective function value	735	740	740

In the above three scenarios generated the low and medium demand scenarios result is the same. The generated portfolios in the above table should be compared and evaluated with certain critical values. The two fundamental factors considered for selection are the objective function value and the risk value of the portfolios. The objective function value of the portfolios is indicated in table 4.16. This value is unitless value that measures the degree of realization of the criteria and sub-criteria. The risk of the portfolio can be expressed by the variance or standard deviation of the portfolio. The variance and standard deviation of the portfolio is calculated and indicated in the table 4.17 below.

Table 4. 17 Portfolios standard deviation in different scenarios

Standard deviation calculation in different demand scenarios for project X_{10} product																	
Project	High Demand	Medium Demand	Low Demand	NPV (high)	NPV (medium)	NPV (low)	Risk (%)	Stdv (σ) (high)	Stdv (σ) (medium)	Stdv (σ) (low)	Budget (high)	Budget (medium/low)	Budget fraction (K_i) (high)	Budget fraction (K_i) (medium/low)	$K_i^2\sigma_i^2$ (high)	$K_i^2\sigma_i^2$ (medium)	$K_i^2\sigma_i^2$ (low)
X_1	1	1	1	10	10	10	2	5	5	5	28	28	0.056	0.059	0.079	0.086	0.086
X_2	1	1	1	60	60	60	8	43	43	43	35	35	0.070	0.073	9.133	9.913	9.913
X_3	1	1	1	35	35	35	10	27	27	27	25	25	0.050	0.052	1.837	1.994	1.994
X_4	1	1	1	65	65	65	7	44	44	44	40	40	0.080	0.084	12.490	13.557	13.557
X_5	1	1	1	30	30	30	5	18	18	18	50	50	0.100	0.105	3.266	3.545	3.545
X_6	1	1	1	55	55	55	6	35	35	35	30	30	0.060	0.063	4.445	4.825	4.825
X_7	1	1	1	45	45	45	12	38	38	38	30	30	0.060	0.063	5.240	5.688	5.688
X_8	1	1	1	70	70	70	10	56	56	56	50	50	0.100	0.105	31.612	34.313	34.313
X_9	1	1	1	20	20	20	13	18	18	18	20	20	0.040	0.042	0.523	0.567	0.567
X_{10}	1	0	0	98	70	42	3	23	37	52	120	0	0.241	0.000	30.716	0.000	0.000
X_{11}	0	0	0	100	100	100	8	71	71	71	0	0	0.000	0.000	0.000	0.000	0.000
X_{12}	0	0	0	80	80	80	6	51	51	51	0	0	0.000	0.000	0.000	0.000	0.000
X_{13}	0	1	1	75	75	75	7	51	51	51	0	100	0.000	0.209	0.000	113.837	113.837
X_{14}	0	0	0	85	85	85	1	37	37	37	0	0	0.000	0.000	0.000	0.000	0.000
X_{15}	1	1	1	100	100	100	14	93	93	93	70	70	0.141	0.146	170.885	185.484	185.484
Total											**498**	**478**	**1.000**	σ_p^2	**270.226**	**373.810**	**373.810**
Portfolio standard deviation σ_p															**16**	**19**	**19**

The portfolio variance is calculated as follows:

$$\sigma_p^2 = \sum_{i=1}^{i=n} K_i^2 \sigma_i^2 + \sum_{i \neq j} K_i K_j \rho_{ij} \sigma_i \sigma_j$$

Where, σ_p^2 *is the variance of the portfolio,*

K_i and K_j is the fraction of the budget on project i and j,

ρ_{ij} is the correlation coefficient of project i and j,

and σ_i and σ_j are the standard deviation of NPV of project i and j.

ρ_{ij} of projects is determined from the information collected in the previous historical relation of projects. Since most of the projects are new and difficult to determine the correlation coefficients between the projects, the ρ_{ij} are assumed to be zero.

Therefore,

$$\sigma_p^2 = \sum_{i=1}^{i=n} K_i^2 \sigma_i^2 = K_1^2 \sigma_1^2 + K_2^2 \sigma_2^2 +,\ldots,+ K_{15}^2 \sigma_{15}^2$$

In the above three scenarios only two portfolios are generated. The portfolio generated in the low and medium demand scenarios are the same, and hence, the standard deviation and objective function values are the same. Therefore the two portfolios in the high demand of the product of X_{10} and in the medium or low demand of the product of X_{10} are compared by the standard deviation and objective function values of the portfolio. The summery of values are indicated below in table 4.18.

