# DESIGNING A DECISION SUPPORT SYSTEM FOR DEBT PAYMENT PLANNING UNDER INFLATION

A THESIS
SUBMITTED TO THE DEPARTMENT OF
INDUSTRIAL ENGINEERING
AND THE INSTITUTE OF ENGINEERING AND SCIENCES
OF BILKENT UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE



By
Mehmet ÖZKAN
September 1994

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I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

Prof. Dr. Halim Doğrusöz(Principal Advisor)

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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# ABSTRACT

## DESIGNING A DECISION SUPPORT SYSTEM FOR DEBT PAYMENT PLANNING UNDER INFLATION

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M.S. in Industrial Engineering
Supervisor: Prof. Dr. Halim Doğrusöz
Sept, 1994

Computer technology has been developed very rapidly in recent years and now computers are even replacing human in some areas. Use of judgment, however, is still very important in many other fields. Financial management is one of the areas that need managerial judgment and intuition while making decisions. In this study, we propose a methodology for designing a system to assist the decision maker (DM) in using his judgment to make effective decisions. The system also has to facilitate and enhance learning since judgment is excelled by experience. We specificly analyze decisions regarding the Debt Payment Planning (DPP) problem. This problem, which may be briefly stated as 'development of an operational plan for the liquidation of debts', is a new problem and does not exist in the literature. The analyses are conducted keeping in mind that the uncertainty of the financial environment and burden of inflation increase the complexity of the decisions. A model which we call, 'Growth Model of Debt' will be used in the analyses and a sample session will be shown to provide a clear understanding of the system operation.

*Key words*: Decision Support Systems (DSS), Financial Management (FM), inflation, decision making, learning, expert judgment, survivability in business, credibility.

# ÖZET

## ENFLASYONLU ORTAMDA BORÇ ÖDEME PLANLAMASI İÇİN BİR KARAR DESTEK SİSTEMİ TASARIMI

Mehmet Özkan
Endüstri Mühendisliği Bölümü Yüksek Lisans
Tez Yöneticisi: Prof. Dr. Halim Doğrusöz
Eylül, 1994

Bilgisayar teknolojisi özellikle son yıllarda çok gelişti, hatta bazı alanlarda insanların yerini almaya başladı. Buna rağmen yargı kullanımı diğer alanlarda önemini koruyor. Mali Yönetim de karar aşamasında yönetici yargısı ve sezgisinin kullanılmasını gerektiren alanlardan biri. Bu çalışmada karar veriye daha etkin kararlar verebilmesi için yargısını kullanmasında destek olacak bir sistemin tasarımı için bir yöntem öneriyoruz. Yargının gücü öğrenme ile arttığından sistem aynı zamanda öğrenmeyi de kolaylaştırmalıdır. Çalışmada Borç Ödeme Planlaması ile ilgili kararlar üzerinde duracağız. Literatürde bulunmayan bu yeni problem kısaca 'Borcun ödenmesi için işlevsel bir strateji geliştirilmesi' olarak tanımlanabilir. Analizler, mali piyasalardaki belirsizlikler ve enflasyonun piyasa üzerindeki etkileri gözönünde bulundurularak yapılmıştır. Analizlerde "Borç Büyüme Modeli" adı verilen bir model kullanılacak ve sistemin çalışmasını daha iyi anlatabilmek için bir örnek verilecektir.

*Anahtar sözcükler.* Karar Destek Sistemleri, Mali Yönetim, Enflasyon, Karar Verme, Öğrenme, Uzman Yargısı, Kredi Değerliliği.

To my mother

# ACKNOWLEDGEMENT

I am grateful to Dr. Halim Doğrusöz for his supervision, and suggestions throughout this study. Also I am thankful to Dr. Cemal Dinçer, Dr. Dilek Önkal and Dr. Gülnur Muradoğlu for reading and reviewing this thesis.

I would like to extend my deepest gratitude and thanks to my mother and sister for their continuous morale support, encouragement and patience. It is to them this study is dedicated, without whom it would not have been possible.

My special thanks go to Aslı Gürün for her love, patience, understanding and encouragement, especially at times of despair and hardship.

And my sincere thanks to my classmates Selçuk Avcı, Okan Balköse, Orhan Dağlıoğlugil, Elif Görgülü and Haluk Yılmaz with whom I have shared my time during the graduate study; to my former officemates Aslı Sencer Erdem, Pınar Keskinocak, Sibel Salman and Gülcan Yeşilkökçen and to Ediz Kökyazıcı, Reha Argaç, Suat Ekinci and Levent Öktem for any kind of help and support they have given for this thesis.

# Contents

# List of Figures

# List of Tables

# NOMENCLATURE

| | | |
|---|---|---|
| DBMS | : | Database Management Systems |
| DM | : | Decision Maker |
| DPP | | Debt Payment Planning |
| DPPSS | : | Debt Payment Planning Support System |
| DPS | : | Debt Payment Schedule |
| DSP | : | Debt Servicing Problem |
| DSS | : | Decision Support System |
| ES | | Expert System |
| FM | | Financial Management |
| GMD | : | Growth Model of Debt |
| IDSS | : | Intelligent Decision Support System |
| IS | : | Information System |
| MIS | : | Management Information System |
| MS/OR | : | Management Science /Operations Research |
| RIR | : | Real Interest Rate |
| SI | : | Survivability Index |
| SPF | : | Self Payment Fund |

# Chapter 1

# INTRODUCTION

Financial Management (FM) plays a key role in any organization. Also called "corporate finance", it involves decisions within a firm and it has undergone significant changes over the years. Especially after 1980's, FM has gained utmost importance due to three major issues. One of them is inflation and interest rates; the other is the decentralization of finance in organizations and finally third, the dramatic increase in the use of computer technology in financial analyses and decisions. These changes have greatly increased the importance of financial management; in today's firms, decisions are made in a much more coordinated way than before. Today, every decision maker in an organization has responsibility in financial decision making and finance managers have direct responsibility for the control process.

Financial management is a very broad area and it is divided into many subproblems which are studied separately. These subproblems are almost well-structured and it is relatively easy to analyze them one by one. However, they interact with and affect each other as a result of corporate financial decisions. So, FM decisions should be based upon new approaches which integrate various subproblems that exist in the literature. In this study, we will deal with the Debt Payment Planning (DPP) problem, which is an example of the above mentioned integrative approach. It is a new problem since it does not exist in the financial management literature. However, it may be regarded as a combination of subproblems of FM, so it is not well-structured, and furthermore must consider the interactions among those subproblems. Debt payment refers to liquidation of all of the debts that the firm has. It is more than balancing inflows and outflows for paying debt on time, which is a known problem called the Debt Servicing Problem. The purpose of DPP however, may be briefly stated as *development of an operational strategy for the liquidation of debts.* This means determination of the group of decisions that will lead the firm to 0-debt state (or safe-debt state). Later it will be discussed that it is not very realistic to assume that the firm will liquidate totally. The main objective of the firm must be stated as achieving a healthy status in the market, which also includes continuing debt financing in acceptable levels.

In this study, we design a Decision Support System (DSS) to assist decision maker (DM) in decision making for the DPP problem; therefore we call it the Debt Payment Planning Support System (DPPSS). Decision making in financial management and hence in debt payment planning is not easy due to the uncertainty inherent in the dynamic environment. There are too many uncontrollable variables and these have a dramatic effect on the state of the problem and hence on the solution. Inflation is the most known example for variables of this kind and will be discussed later.

Assessing the situation and forecasting probable values for those variables are not straightforward tasks. So we need an experienced DM, since a good decision depends on DM's judgment and intuition. Based on this fact, the purpose of this study can be stated as *designing a system to assist decision maker in using his judgment effectively, while making decisions in an inflationary environment.* During the study we will use the term DM often,so we will give a brief description and required skills of a typical DM, before we start discussing the details of the proposed system in Chapter 3. Two major properties of the proposed system will help the user to acquire those necessary skills. One is the ability to provide understandable and digestible information to the user and second is the ability to provide and enhance learning. The most valuable tool in achieving these properties will be the Growth Model of Debt (GMD) which constitutes the major part of the modelbase. The model's power lies in its ability to derive simple and meaningful information from a single differential equation. The measures that are developed via this model can easily be understood and interpreted by experienced DMs without knowing the details of their derivation. Adaptation and flexibility are other properties of the system which allow the designer to perform necessary modifications on the system. The need for such modifications may arise due to changes in the problem environment (macroeconomic changes) or organizational differences. Even changes in managerial perceptions may require adaptation of a proper working system.

Now we will give the organization of the thesis with brief discussion on chapters. Before that, however, note that prior to the Introduction Chapter there is a nomenclature where we stated the abbreviated words that are used in the study extensively. In Chapter 2, which is an introductory chapter, the Debt Payment Planning problem and its objectives will be defined in detail. The objectives are not specific to DPP,they are the objectives that any firm tries to achieve. The emphasis will be on the relevance of these objectives to DPP and their priorities. Priorities that are assigned to those objectives may be different for different subproblems, as in this case. Then, the effect of inflation on the problem and on the environment will be discussed.

After introducing the DPP problem in Chapter 2, in Chapter 3 we will describe the problem that constitutes the core of this study. Our aim is simply to design a system and we will give the details of the target system in this chapter. In such a system, there's a requirement for a subsystem( information system or computer system) which will assist DM to make effective decisions efficiently. The design process for a system to assist the solution of an unstructured problem becomes very difficult; especially when the integration issue that is mentioned above, is considered. In the literature, it is observed that Decision Support Systems have the potential to overcome these deficiencies to a significant extent. In fact, when the objectives and properties of a DSS is compared with those of our intended system, most of them are common. Therefore, a DSS design framework will be followed in the study. Of course, this framework should be regarded as only to form the conceptual basis. The system may require modifications after being implemented and evaluated on different

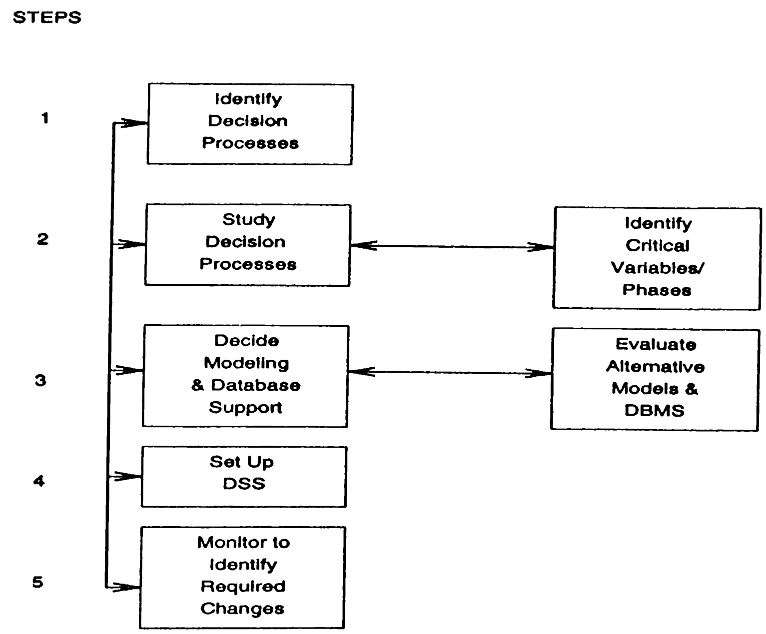


Figure 1.1: A General Framework of DSS Design. [39]

scenarios. These will be discussed in Chapter 3, with a literature review on Decision Support Systems.

There are many suggestions for the procedure to be followed in DSS design [12] [27] [38] [43] [44]. All of these have a common base-structure which follows *analysis, design* and *implementation* stages. Based on these, we will use the framework given in Figure 1. Note that, only the first two stages are considered in the scope of this study; that is, we will not deal with the implementation of the system. Finally in Chapter 3, we will explain the objectives and properties of the system that is designed to assist the decision maker.

In Chapter 4 Growth Model of Debt will be introduced and analyzed in detail. The model, used in this study, is basically derived from a differential equation; so it is easy to understand. But usually DMs are people who do not have much knowledge of mathematics, hence it is often difficult for them to analyze such models and associated results. The power of our model lies in here. The measures that are produced via this model can easily be understood and interpreted by DMs, without knowing the details of their derivation. The model has two versions: continuous and discrete. We will prefer to use the continuous version of the model so we will derive the formulas through this version, then will show the case for the equivalence of discrete and continuous models. While deriving the model we will assume that the firm's aim is to achieve full-liquidation; thus the most important measures are the ones that show the 0-debt state. In most cases however, the firm does not look for liquidation, so it is not very realistic. We will later explain that the model can easily be adapted to bring the debt to a safe level, instead of 0-level.

Chapter 5, which is called System Design and Operation may be thought as a supplement to Chapter 3, where the methodology for a DSS was explained. In Chapter 5 we will give details specific to DPPSS and clarify *how* we have applied the properties and requirements of the problem to our system. The chapter will begin with restating the properties that we want DPPSS to acquire. Then, we will describe how we had formed the components of the system. They will be explained in Chapter 3 in general, but requirements and properties specific to the DPP problem will be discussed in Chapter 5. Performance measures of the system, which are derived through GMD will also be introduced here. Then in the last section, we will discuss the operation of the system by five subsections which are the steps of an operational design procedure for our system. The purpose of this part is not to implement the proposed design but only to visualize how the system will operate after being installed. The interaction between the system and the user is the main strength of the system so we tried to develop a user-friendly prototype. It will not be a complete system but a sample session will be given with its description. The thesis will conclude with a brief description of the benefit acquired from the system and possibilities for further research.

# Chapter 2

# FORMULATION OF THE DEBT PAYMENT PROBLEM

The purpose of this chapter is to ensure that both the user (DM) and the designer of the system have a clear understanding of the debt payment process and the associated Debt Payment Planning (DPP) problem. We must be sure that the problem is fully understood right from the beginning, because in the rest of the study we will deal with the design of a system to assist decision making for this problem. The chapter is especially important, since DPP does not exist in the financial management literature.

In the first chapter, the DPP problem was stated as "the development of an operational strategy for the liquidation of debts for the survival of the firm". By this definition, debt payment process can be explained as process of liquidating, i.e. paying all of the existing debt. These explanations, however, are not sufficient to visualize the debt payment process and to understand the problem. Moreover these do not clarify how one can determine the existence of the above mentioned problem. The best that the decision maker can do will be to signal the existence of a problem, but s/he will probably not be able to name it as "DPP problem". Being aware of an extraordinary or unexpected situation is called 'diagnosing a problem'. There is however, a need for further analysis of the situation to find an answer to the question "what is the problem?". This additional effort is called 'formulation of the problem'. After formulation of the problem we may be specific in terms of reasons and consequences of the problematic situation. R.L.Ackoff defines problem formulation as the determination of the following four elements [2]:

- Decision Maker (DM)
- Objectives of the Decision Maker
- Alternative Courses of Action
- System and its Environment

The following analysis and discussion on these elements will develop a clear understanding (formulation) of DPP, which will lay the foundation for DPPSS design. Determination of the decision maker (DM) is critical in formulating a problem. We need to identify the DM, since different decision makers may have different thinking styles and perceptions. Also decision makers have varying degrees of authority in organizational hierarchy. This variability may be due to conditions, or due to the position and experience of the DM. Decisions are made at every level of an organization; however, final decisions are generally made at higher levels. Such decisions may be based on assistance taken from lower levels but the final decision maker, of course has the option to ignore his subordinates' opinions. Of course, the final DM, who has the option to ignore all others, is not selected arbitrarily; there are some skills and criteria required in a decision maker. These skills are called 'expertise' in the literature and an 'expert' is an individual who has these skills. Judgment, intuition and insight are among elements of expertise. In a study which examines quality of expert judgment, Bolger and Wright [11] mention that; 'experts are assumed to have well-learnt, highly practiced skills; a large body of knowledge; heuristics or rules of thumb to allow them to apply their knowledge to real-world situations; and certain general problem solving skills which constitutes a form of filtering, as does "recognizing problems they face as instances of types with which they are familiar"'. They also point out a distinction between "substantive experts" whose skill lies in analyzing large bodies of data and "assessment experts" whose skill lies in making judgments under uncertainty [11]. In our case, the decision maker has to have both types of skills since s/he will analyze the situation to diagnose and formulate the problem; and make decisions under uncertainty. At the beginning, we may assume that an experienced decision maker will have these skills, however we must examine the performance of our 'expert' and check that s/he has these skills. In order to have a practical meaning, expertise should be excelled and we should be able to measure it. There are various approaches on assessment and measurement of expert performance. Performance evaluation constitutes a very important part of our system and therefore design methodology which will be explained later in this chapter.

In the scope of this study, the purpose of the decision maker is to solve the Debt Payment Problem, if it exists. More importantly, however, there are objectives of the firm which are determined by the specific conditions of the environment that the firm operates in. These objectives interact with each other and we will discuss them in detail in section (2.3). Before that, however, there are two sections in which we try to clarify the environment and scope of the problem. First, we will give a literature review on financial management and explain DPP in that context; then inflation process which increases the uncertainty of the environment will be discussed. In the last section we will explain how alternative courses of action are determined and evaluated when faced with a problem.

There is no published work in the financial management literature on "Debt Payment Planning" (DPP), so it is a new problem. But the problem includes many lower level decision making situations which are treated as separate decision making problems in the literature. The scope of the problem will be understood at the end of this chapter, especially after the examination of objectives of the system. For now we can say that we will deal with issues related to both asset and liability management, since our aim is to prepare a schedule by considering both cash inflows and outflows. Because DPP's purpose is not only to liquidate debt but also to establish a healthy financial status to operate the firm. A similar problem, which is called Debt Servicing Problem (DSP) however simply conceived as to pay debt when it is due without concentrating on establishing a healthy financial status of the firm. Its main objective may be basically stated as "to save the day", which may be at the expense of the future. In DPP however, we control the whole process since we put it on a schedule. Debt may increase up to a maximum level which we call $B_{max}$. Although there is no theoretical limitation for the value of $B_{max}$, we should determine an acceptable level and control it. The meaning of 'maximum level of debt' may be understood clearly after the mathematical analysis of the model. Now, we will give a brief overview of financial management.

## 2.1 An Overview of Financial Management and The Place of DPP in It

"Finance consists of three interrelated subareas: *(1) money and capital markets*, or microfinance, which deals with many of the topics covered in macroecenomics; *(2) investments,* which focuses on the decisions of individuals and financial institutions as they choose securities for their investment portfolios; and *(3) financial management,* or business finance which involves decisions within the firm. Each of these areas interact with the others, therefore a corporate financial manager has to have some knowledge of money and capital markets as well as the way in which individuals and institutions are likely to appraise the firm's securities."[13]. **Financial management** (FM) has undergone significant changes over the years. A summary of financial management history, taken from Brigham & Gapenski [13], is given below to describe the content of financial management studies. Then we will discuss the place of Debt Payment Planning Problem in the FM context.

Financial Management has first emerged as a separate field of study in early 1900s, with legal and operational aspects of mergers, consolidations, formation of new firms and of various types of securities issued by corporations. After this period of capital extension, which continued until the great depression in 1929, focus shifted to bankruptcy and reorganization, to corporate liquidity, and to governmental regulation of securities markets. During the 1940s and early 50s, finance continued to be taught as a descriptive, institutional subject, viewed from the outside rather than from the standpoint of management. However, managerial finance techniques designed to help firm maximize their profits and stock prices were beginning to receive attention. In 1950s the major emphasis began to shift from the right-hand side of the balance sheet (liabilities & capital) to asset analysis. Computers were beginning to be used, and models were being developed to help manage inventories, cash, accounts receivable, and fixed assets. Moreover, the focus of finance shifted from the outsider's to the insider's point of view, as financial decisions within the firm were recognized as the critical issue in corporate finance.