Table 4. 18 The standard deviations and objective function values of high and low/medium demand scenarios

	Standard deviation (σ_P)	Objective function values
High demand	16	735
Low/medium demand	19	740

In the above table the risk values and the objective function values are higher in the high demand scenario than the low demand scenario. The lower the risk is the better the portfolio and the higher the objective function value is the better the portfolio. Therefore there is no dominant portfolio out of the two portfolios. The selection out of the two portfolios is basically made by the insight and experience of the management.

4.4 Result Discussion

The test of the model in the previous section indicates that the developed model is an important tool to support the management in portfolio selection process. For the testing of the model large amount of data are used. All the data used for the test are not real data. Certain amounts of data are estimated in collaboration with the senior experts of the Endowment. Because some of the data are not collected and made available by the Endowment for its own project evaluation purpose and some are kept secrete for confidentiality.

To implement the model in the portfolio selection process further efforts are required to fulfill the deficiency of data. The more the real data are used in the analysis, the higher becomes the validity of the model output. The viability and precision of the model output is also evaluated by the precision of the data available. Although the model has a significant contribution to process and generate an optimal solution, the output of the model is not an ultimate decision. An adjustment on the output portfolio based on the experience and insight of the management to reach on consensus between the participants in the process is essential. As we have discussed in the above section the final decision after the optimal portfolios are generated is made by the management considering the tradeoffs between the risk and objective function values of the portfolios.

CHAPTER FIVE

5. Conclusions and Recommendations

5.1 Conclusions

The most reliable way to anticipate the future is by understanding the present. Currently, a typical company's level of understanding the project that makes up its business is not only to manage the ongoing endeavors, but to anticipate future opportunities. Following good portfolio management process can improve this in many ways.

There are indication of evolution as described in many researches and literatures, in the international level to meld newer and more dynamic portfolio management techniques with the business realities. Certain international organizations are consolidating planning and project exclusion at the corporate level-merging strategic planning with traditional project office roles in the area of defining strategy, maintaining the corporate portfolio, helping project managers and sponsors and maintaining alignment of the strategy with project priorities. As the project management and strategic-level management player draw closer together through a shared, documented process, the historic disconnect between strategic management and individual projects will increasingly fad away.

In the national level the concept of project portfolio management is not even conceived in the mind of corporate managers in a complete and correct sense. But recently many corporate offices are emerging that undertake projects in different sectors. The prioritizing, selecting, and monitoring of projects in these corporate offices are not better than from a one-to-one conventional prioritizing, selecting and monitoring approach. Now it is high time to introduce the project portfolio management (PPM) in these corporate offices.

The concept of PPM has a wider role in government budget allocation as well. As the government objectives are wider than the private investors, allocating the scarce budget to different sectors and to different projects within the sector requires a better approach than the conventional one. According to the interview survey conducted in this research in different governmental and non-governmental organizations the concept and approach of the model developed in this thesis work is not applied in the domestic companies currently. Even the use of operation research and mathematical model optimization technique seems strange for the domestic companies.

Even though the project portfolio selection model developed in this thesis is tested in a specific corporate office, the model has a generic nature that other governmental and non-governmental corporate office can adapt and use it to make best of it for its worthiness.

5.2. Recommendations

In the present Ethiopian context the researcher believes that the application of PPM has to begin in certain corporate private companies and in governmental organizations that undertake many investments in different sectors. In the governmental organizations it is appropriate to apply in the allocation of budget on different sectors and projects.

For the application of PPM both in governmental and non-governmental organizations it is vital to create awareness on the concept of PPM and its application process. The PPM process to a specific company may be redesigned as per the company's requirement, objectives and its policy. Knowledge dissemination to the appropriate personnel in detail on the evaluation process of investment with a PPM approach is a prerequisite for the implementation process. In the application of PPM the management has to be aware of the issues stated in the table 5.1.

The common pitfalls of project portfolio selection process are identified by certain researchers in the field. Some of the pitfalls are listed below in table 5.1 as it is summarized by Juhan Martikainen, 2002.

Table 5. 1 The empirical research indications of common pitfalls in portfolio selection process.