The 1960s and 1970s witnessed a renewed interest in the liabilities and capital side of the balance sheet, with a focus (1) on the optimal mix of securities and (2) on the way in which individual investors make investment decisions, or *portfolio theory,* and its implications for corporate finance. Thus far in the 1980s three issues have received emphasis: (1) inflation and interest rates, (2) deregulation of financial institutions and the accompanying trend away from specialized institutions and toward broadly diversified financial service corporations, and (3) a dramatic increase in the use of computers for analyzing financial decisions. Among these, inflation has affected both financial theories and financial decision processes, which will be discussed in the following section. The evolutionary changes have greatly increased the importance of financial management. Finance has been decentralized in organizations and today everybody has responsibility in financial management. Before decentralization, the marketing and sales managers would project sales, production managers would determine the necessary assets to meet these demands and finance manager would raise the money necessary for the purchases. This is no longer valid, now everybody has to follow the financial situation of the firm and filter their decisions from a financial manager's viewpoint.

Financial management may be classified into two as *asset management* and *liability management*, which deal with the left-hand side and right-hand side of the balance sheet, respectively. Further classification leads to *receivables management*, which deals with balancing of inflows due to credit sales; *inventory management* that deals with providing necessary inventory of all kinds (finished product, raw material, work-in process) with minimum cost; and *cash management* that tries to obtain maximum return from excess cash or compensate the deficit with minimum cost. Liability management may be divided into two as *debt management* which deals with external debt; and *equity management* that manages funds provided by owners.

Every financial management problem, directly or indirectly, has a touch of these subproblems. Similarly, DPP also involves some of them. Although it may be conceived in the context of liability management, it is surely related with working capital management. The goal of working capital management may be stated as balancing and timing flows of resources and funds. An excellent working capital management would lead to 0-balance, if we assume that there is no need to hold excess cash on hand. The importance of working capital management may be understood better by the help of an example. Think of a situation where the cost of money is 78% and average turnover for receivables is 2 weeks. In this simple case, the loss due to late collection of receivables is 3% of revenue and this is approximately 30% of net profits assuming a 10% profit margin. A similar argument can be made for inventories instead of receivables and both show their effect under inflation.

## 2.2 The Process of Inflation and Its Effects on Financial Decisions

Changes in the price level (PL) are one of the characteristics of our time. The process of inflation and disinflation are prime examples of the interaction between economics and politics. Without the involvement of politics and politicians, inflation itself is a much simpler phenomena and there are macroeconomic policies against inflation. Economies, however are generally managed by politicians , and it is often argued that the major reason of inflation is wrong diagnosis and so false policies and actions by politicians [8] [46].

Dealing with process of changes in prices is like focusing on symptoms, rather than the underlying reasons which produce the symptoms. In financial decision making the reason of inflation is not so important; the effects of inflation, however, must be considered seriously. The emphasis shall be on the expected change in prices of outputs and inputs; as well as the possible effect of actual price changes in the future.

It is obvious that inflation affects everybody, since it decreases the 'purchasing power of money'. It is not the 'value of money' that is reduced by inflation, as usually told. The important factor that needs special attention is the deceptive effect of inflation [14], since inflation effect is doubled when it is not examined and controlled carefully in industrial firms. In an inflationary environment, managers may be misled by figures that are increasing in nominal terms although decreasing in real terms. In such a case the firm may go broke while showing profits in income statements, unless it can realize that the reported income figures are false due to inflation, and consequently makes the situation worse by taking actions which are not appropriate for the real situation (like paying income taxes, distributing dividends, increasing financial leverage for new investments, etc.)

Financial decisions are affected from inflation only to the extent to which they differ relative to a noninflationary situation. This is described by *nominal* and *real* rates. When something is represented in real terms, we can understand that the effect of inflation is eliminated from it. This may be provided by the well known Fisher formula, which shows the derivation of real rate of interest from the nominal rate.

$$r = \frac{f - e}{1 + e}$$

where $r$ represents the real rate , $f$ represents the nominal rate and $e$ stands for inflation. Although both real and nominal figures give some insight about the situation, real rates should be used in financial analyses, in order to eliminate the deceptive effect of inflation. Now, we will give a brief summary of the literature on inflation.

In references by Agmon & Horesh [3], Evans [21] and Pennacchi[37] , two factors related to inflation are reported to be the major reasons affecting financial decisions. The first is the association between the rate of inflation and the real interest rate (RIR) and the second is the uncertainty related to the expectations of future rate of inflation. These two factors together constitute the nominal rate of interest, which is the realized cost of capital, so, special attention must be paid to these. Analysis of the relationship between interest rates and inflation begins with Fisher's study in 1896 and there is an extensive literature on the subject. In one of the recent studies, Pennacchi [37] summarized these studies and reported some findings based on a survey data. His findings are: "RIR and inflation follow jointly dependent processes. The instantaneous RIR and instantaneous rate of expected inflation are found to be negatively correlated. Also RIR is more volatile than the expected inflation." Another study by Evans [21] analyzes the link between inflation rates and inflation uncertainty. His study is claimed to be the first one that is based on statistical analysis among those which showed the existence of a relationship between long-term inflation uncertainty and inflation rates. Agmon & Horesh also mention that shifts in exchange rates are a major factor affecting financial decisions, especially in today's global business environment. They also analyzed the effect of inflation on the cost of funds, both debt and equity [3].

### 2.2.1 The Inflation Experience in Turkey

While the debt payment problem itself is highly complex and uncertain, it becomes even harder in countries like Turkey due to high inflation rates. Remember that a 15-day delay in receivables collection deleted 30% of profit, in the example given before.

Inflation has been an extremely important issue after 1980. The economic policy decisions made by the government at that year changed the economy radically. In fact this was the time when people realized that they have to think in real terms rather than nominal. It is logical that in a healthy economy, nominal interest rates must be higher than inflation rate so that savings are motivated and the banks can maintain liquidity. Before 1980 this was not valid for Turkish economy , nominal rates were very low and banks were having difficulty in funding themselves. Due to low rates of savings accounts, loans were also very cheap and companies which had the opportunity to get loans from banks made very good profits. Firms did not face any problems in financial planning; existing problems were mostly related to production or marketing functions.

Moreover, in 1980's many firms did not take financial planning seriously and quickly became insolvent, since they could not change their habits which were dangerous in the new situation. They were used to operating with negative real rates, but in the new situation real rates were about 30% . The firms which could not realize the change, could not adapt themselves to new conditions and tried to continue by paying their due debt with more expensive debt. Such firms fell in worse conditions and most of them went bankrupt, since it is seldom possible to operate with a profit margin higher than 30% . Firms which could foresee the future and take necessary actions to liquidate debt immediately were the lucky ones. Most of these firms were able to achieve growth with equity financing. Another mistake was insisting on debt financing without the ability to create adequate funds to repay these debts. So, experience shows that, a firm should have an approach that is able to determine whether the firm will survive or not with given environmental conditions and available funds.

## 2.3 Objectives

A good formulation of the problem requires a proper specification of objectives. The objectives should be clearly specified and defined since it is necessary to understand the importance of the problem and the structure of the associated system. Otherwise the designer and the user are faced with problems in the design or decision making stages. We may know the problem and the ways for solution; however it is not easy to state these in an understandable format. An objective, in order to be meaningful, should be specified so that it is operational and gives guidance. That is, one should judge what to do to achieve an objective. Otherwise it becomes ambiguous and we can not evaluate the performance of a decision made for that objective. We should also mention that the interaction between the main objective and subobjectives is very important. The main objective generally does not satisfy the criteria to be a well-defined objective and in our case it may be stated as "to maintain a successful state of the firm". This means satisfying all parties that are related with the firm, while keeping or providing a good reputation. As can be seen, we have to clarify this definition by more meaningful, operationally defined subobjectives. The important thing about these subobjectives that are worth mentioning is that they interact with each other either positively or negatively: however, they all contribute to the achievement of the main objective. If a subobjective jeopardizes the main objective, then it should be immediately discarded. We have tried to determine such subobjectives and found the following ones as fundamental objectives of a typical industrial firm:

1. to survive in business
2. to ensure solvency
3. to preserve credibility
4. to make profit
5. to maintain growth
6. to satisfy stakeholders (shareholders, employees, customers, etc.)

The above mentioned support of subobjectives to achievement of the main objective is a result of the interaction between these subobjectives. The interaction may be in both directions; either as a contribution or as a conflict and such interacting objectives form a system. Of course, one can not claim that the above list is a complete list of objectives; others may be added to the list. However, we assume that, it contains the most pertinent objectives relevant to DPP and is sufficient for our purposes. It is obvious that some of these objectives are directly and others are indirectly related to our problem. Especially the first three are directly related with the Debt Payment Planning. Others may be conceived either as prerequisite or consequence in the process, or they may be viewed as indirectly related. It is important to clarify that this list does not represent any order either. Each firm may delete some of these objectives or add others and give different priorities according to the specific context that it is in. After this brief discussion on corporate objectives, now we will try to clarify their meanings in more depth. Then we will discuss the interaction among them since it is impossible to understand the problem fully without recognizing the system of objectives concerned.

### 2.3.1 To survive in business

By this objective, we aim to guarantee the existence of the firm in the market. The term 'survivability' will be used instead of 'ability to survive', and indicates the ability to pay all of the existing debt ultimately. The firm must be analyzed in the long term in order to have a correct assessment of survivability. We claim that the firm cannot survive if the firm is not able to pay its total debt even if it liquidates all of the existing assets. So, we may determine whether the firm may survive by analyzing the balance sheet. Liquidation of assets, however is not possible if the firm is trying to continue operations, so the survivability of an operating firm should be determined by the amount of cash generated from operations and reserved for debt payment, which is called "payback fund". We can say whether the firm has the ability to survive or not, however we have to find a measure to evaluate survivability for a meaningful analysis. For that purpose, we have used a measure called *'survivability index'* (SI) as an indicator of the firm's ability to liquidate debt.[15] The amount of initial debt and available payback funds, as well as rate of change in both of them are the parameters of the index, which will be analyzed in detail in Chapter 4.

### 2.3.2 To ensure solvency

Solvency is almost synonymous to survivability in the sense that it also determines debt payment ability. The difference basically comes from the time horizon that they deal with. We call a firm solvent, if it has the ability to pay its debt on time. To make this definition more clear we should make a distinction between different perceptions on solvency, by different approaches. There are so-called 'theoretical' and 'practical' solvency definitions [23]. Theoretical solvency is determined by accounting procedures. The firm is said to be solvent, if its current assets exceed its current liabilities. In this approach, accountants assume that all cash flows are equally predictable and reliable within accepted limits. So, they try to ensure solvency by matching inflows and outflows, for example they issue cheques based on the belief that the customers will pay their bills on due dates. However, in real life, there may be problems in such flows, e.g., there may be deferrals in receivables, and the firm can become practically insolvent, though it was theoretically solvent. So, we have to be ready to solve an insolvency problem that may occur due to any reason. The best thing we can achieve is to have the opportunity to borrow the necessary amount as soon as need arises; so that we can guarantee to pay all liabilities on time.

### 2.3.3 To preserve credibility

Credibility may be simply defined as the ability to borrow whenever need arises. However, credibility has to be measured and there are factors which describe the level of credibility. The most important ones are limit, cost, maturity, etc. Measurement of credibility is not easy, since it depends on various elements and it includes the judgment of the persons who measure it. There is a strong interaction between credibility and solvency; since credibility is highly dependent on the firm's past performance on paying prior debts on time. If the firm has even once became insolvent, or if it has insolvency risk, then the firm will be regarded as less credible. Evaluation of credibility depends on subjective evaluation as well as numerical analyses; so firms should maintain good relations with parties that assess credibility, both on organizational and personal basis. The firm's image (reputation) has a critical role in the determination of credibility so firms should make effort to keep in contact with creditors or their representatives to form a positive perception of their firm. Especially in Turkey, personal relations are at least as important as financial strength of the firm. Now we will briefly discuss how credibility is analyzed in our financial system.

### How Banks Assess Credibility

Assessment of credibility will be analyzed with a bank's point of view, since, by definition, banks are the official financial intermediaries. In practice there may be some creditors willing to lend money directly to the firm; flow of money between creditors and borrowers however, should be through banks. Banks have standard procedures to assess credibility of a firm or an individual, based on analysis of 5 C's; which are listed as character, capacity, capital, collateral and conditions; and are adopted by both practitioners and theoreticians. After the assessment, the level of credibility is reflected by the term, price and collaterals of the credit, if the firm is found to be 'credible'. For example, a firm may be said to have more credibility than another one, if it had been offered less interest rates for a long period with less collateral; and vice versa. Note that we assume that a firm will require credit for a specific project so we will evaluate the firm in view of that project. In case of working capital financing we may take firm's operational targets as its projects that need external financing. Now we will briefly explain 5 C's. Character is determined by the firm's past performance and its image. Like people, the firms also have special characteristics, which affect their financial management and credibility. For example, we may find a firm less credible if we had observed delays in its prior payments. Capacity and capital are related to the firm's operational and financial situation; capacity reflects the assessors judgment on firm's ability to succeed the special project that the firm requires credit for. It is always very hard for a firm to find external financing for the first big project. Especially contractors have difficulty in big opportunities; banks do not want to take the risk and give loans through a syndication, or the firm has to find financing from the government. With capital, we analyze the firm's financing strategy; we check whether the firm has a high debt to equity ratio. Financial statement analyses show the maximum acceptable level of debt that a firm can pay without difficulty; however, we may find a firm credible due to the wealth of its owners which is not reflected in financial statements. So, collateral is an important factor in credibility assessment. The risk may be guaranteed by the 'credible' owner, or we may take cheques and bonds, or mortgage on various fixed assets, etc. as the collateral of the credit. Finally, the term 'conditions' stands for representing the uncertainty of the environment and financial markets which may affect the credibility of the firm either by limits or by prices of credit lines. Now, we will explain how banks operate in Turkey, based on the above description of assessment of credibility. Most of the banks in Turkey, give loans through their credit marketing departments and the procedure of credibility assessment has three basic steps which are:

- Central bank risk terminals
- Financial statement analysis
- Intelligence reports

Central Bank risk terminals is a collection of reports kept in the Central Bank database and is shared by all commercial banks. All of the credit limit and risk that a firm had in the system through banks can be found here. Once a bank is in credit relation with a client, it may reach this information source and check whether the client had a bad record. Moreover the future intention of the firm for debt financing may be determined through historical observation of these records. This is an extremely important data for the past performance of the firm. The second is a standard financial analysis and since the procedure and the format is defined by law, all banks have been submitted the same report. Banks are not allowed to make any comment on these reports, since they are analyzed by auditors of the firm. Comments and other available information are collected in Intelligence Reports. Therefore, the most important information specific to the bank is obtained through Intelligence Reports which are prepared and must be used with judgment. Intelligence Report reflect all of the experience and knowledge of the analyst, on the firm and on the market that it operates in. So it includes detailed description of the above explained 5 C's; and hence constitutes the major part of assessment of credibility.

### 2.3.4 To maximize profit

This objective is perhaps the most known and widely accepted one. In existing studies, the firm is defined economically as a profit seeking organization. A firm has to make profits to continue operations unless it is defined as a non-profit organization which operates for the welfare of the society. Shareholders (owners) of the firm or other parties that invested in the firm want increasing return; therefore making profit is not adequate, hence the firm should maximize profit. By profit maximization the firm will contribute to the main objective since amount of funds that can be used for debt payment or technological development increase, and since the firm offers more return and less risk to creditors and banks. Profit maximization itself is not a robust indicator of firm's situation. We can not be sure whether it is real profit (comes from operations) or is obtained through sale of assets or any other window-dressing operation. So we should also check the Balance Sheet (B/S) and see that B/S is at least more favorable than the previous one.

### 2.3.5 To maintain growth

In addition to increasing profit which shows financial growth, the firm also has to achieve operational growth in order to contribute to the main objective. Usually increasing market share is good for the firm, since it increases profit as well as improving the reputation of the firm. The size of firms affect the credibility of the firm, since revenue and market share are two important factors in the determination of the situation of the firm, they are assumed to have strong financial and technological structures. So, technological growth (development) is also very important. Firms that use modern technology are regarded well.

### 2.3.6 To satisfy stakeholders

All of the objectives that are mentioned above were quantifiable; however, a firm has qualitative objectives and it is harder to define such objectives, since we do not have an absolute criteria for measurement. Measuring the degree of satisfaction is one of these objectives. There is always the possibility of failure in assessing the level of satisfaction, since human perception may lead to biases during evaluation. Satisfaction of parties that exist in the system is important since the degree of satisfaction affects their, and hence the system's, performance. Stockholders, employees, and customers are the major parties that exist in a system and they together are called as 'stakeholders'. Measurement of stakeholder satisfaction is indirectly related to DPP; however it is still important since it interacts with other objectives. We will discuss the interaction in the following subsection, after a brief analysis of our understanding of satisfaction of above listed parties. The motivation of shareholders was described in the preceding subsection as wealth maximization. Shareholders evaluate their wealth by the amount and value of the stocks they own. So, the management should either try to increase the price of stocks or increase the amount of shares that investors have, while keeping their value, of course. It is relatively easy to achieve employee satisfaction which is called 'job motivation' in social psychology literature. In the general management context, employees can be satisfied by good wages and working conditions. In specific terms however, motivation of employees may be affected by the nature of work, subordinates, etc. The most difficult part is customer satisfaction since customers are outside the firm. We have to define what a typical customer is, however, since customers may have different types of behavior distributed in a wide range, so an analysis of typical customer becomes a difficult task. In general terms, we may say that customers desire higher quality, cheaper prices, installment sales, better service, etc.

then the only alternative is to take loan from a bank. Therefore, there is a very close interaction between solvency and credibility. The above discussion implies that solvency is dependent on credibility. On the other hand, credibility is also dependent on solvency. Recall the discussion on credibility which expressed the idea that past performance of the firm affects its credibility. So, we may say that these objectives contribute to each other reciprocally. When insolvency is experienced, firm's credibility immediately becomes zero, and thus it cannot stay operations any longer. Due to this bidirectional relation, we might be faced with a situation where we can lose credibility and become practically insolvent. Hence, in constructing the model, we assumed that the firm has unlimited credibility to borrow. This does not however, mean that we overlook the possibility of insolvency, while solving the problem. On the contrary, by the use of this model, we generate information to point the details of an expected crisis due to insolvency. The detailed discussion is on page 54. It's obvious that it is not easy to provide and maintain high credibility. Moreover, the terms and conditions of a credit may change due to the specific environment, as we do not have standards for credibility. Therefore, we will assume that our decision maker is capable to evaluate whether the conditions and collaraterals of available credits are appropriate or not. If it is not found to be appropriate, then the manager should take actions against insolvency risk, that is should provide necessary funds.

Other objectives, which were stated as profitability, growth and stakeholder satisfaction are especially important for the main objective "maintaining a successful state of the firm". However it is not very important for survivability when credibility is assumed. Otherwise we may find the closely related. For example, profit maximization and ensuring solvency have both conflict and reciprocal contribution. They *conflict* since profit maximization calls for more investment which leads to more borrowing, and therefore increasing the risk of insolvency. On the other hand they *reciprocally contribute* since (a) securing solvency is preserving credibility which increases the borrowing power, hence enables the firm to make more investment and therefore increases the profit and (b) maximizing profit induces higher reputation, and thus more borrowing is DPPSS. As can be seen, DPP is a very complex problem made up of many subproblems and there is a need for an integrative approach to solve the problem. This arises the necessity for the distinction between the problem of planning the payment of debt and the problem of finding an approach to solve this problem. In fact, the subject of this study is the latter of these two problems, which can be regarded as a meta-problem since it includes the former. The term 'meta-problem' is used to describe that the context of the latter problem is larger than the former one. From now on, these problems will be called the "DPP problem" and the "design problem"(DPPSS design), respectively. This section is on the solution strategy for the DPP problem. We will not attempt to solve the problem, but will develop a strategy; which might determine or at least affect the details of the design problem. The design problem will be discussed throughly in the forthcoming chapters. Here it suffices to mention that there is a need for an adaptive system, which may evolve through time. In order to be able to suggest a solution to the system, we must have adequate knowledge about the possible solutions of the debt payment problem. This would be easier if we could solve the problem by mathematical models, but the problem environment is very dynamic and there is uncertainty, so the solution strategy is based on scenario analysis approach. The approach is to describe the uncertainty by several contrasting scenarios which represent alternative courses of action. It requires creativity and judgment of an experienced analyst and gains in appeal where major strategic decisions are being considered, since in almost all cases there is managerial conflict between two alternatives.