Description	Consequence	Source
The methods is a bit complex	Users are afraid to use them	Lee et al. (1986)
Users are given little or no education about the model	Misinterpretation	Lee et al. (1986), Loch et al. (2001)
False sense of accuracy	The model can only be as precise as its estimates are.	Archer & Ghasemzadeh (1996), Steele (1988)
Too much reliance on the model output	Models should not be as a substitute for strategic analysis	Levine (1999)
In most cases management do not truly understands the methods	They may be used incorrectly	Levine (1999)
Some information is impossible or very hard to acquire (e.g. distinct resource constraints)	Users are not encouraged to use	Jackson (1983), Lee et al. (1986)
Models are inadequate to fit the nature of the investments. This might originate from wrong definition of model needs or from a changed environment that makes the models obsolete	Mislead the users	Lee et al. (1986), Loch et al. (2001)

The implementation of project portfolio selection process becomes smoother if the company has a well-organized and systematic practice of selecting projects in a conventional one-to-one evaluation technique. If the company has a well formulated and structured data collection and analysis procedures and techniques for individual project evaluation, the application of the project portfolio selection and monitoring becomes an extension of the previous effort. But if the company has no professional approach of collecting and analyzing data for individual project evaluation, the implementation of PPM becomes more difficult and requires additional effort even to establish a well-structured system for individual project feasibility evaluation. Once the data and information are collected and analyzed for project feasibility evaluation, the same data and information becomes the basis for portfolio selection, adjustment and monitoring with the inclusion of constraints, interdependence, etc.

Before the decision on the project portfolio, the model has to be tested and the output portfolio should be reasonable to convince participants of the selection process and the management. Basically the mathematical model is used as an informative tool to handle all the available data and to give an optimal solution based on the given inputs to the model. Due to the formulation error and/or the disagreement on the input information by the management or investment team the output of the mathematical model is not implemented without raising any question. Disagreements on the portfolio output are not uncommon. In this case certain adjustments by varying some parameters of the model input data, for instance demand of certain products, an alternative portfolio could be generated. So that different portfolio might be compared in certain factors, such as the portfolio risk and some critical criteria.

5.3 Further Scope of Research

According to some research indications, even though PPM is introduced and practiced in a certain international corporate organizations, the concept of PPM is not perceived in its correct and complete sense in many companies. Especially, in this research interview survey it is identified that in Ethiopia the concept of PPM is not even known in governmental and non-governmental organizations. Hence it is unexplored area for researchers to conduct researches in the field.

The following research areas could be taken as a preliminary direction to undertake a research in the field.

- The model developed in this thesis is not specific to any sector, and hence the model cannot be fitful to all areas without modification. Therefore, a new model can be developed on a specific corporate company or in a specific sector in a simplified manner.

- When the model is tested, the ongoing projects are considered as mandatory projects due to the difficulty of including the shutdown cost. But the ongoing projects may have diverse effect on the portfolio and portfolio might have been better if some mandatory projects hadn't included in the portfolio. Of course, the inclusion of ongoing projects in the analysis is important due to resource sharing, interdependence, etc with other new projects. In this respect the future research may consider an appropriate evaluation of the ongoing projects and avoid binding constraints on the ongoing projects to be included.

- To understand the overall impact of the process of PPM on the decision making of the portfolio, the pros and cons of the process should be examined. What are the real costs of the process? What kind of additional benefits does the implementation provide for the company? These will require empirical research that covers the whole process of PPM.

- The interdependence of factors or criteria considered in the project evaluation process of this thesis is not considered. The future research may consider the interdependence of criteria and develop some relationship between the criteria in the project evaluation process.

- In the future research, the efficiency of the PPM can also be compared and contrasted with the conventional one-to-one project evaluation and selection technique. The portfolio selection model output in this thesis could be compared with the conventional technique output by considering certain values, such as, NPV, IRR, etc. But obviously the result of this comparison does not give the full picture of portfolio values to the company. If a comprehensive comparison that can consider all the tangible and intangible values are investigated and compared the merit of PPM approach over the conventional one-to-one project selection can be seen clearly.

- The other possible future research area in this topic is in the areas of product development, suppliers' selection, equipment maintenance and utilization by considering different criteria, constraints, interdependence, etc.

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Interviews

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2. Ato Sewasew Pawelos, Project Expert, (EFFORT), March 22, 2007
3. Ato Tegaye Gershen, Manager of Investment and Business Development Department, EFFORT, May 5, 2007
4. Ato Mesfine Lakew, Lead Project Engineer, Industrial Project Service (IPS), From March to June, 2007 in different days.
5. Ato Benalfe Gugesa, Senior Project Engineer, Industrial Project Service (IPS), from March to June, 2007 in different days.
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7. Ato Metalegne Ayechew, Team Leader, Ministry of Finance and Economic Development (MoFED), Aptil 11, 2007.
8. Ato Assefa Mogess, Senior Expert, Ministry of Finance and Economic Development (MoFED), from October to June, 2007 in different days.
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10. Ato Berehanu Habtu, Senior Project Expert, Dejenna Endowment, from March to June, 2007 in different days.
12. Ato Giday Fisseha, Senior Project Expert, Dejenna Endowment, from March to June, 2007 in different days.