Now we will examine some possible courses of action which will be considered as most typical cases during the discussion of the design problem. Note that these alternatives are not the only actions that can be taken to solve the problem. After achieving a successful system for these alternatives, we may increase the number, or better, we may adapt different cases to these alternatives. DPP is different from DSP since it tries to achieve full liquidation, or secure survival. In fact, the simple logic that lies under each alternative is to change the values of the items in the Balance Sheet. To liquidate debt, we have to take an action which will decrease the total liquidities in the Balance

Sheet (B/S). Of course, it should be noted that, the solution can not be obtained through one shot decision making. It requires continuous planning and implementing, appropriate to the changing conditions. The alternatives and their special requirements are as follows :

1. **New Debt :** This alternative does not decrease the level of existing debt, but it is regarded as a short-term activity to continue operations. The assumption related to this case was stated before as the ability of the firm to borrow at any time. We must also mention that in DPP, we may allow debt to increase for a period, which may be called a 'warm-up period'. This may be chosen due to the need for working capital, or to decrease the cost of debt. Depending on the market conditions,we may find new debt with longer maturity or less interest. These are the opportunities that must be considered for flexibility in future actions. Market and its conditions must be observed carefully; since it's the most common channel to borrow and determines the credibility of the firm.

2. **Increasing Owner's Equity :** There are two ways of increasing the capital accounts. The first and the easiest one is valid if the firm is an ownership or a simple partnership. In this case, the owner can inject a lump sum of money by the sale of private assets. This can be regarded as a "very long term, low ( maybe zero) interest debt". Of course, it must be ensured that the amount of funds that will be injected in such cases is within acceptable limits. In a corporation, the owners are legally different from the management of the firm; so we have to issue the amount of outstanding shares in order to increase capital. The firm may issue new shares or sell existing capital stocks and use the funds that are provided by the new partners or old ones who have increased their shares. The important thing that must be discussed here, is the dividend policy of the firm. Issuing new shares causes distributing a higher percent of the profit in the following years, in order to preserve the position of the shares in the financial markets. This must be formulated by a reduction in payback funds, either by decreasing initial payback or its rate of growth, or both.

3. **Sale of a facility** : In fact this may be restated as selling an asset, because it is simply decreasing asset side to decrease the liquidity side of the B/S. This transaction will provide source of funds but probable return of that asset will be lost.This must be analyzed depending on the efficiency of the asset. Of course, each facility has a different impact on the operations of the firm, so these may be analyzed and the DM must be supported with relevant information which might be utilization rates, the contribution to profit, production capacity, etc. So, s/he can decide on the amount of expected losses (even gains for some unprofitable facilities) and incorporate it to the model. Leasing a facility can be analyzed in the same manner.

4. **Do nothing** : Though it is trivial, doing nothing in terms of changing the Balance Sheet items is also an alternative. Major actions like selling assets or issuing shares are not easy to decide and implement. Moreover, it takes too much time to see the implications, so they are not frequently preferred. Of course "do nothing" alternative is preferable, if DM is confident that debt is payable by the self-generated funds, at least in the long run. If market conditions are expected to change, then our action may cause another deviation, but now in the opposite direction. That is, the effect of uncontrollable variables may change the results, so the state of the problem may change. Moreover, it may be more difficult or expensive to solve the problem. The manager being aware of this fact, may prefer to wait and see the results; provided that solvency, which is the most important objective, is ensured. In this case, the manager makes a cost-benefit analysis and decides that the problems that may arise from alternative actions are more serious than the existing problem. In such a case, sensitivity analysis is needed in order to have an idea of the possible states of the problem, in advance. Unfortunately, sometimes this alternative may be chosen unconsciously. The DM cannot realize the existence of a problem, or s/he may lose control of the situation. In such cases, delays in taking appropriate actions may cause bigger problems due to lack of sensitivity analysis.

# Chapter 3

# METHODOLOGY USED IN DESIGNING THE DPPSS

In the preceding chapter we have tried to formulate the DPP. Now, in this chapter we will discuss the methodology used in designing the system to assist DPP. We have called the system Debt Payment Planning Support System (DPPSS); since systems which possess similar properties are named Decision Support Systems (DSS) in the literature. We will begin with a literature review and discussion on DSSs ; then we will describe the methodology that we will use while designing the DPPSS. In this chapter we intend to specify the objectives, properties and components of the system to be designed. So this chapter will form a basis for the design of the DPPSS, which is discussed in Chapter 5.

## 3.1 What's a DSS

There's no single definition for a Decision Support System (DSS). However, there's a consensus on why a DSS should be preferred to other information systems, and each DSS designer or user may give his own definition based on that common idea. One of the earlier definitions is by Keen and Scott-Morton, who may be regarded as two of the originators of the DSS idea. They define

DSS as follows:

"Decision Support Systems couple the intellectual resources of individuals with the capabilities of the computer to improve the quality of decisions. It is a computer-based support system for management decision makers who deal with semi-structured problems. Furthermore DSS implies the use of computers to :

- Assist managers in their decision processes in semi-structured tasks
- Support, rather than replace managerial judgment
- Improve the effectiveness of decision making rather than its efficiency
- Incorporate both data and models", [29]

Another definition is implied by the following statement of J.D. Little: "A Decision Support System is a model-based set of procedures for processing data and judgments to assist a manager in his decision making. A DSS must be

- simple
- robust
- easy to control
- adaptive
- complete on important issues
- easy to communicate with" [33]

Other good definitions of DSS are also provided by Beulens and van Nunen [9], Jelassi et.al. [27], Sprague [42] and Turban [45].The characteristics that are emphasized by these definitions are summarized in Figure (3.1).

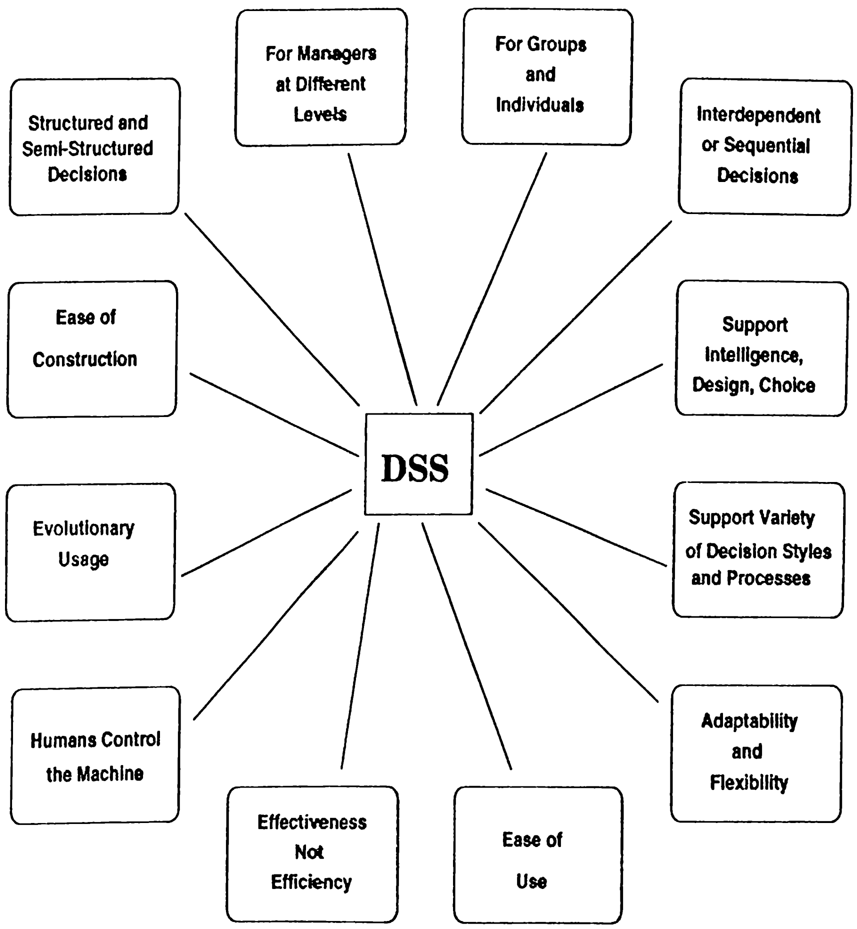


Figure 3.1: Characteristics and Capabilities of DSSs

The development of DSSs should be examined under the evolution of Information Systems (IS). In the beginning there were Operational Information Systems which were dedicated systems to perform specific tasks derived through classical MS and OR techniques. These systems aimed to increase the speed of computation and reduce number of repetitive tasks that should be done by the decision maker. After Operational Information Systems and classical MS/OR, the power of Information Systems has gradually increased with the interactive use of computers. The era of Management Information Systems (MIS) and Decision Support Systems (DSS) began in late 1970s. DSSs assist the decision maker by providing processed information, while MS/OR techniques simply provide data to be analyzed by the decision maker. This is a type of master-servant relation, while the former is assistance. MISs and DSSs arose due to deficiencies of MS/OR systems. Beulens and van Nunen list some of the problems associated with MS/OR systems as:

- poor managerial acceptance
- poor development productivity
- poor usage of new technologies which includes user friendly system interfaces, representation capabilities, etc. [9]

Of course, DSSs have solved these problems with their properties given in the figure above. Beulens and van Nunen report that they have found many similarities and differences when they compared MS/OR and DSS. The comparison of these two systems has utmost importance for us, because some DMs have a desire to hear "optimal" solutions obtained by MS/OR techniques. In such cases their responsibility is reduced although they may know that it is not possible to implement the optimal solution. According to Beulens and van Nunen, MS/OR techniques and DSS differ, since in DSS:

- decision alternatives must be judged by several quantitative and qualitative criteria; so, DM looks for satisfactory, not 'optimal' solutions
- DM is able to evaluate the consequences of his 'own' alternatives and 'what-if' questions
- DM needs 'goal-seeking', e.g. decision alternatives that satisfy certain criteria have to be found
- the evaluation of decision scenarios requires their comparison
- we require more efficient solution procedures to be able to generate necessary decision alternatives and to perform sensitivity analysis
- the user-system interface should enable model and report generation
- model building is more difficult for semi-structured and unstructured problems and thus we need more expertise in such problems

- There may be multiple decisions and the DSS should support the DM to be consistent in such hierarchically related decisions. [9].

After Management Information Systems and Decision Support Systems, today Expert Systems (ES) and Intelligent Decision Support Systems (IDSS) are widely accepted and being used. Although ESs are historically newer, this does not mean its superiority over DSSs. The two systems deal or at least should deal with different problem domains. ES claims to escape the need for human intelligence but DSS incorporates it. Doukidis [20] in his survey paper reports that DSSs are mainly used for strategic and management level whereas ESs usually support operational activities. This remark is consistent with the statement that DSSs deal with unstructured and semi-structured problems while ESs and MS/OR systems mostly deal with structured problems. This is due to the fact that unstructured problems require judgment and sometimes inspired creativity.

After comparing the types of Management Information Systems, now we will briefly present the types of Decision Support Systems with a classification by Keen, based on the level of support provided to the user :

- **Passive Support** : This kind of DSS gives managers tools they are comfortable with and stimulates changes in the decision process.
- **Traditional DSS Support** : These provide a computerized staff assistance. The manager's judgment selects alternatives and assesses results, these include 'what-if' type analyses.
- **Normative Support** : The aim is to provide tools based on a normative view of how decisions should be made rather than how they are made and extend the bounds of rationality.
- **Extended Support** : This type involves an explicit effort to influence and guide decision making, while respecting the primacy of judgment and focusing very carefully indeed on how managers think, what aspects

> of decision process they are likely to be willing to delegate, their expectations and attitudes about the use of analytic tools, etc. [28].

It is clear that our decision support system can not be said to give *'passive'* or *'extended'* support. When we think of the properties of the system, it has a touch of *'traditional'* support that is given to the user; however the effect of the mathematical model in the learning process implies also a touch of 'normative' support.

In order to understand a system's behavior fully, we must be aware of its components. Everybody agrees on three components of a DSS, in the literature. The names given to these components may differ, but the definitions are similar. According to Turban's definition, these are:

1. Data Management. The data management includes the database(s) that contains relevant data for the situation and is managed by software called database management system (DBMS).
2. Model Management. A software package that includes financial, statistical, management science, or other quantitative models that provide the system's analytical capabilities, and an appropriate software management
3. Dialog Subsystem. The subsystem through which the user can communicate with, command the DSS and receive its assistance." [45]

After this brief introduction on what a DSS is, we will continue with the objectives and properties of the system that we will design. From now on, the term **"system"** refers to the decision support system that is to be designed for DPP. Note that in this study, we called it *"the DPPSS (Debt Payment Planning Support System"*. The computer system (DSS) and the DM are two interacting components of a bigger system, "the *main system*"; where DSS is an instrument used by the DM to find solutions to main system's problems.

## 3.2 System of Objectives of DPPSS

The motivation in designing a system for DPP is to assist the DM to identify and solve the problematic situations. It is not intended to prescribe a solution to the problem; since in view of the complexity of the problem, it is impossible to construct an optimization model and provide an algorithm to arrive at an optimal solution. As previously mentioned, there is no 'best' solution to a real problem; optimal solutions exist only to assumed (properly structured) problems. So, the decision maker has to diagnose, formulate and evaluate the problems and then generate solutions judgmentally.

The first objective in designing this system is to assist decision maker to solve the associated DPP problem according to its predefined objectives, which were stated in Section 2.3. In addition to that, the decision system also has to have some objectives of its own to provide effectiveness. These objectives are very important, since system is highly dependent on the interaction between the computer system and the decision maker, so on the effectiveness of the DPPSS. Some of these objectives that we hope to achieve may be listed as follows:

- To enable participative management in decision making
- To be capable of deriving meaningful and realistic information
- To facilitate the use of DM's judgment and intuition
- To enhance learning

In the following discussion, we will clarify what we expect from the system; i.e., we will explain the above objectives. It is clear that the system should possess some properties in order to achieve the above listed objectives. After discussing the system's objectives, we will explain the properties that we expect from the system. Clear understanding of these properties is necessary for a successful design and efficient operation.

1. **Accurate reporting of the current situation.** As discussed before in the first chapter, classical financial measures and figures in inflationary economy are misleading. We try to overcome this deficiency by using real or currentized (inflation adjusted) figures, so that the DM will work with data which represents the current situation correctly. Of course such data does not mean anything unless it can be used for generating meaningful information. If the user fails to evaluate the data, it will be lost before problems are identified. The situation may change and it may be harder, or even impossible to arrive a feasible solution, because usually the deviation increases in the same direction and make things worse.

2. **Identification of opportunities and threats, to assist problem diagnosis.** The computer system must call the user's attention to probable problems. When there are specific values or ranges that can be assigned to performance measures, the user may be warned in case of violation of these limits. However, the system cannot explain whether this is a problem indicator or not. It is the DM's responsibility to analyze the message and understand whether it indicates a problem. Because DM makes the final decision and s/he is the person who has the expertise to evaluate the environmental conditions in order to identify a probable extrordinary factor.

3. **Derivation of accurate information for problem solving and decision making.** The DM would need assistance from the information system while making his decision. For example, in order to choose among alternatives s/he would want to know their probable outcomes, so that s/he can make a comparison. Problems which can be handled via mathematical models have difficulty in the modeling stage. In such problems we may find the "optimal" solution after ensuring the validity of the model for the problem. However, in our case, there are many objectives, most of them being qualitative, and the computer system can not make a decision without involvement of user judgment. Thus, a good system shall give the probable outcomes of alternatives and evaluate in view of objectives concerned in a comparable format. The level of detail for the

information to be given, depends on the user and the specific problem environment. Determination of this level is a difficult task, since people generally feel comfortable with as much detail as possible. However, there are technical limitations for computer systems. Also it is known that after a certain level, details don't help but begin to confuse the DM.

4. **Assisting efficiency and effectiveness in decision making.** According to Heymann & Bloom's definition; we evaluate the degree of ' *doing the* **right thing**' by *effectiveness* and the degree of ' *doing the* **thing right**' by *efficiency* [26]. Clearly, the system shall measure its quality both in terms of effectiveness and efficiency. In a DSS, effectiveness is related to the quality of user interaction and the main system"s effectiveness depends on the quality (or appropriateness) of the computer system and user. If the user is not aware of the problem environment, a perfect system will not help to produce acceptable results. Efficiency , on the other hand, shows the quality (or correctness) of decisions that are made, or the performance of the parties that make the decision. In the main system, the DM will be responsible for the efficiency, while s/he may judge the efficiency of the computer system.

   Different users may have different experiences and interpretations about the operation of a system. Considering these differences, assurance and measurement of effectiveness and efficiency for both DSS and the main system is very difficult. This process must begin during the decision making stage. The computer-user interaction might prevent the user to give inconsistent or infeasible sub-decisions, of course within a predefined scheme. The system may limit user's choices through the operation and so prevent inconsistencies. Also there may be some checkpoints, where the operation is ceased and data-reentry is required. In such cases, the DM explains the reasoning behind his extraordinary decision. This situation may occur frequently, since the market that we are operating in is inefficient; i.e., information is not necessarily shared by everyone in the organization or in the market. Unless we force DM to give reason, the DSS may be perceived as being inefficient, although it is not. These will be discussed in more detail later, in section (5.3). In DSS, both of them will be determined by the user, others can only measure main system's or DM's performance. If we think that the user and the analyst (or programmer) as two different persons, we have to provide a good interaction between these during the design of the system, and come up with an adaptive system in order to make it effective. Its effectiveness will increase through time, parallel to the user's learning. On the other hand, efficiency of DSS is related to repetitive usage and learning. Efficiency will increase as the DM gets feedback from his past performance and renews his knowledge and perceptions.

5. **Learning and adaptation.** In fact this is the most important task that the system should perform in order to be called an efficient and effective 'system'. If the computer system can not support learning and adaptation, it will be static and will not be proper for the dynamic DPP problem. Briefly, we can say that the user learns by repetitive usage and through comparison of system outcomes with their observed outcomes after being implemented; and the DSS learns through adaptation which will be discussed in subsection (3.4.2). Since these are among the properties of the system, they will be discussed in detail in the next section. Learning is an extremely important property of the system and will be observed in two dimensions. These are :

   - Learning system behavior. This must be discussed for both the computer system and the decision system (main system). The user will learn the details of the information system, as s/he uses it. Repetition will enable him to obtain relevant information quickly. Also s/he will feel more comfortable in analyzing the data. This is a cyclic process since the user suggests modifications on the operation of the system and then learns the behavior of the modified system.

     The user will also learn the main system; i.e. the organization that s/he is responsible for and its environment. It is very important to understand the main system in order to be able to make good decisions and to implement them. If the user could not predict the response of the system, s/he would probably fail during implementation, even if s/he had succeeded in the analysis and decision making stages.

- Improving self performance. After implementation, the DM can observe the situation and evaluate the decisions. So, s/he will not repeat any mistakes and this will increase the self performance. Repetitive usage of the same DSS in the same system will enable the user to make his decisions quicker, also s/he will be sure about the correctness of the decisions in routine cases. This may psychologically affect the user and his/her future decisions in a positive manner.

## 3.3 Components of DSS

There are three major components of DSS as briefly mentioned above, in section (3.1). These subsystems constitute most of the work to be done in the design stage and need special attention. Although it is desirable for the system to allow us to make the necessary modifications at a later time, the initial design is still important in the sense that the decision maker should have a proper working system to start with in order to elaborate on and suggest further improvements. In this section there is a brief summary of the components of a typical DSS. The details specific to DPPSS will be mentioned during the discussion on system operation. The structure of components must be determined according to the specific needs of the user and the problem. That's why we have left the discussion for Chapter 5, after discussing the model in Chapter 4.

### 3.3.1 Database

Database is the most important component in our system, in fact in almost all systems. Other components and DSS can not work effectively unless database management subsystem does. Of course, technically it is possible to include all the information that is available in the firm. However, such an action would not be too meaningful in the practical sense. By effective database management we mean not only reaching all the necessary data , but also reaching it quickly and cheaply. So, we must define the limits of the database according to the context and needs of the problem. The structure and content of the database will be determined by the user and the modelbase. In addition to the requirements of the mathematical models and other tools that constitute the modelbase, the user may also like to have some additional data in order to use during his analysis. Since decision making process is different for each individual, database may be larger when there are multiple users.

Related with the modelbase and user interaction, the database should contain historical records of some performance measures, ratios and model parameters. These will be used to generate forecasts based on the historical data. Of course, the forecasts will not be used directly, otherwise the system would behave like an expert system, however it may give insight to the user. This will be achieved by the user interface. In order to allow the user to select among all the alternatives, it might be beneficial to include everything in the database, but this will decrease efficiency of the database and even it may be confusing for the user. So we will keep historical records for some of the above mentioned items. Similarly, a selection of available performance measures will be introduced and used. Using all of those measures is not logical, since some of them require almost all transactions of the firm. For our purposes, we will use classical financial statements : Balance Sheet, Income Statement, and Cash Flow Statement and try to convert them to real (current) terms.

### 3.3.2 Modelbase

The main element of the modelbase of DSS under consideration is the Growth Model of Debt, which will be presented in detail in Chapter 4. Since the model has the capability to generate information, an important part of the analysis is based upon the information derived through the model. In addition to that, the model is useful in generating 'accurate' information which can be used during the modification of performance measures. In order to have a clearer idea of what a modelbase contains, we should mention the type of analysis that can be carried by the model. Using the model we can calculate the survivability index (SI), mentioned in subsection (2.3.1) and defined mathematically in Chapter 4; and make the survivability check which will determine the steps for the further analysis; get the basic information on payment of debt and generate a debt payment schedule which shows the situation period by period until debt is fully liquidated; find threshold values of parameters and observe sensitivity of the results to changes in parameters which is useful for decision making under uncertainty.

The modelbase also contains necessary formulas and equations to calculate the values for performance measures. In addition to that, as mentioned in database, the modelbase will generate forecasts based on trend analysis of the selected measure or parameter based on trend analysis. In fact, forecasting models might be used to have better forecasts which would probably increase the quality of the decisions; however, we did not take it as a major problem and used TREND and AVERAGE functions of EXCEL.

### 3.3.3 User Interaction

This is the component that distinguishes DSS from other management information systems. Since the essence of DSS is the involvement of user's intuition and judgment, we have to design it so that it can improve the efficiency of the decision maker. The quality of the DSS interface may be determined by effective user interaction rather than its output to users. Of course the user interface is bound to change by time. Learning process plays an important role in here; the user will learn about the problem, the associated model and DSS through interaction. This will enable the user to make changes in the system including the user interface. This property makes predesign easier, since the user is allowed to require additional database and modelbase support if s/he does not find the existing support adequate. Nevertheless, it is very important to know the needs of the user in order to achieve a successful draft.

The most important feature of a friendly user interface is its graphics capabilities. In our system information will be given via tables and graphs. Such presentations make information more understandable and digestible. In the literature it is stated that visual aids including tables and graphics are found to be 32% more persuasive than an unaided presentation. [36] The importance of the user interface becomes more clear for some of the tasks that system will perform, for example threshold and sensitivity analyses are done with simple operations.The thing that increases their importance is the way that their results are presented to the user. This also depends on the choice of the spreadsheet package that will form a base to the system. There are some integrated packages which are very powerful both in database and modelbase management as well as extended graphics capabilities. A detailed discussion on selection of spreadsheet will be made in Chapter 5. Briefly, it should be powerful enough to combine the mathematical model with data access functions. Different menus and worksheets are designed for each task, so that any confusion that the user may have is aimed to be prevented. Another thing to mention is that, this design and the user interaction properties is specific to only DPP; so, one should not expect that this can be used as a part of a Financial Management package without modifications. Probably, it would be easier to design a new system from scratch, for a new problem.

## 3.4 System Properties

In this section, the properties that we aim our DSS possess will be defined, characterized and discussed. These are

- Learning
- Adaptation
- Flexibility

### 3.4.1 Learning

A good decision depends on intuition and experience which are obtained through the learning process. Here, it is clear that a rational DM would not use his feelings; intuition is different than instincts. The power of our system is in its learning ability. The system's learning is provided by the involvement of DM and good record-keeping. It is important to keep the records of analysis results and decisions to evaluate after implementation and 'learn' from mistakes or even unexpected results. That is, for a specific case, if we record system's outcome, the decision that is implemented and real observation; we may make a comparison and evaluate the results to make necessary adjustments for similar cases that may occur in the future. The user will also evaluate his decision process and find probable mistakes that might have caused the deviation. This is what a normal person would do in life. Organizational learning is also very similar to individual learning. To give some information we will refer to Levitt & March's [32] survey paper, in which they view organizational learning as routine-based, history-dependent and target-oriented. There are two forms of learning :

- learning from direct experience
- evaluating experience of others

In our decision system, decision is made by the user of the information system. There is no single user, so direct experience does not guarantee organizational learning; because people usually employ a number of different strategies, when presented with a judgment or choice task. Therefore, observation and interpretation of other people's experience is extremely important and must be done with great care. This brings the organizational memory concept into attention. "Since learning is routine-based; experience is maintained and accumulated within routines despite the turnover of personnel and passage of time. Rules, procedures, technologies, beliefs and cultures are conserved through systems of socialization and control. They are retrieved through mechanisms of attention within a memory structure" [32]. Of course, as a part of the total system, financial management is also observed in this context.

There are three stages of organizational learning and associated memory :

- Recording of Experience
- Conservation of Experience
- Retrieval of Experience

Of course, everything can not be recorded. Organizations make distinction between outcomes that are considered relevant for future actions and outcomes that are not. Organizations facing complex uncertainties rely on informally shared understandings more than the organizations dealing with simpler, more stable environments. There is also variation within organizations. Higher level managers rely more on ambiguous information than do lower level managers. Such information is recorded in the organizational memory to evaluate inconsistencies and contradictions. However, information may be lost as time passes, unless experience can be transferred from those who had the experience to those who did not. Experience can be transferred and thus conserved by written rules, oral transitions, formal and informal meetings, etc. However, under some circumstances it can not be conserved and disappears from the organization's active memory. This may result from size of the organization, weaknesses of organizational control, conflict of orders, etc. This clarifies the need for **participative management**.

The most important feature of organizational memory is retrieval of experience. Even within a consistent and accepted set of procedures, it is not easy to retrieve all the necessary information at a particular time. Finding the appropriate data is a time-consuming task and in addition to that, the data has to be processed before being presented to the user. As it will be explained later, the information must be given to the decision maker briefly, by use of graphs, tables, schedules, etc. Of course these increase the cost of finding and using what is stored in memory.

### 3.4.2 Adaptation

As mentioned earlier, in order to be practically valuable, a system should be applicable to many situations. The decision maker would find it ineffective, if dealing with a similar problem requires too many modifications on the system. So, the system must be able to 'adapt' itself to changing conditions. Since conditions change rapidly, we are primarily concerned with 'database adaptation'. As soon as a change occurs, a new analysis can and should be made and the solution strategy may be adapted to the new situation. In addition to that some improvements may be made on the user interface. Sometimes actual users of DSS may be different from those who were originally intended, or user profiles may change as time passes and they get experienced. Finally, modelbase may need adaptation in cases where the results obtained through the model become unrealistic and contradict with decisions made by the user. Therefore, the system will be able to record the decisions and its implications. As told before, the DSS will not be responsible for the judgment of the user, if s/he makes extraordinary decisions. Another helpful thing which will also support learning is a post-analysis. The DM can analyze his case with new information and evaluate the result comparative to the best solution s/he found; i.e., the decision made previously. This is useful to understand the value of information to the company; if it is found to be very high, the company may prefer to invest in collection of accurate information.

### 3.4.3 Flexibility

In fact this is a result of *Learning* and *Adaptation*. At first, we usually cannot specify the functional requirements and users do not know what they need exactly. They will feel more comfortable with an initial system to which they can react and so improve as they learn through time. To do this, the system shall have adequate flexibility. The subjectivity of DMs also require flexibility; there are differences in the ways how DMs use the DSS and how they derive solutions through it. In fact, perceptions of a specific user may also change through time. Of course, there are some problems in determining the level of flexibility. These arise due to the conflict between benefits and costs of flexibility. The following remark made by Te'eni & Ginzberg explains the situation very well.

"Flexibility will usually promote use, creativity, exploratory learning, and adaptability. Further, it may enable decision making using confirmatory analyses. Nevertheless, flexibility usually increases costs and may result in suboptimal or organizationally undesirable strategies, and add to the complexity of learning and operating the decision system. So, we may assume that some degree of flexibility is beneficial, but we do not attempt to determine its optimal level." [44]

## 3.5 Performance Measures

It was mentioned before that in a design process, it is not sufficient to define and explain the properties and elements of the system and that we need to develop some measures to evaluate the performance of the system as a whole. This includes evaluation of both the main system, the computer system and the user. Selection of these measures is an important part of the system design. In any system we need some measures to judge how effective the system components are and how efficiently they operate. Since each system is different, it will have its own measures and evaluation criteria. In this study, the effectiveness measures designed for the main system are called **'performance measures'**. Our purpose in selecting these measures is to enhance learning as well as measuring past performance to diagnose problems. The user can improve his decision making style and skills by evaluating his performance in previous decisions. Also note that the decision maker may be right theoretically, but he may fail due to environmental conditions. The decision maker will learn the factors that interrupt the situation and affect the problem, through evaluation of performance. On the other hand, if DM can not find any reason for the poor performance, then this indicates a problem and performance measures are used in diagnosing and formulating the problem.

Most of these are produced through modification of classical accounting measures according to the specific needs of the Debt Payment Problem. There are also some special measures developed for the DPP problem. Although this is not our primary concern, we have to be able to evaluate the environment in which we are trying to solve a design problem.

It is relatively easier to define and measure system performance, when there is a single objective or even multiple objectives supporting each other. In such situations, one can come up with standardized measures or evaluate different objectives with assigned priorities. It can be guessed that the determination of performance is a complex task in DPP where there are mixed and conflicting objectives. The objectives that we had stated before, in page 15, involve both qualitative and quantitative objectives and some of them are in conflict; so it is very difficult to standardize them, where by standardization, we mean a predefined evaluation criteria for each measure. It could be possible if all of the objectives were quantitative, but there are others like satisfaction, goodwill, etc. Doğrusöz [18] states the issue as follows :

" One of the fundamental issues in decision making is the comparability of the alternative choices ( systems, courses of action, etc.). It is wished to establish a unique measure over the alternatives which would establish a preference ordering among them. Such a measure is generally called value or utility or effectiveness or measure of performance, interchangeably. Such an all encompassing measure is very difficult to define, if not impossible. Many simple measures, however, can be defined each of which help to compare the alternatives from a particular point of view. Cost, revenue, reliability, availability, capability, survivability, etc. can be viewed as such measures....... But in the overall comparison, all such measures should be taken into account simultaneously, meaning that comparison is to be based on a multidimensional value measure. How can one do this, that is, how can one compare vectors? *The best way would be to combine all of these component measures into one measure... This heavily rests on judgment*"

There are two approaches to define a measure of performance [2]. The first is the *a priori* method, in which a complete measure is defined before a model of the problem situation is constructed. In the second, so called *a posteriori* approach, the outcome is expressed either as a measure of expected efficiency for one objective or as an expected effectiveness. The latter is more appropriate for our problem. In that approach to decision making, outcomes are expressed in terms of efficiency and effectiveness of courses of action and the DM must select the course of action which in his judgment yields the best combination of these measures, where best is not explicitly defined. It is not possible to distinguish the best alternative or the best situation in Debt Payment Problem. Everybody will have a subjective ranking of objectives and so will come up with different evaluation schemes. We are forcing survivability to be considered as the most important objective, but we can not influence evaluation of other objectives. Of course, a well defined corporate objective statement will clarify the order of importance for various objectives, but even in that case there may be personal biases and differences due to perceptions. Also there are too many conflicting objectives and the decision maker may have different preference maps in different times, which implies that there is no 'ideal case'.

Classical performance measures are items of the Balance Sheet and Income Statement and ratios obtained by using these items. Financial ratios are usually categorized according to the rapidity with which assets can be turned into cash, the efficient management of assets, the degree of protection for creditors and investors, and the profitability of assets. The result is four categories corresponding to these descriptions :

- liquidity
- activity
- coverage
- profitability

We will not follow this classification, instead we will make proper adjustments and additions when necessary. As it was discussed before, classical measures may be misleading due to inflation since they are generated by ignoring inflation, and inflation accounting, which might be an alternative, is difficult to use. So we need to develop or redefine our measures. These will be discussed in Chapter 5.

# Chapter 4

# THE GROWTH MODEL OF DEBT

As it was explained in the preceding chapters, the motivation is to supply information to the decision maker (DM) to support the use of judgment effectively. Modelbase, as briefly mentioned in Chapter 3, is the component where data is processed and transfered into information. This information could directly lead to a decision if we did not need subjective judgment of an expert. In most problems, however, we need judgment, and models provide assistance to the expert. Therefore, modelbase is very important in decision support and now we will give details about our modelbase before analysis of the DPPSS. Since the problem is too complex to be solved by simple optimization, we will use scenario analysis and what-if analysis to understand how system's behavior is affected by external factors. Recall that "system" refers to the organization that the decision maker is responsible for, and the computer system that is a part of the "main system" is called the DPPSS. We want to enhance learning by these analyses , so the mathematical model (or models) that will be used in this analysis shall be *'descriptive'* rather than *'prescriptive'*. That is, the model should give necessary information to add insight and leave the decision to the decision maker; instead of giving mere results. For that purpose the so called *Growth Model of Debt* (GMD), developed by Feşel [22], will be used as the core of the modelbase of the DPPSS. The mathematical model is basically derived from a differential equation and allows the analysis of debt payment under various scenarios. In this chapter the growth model of debt will be presented. Then the model will be analyzed to show how information is derived through the model.

The model basically expresses the variation of debt over the future years under perceived values of parameters and courses of action. Its value however, is more than being a simple equation of debt over time. Through the analysis of the model, the user can derive many important information and gain insight on the problem. The information that is obtained through the model can be categorized into two :
*a) indicators of debt payment process* and
*b) performance measures.*
The former gives information on important time-points during the liquidation of debt like time of full liquidation or time of maximum debt, etc.; and the latter refers to the measures that are developed for evaluation of performance of debt payment plan. The power of the model comes from its ability to give updated information whenever need arises. The model is developed in two versions,which are:

- Continuous Growth Model of Debt
- Discrete Growth Model of Debt

Below we will analyze the *Continuous Growth Model of Debt* in depth. After deriving it, we will introduce the discrete version and then state the logic behind developing the model in two versions and compare them in section 4.3.

## 4.1 Continuous Growth Model of Debt

In this section , the continuous time version of the model will be derived, i.e., it will be assumed that the debt will grow continuously due to continuous compounding of interest. Before the description of the model, it is better to mention about the *'general growth model of cash flows'* which constitutes the basis for the Growth Model of Debt. The approach by Doğrusöz defines investment as a growth process, which gives a powerful technical basis for modeling investment decision situation, which also constitutes the basis of GMD (see [15], [16] and [22]). General growth model is given by the solution of a simple differential equation which shows the rate of change in the amount of cash over time. The growth process can be decomposed into two interacting components :

- Reproductive growth
- Productive growth

where 'reproductive growth' is the change resulting from interest earned for excess cash or interest paid for cash deficit; and 'productive growth' is net cash that is generated or lost by operations. In DPP case, since our variable is debt over time; reproductive component of growth is interest or any other expenses charged on the existing debt, while productive component is composed of pay back funds (negative growth) or new debt (positive growth).

### 4.1.1 Construction of the Model

The debt of a firm changes according to two components as in the case of decomposition of growth :

- The rate of interest ( reproductive component)
- The amount of payback (or new debt if necessary) (productive component)

The solvency of the firm in the short run is dependent on a comparison between annual interest charges and annual pay back; either the debt decreases or the firm gets new loan. The important issue in representing this relation by a mathematical model is to express debt as a function of time, $t$. This requires some assumptions some of which were mentioned before :

1. The firm can borrow money whenever and as much as it needs.
   The logic behind this assumption was discussed in the previous chapter where we had stated the objectives of the firm. The firm must ensure credibility in order to guarantee to remain solvent.

2. Debt is charged by an interest rate $\alpha$ compounded continuously.
   This rate is also assumed to be constant over time. This assumption is necessary to be able to express the model with a simple equation, although this assumption can be relaxed, if a complexity can be tolerated, which is not necessary.

3. Pay back is made at a continuous rate of self generated funds by the firm.
   The unit growth rate of pay back ($\beta$) is also assumed to be constant for the same reason. In fact for all practical reasons $\beta$ may be taken as the inflation rate. The firm that is under analysis is assumed to operate under steady state in terms of volume of business and productivity discarding the effect of inflation, so there is no sense to expect a change in available funds in real terms. Of course this is true for real terms, so we use $\beta$ to express it in nominal values which are going to be used in the analysis. The next assumption also supports this discussion.

4. No loan is used for investment or amount of funds used for investment is deducted from self generated funds to derive payback fund . We may classify the investments as obligatory and non-obligatory. In fact we may record the former as expenses, so we can assume that no investment is made by using pay back fund. New investment (and also sale of assets) possibly affects operations and causes changes in pay back. This will be discussed in detail in Chapter 5.

In order to represent debt as a growth model, we must be able to differentiate between components of debt and to represent them correctly. It is obvious that debt increases at the unit rate $\alpha$ (unit reproductive growth rate) and since new investments are not allowed, the productive component is solely composed of available pay back funds which lead to negative growth. Now we can represent $\frac{dB}{dt}$, *the rate of change of debt* $B$ by

$$\frac{dB}{dt} = \alpha B - a(t) \tag{4.1}$$

where

$B$ : The size (amount) of debt

$\alpha$ : Unit reproductive growth rate of debt per unit time ($\alpha \geq 0$)

$a(t)$ : Pay back rate (rate of self payment fund (SPF) (see section (5.3)))

Here it is obvious that, $\alpha B$ is the growth rate of debt due to *reproduction* and $a(t)$ is the negative growth rate due to *production.* A proper $\alpha$ has to be determined. This value will be based on inflation forecasts and real rate expectations, which is dependent on the current situation of the financial markets. The solution of equation (4.1) yields :

$$B(T) = e^{\alpha T} \left[ - \int_0^T a(t)\, e^{-\alpha t}\, \mathrm{dt} + c \right] \tag{4.2}$$

$t = 0$ gives B = $B_0$ so c = $B_0$, where $B_0$ is the initial size of debt. Hence the final form of the equation (4.1) is :

$$B(T) = e^{\alpha T} \left[ B_0 - \int_0^T a(t)\, e^{-\alpha t}\, \mathrm{dt} \right] \tag{4.3}$$

which we call the **Continuous Growth Model of Debt**

We will analyze the model both mathematically and numerically. In fact, the numerical analysis is necessary to ensure that the results of mathematical analysis are correctly understood. We will give examples of numerical results while discussing the operation of the system in the following chapters. In fact, it is a very important issue, since presentation of the information is very important for satisfying suspicious minds, and this will be explained in detail during the design of the system. For the moment, we will only deal with the mathematical analysis of the model.

The assumption of unlimited cerdibility (i.e. the firm can borrow money whenever and as much as it needs) appears too strong. In fact, as in real world, creditors stop giving credit (loan) to the firm when the debt level exceeds an upper limit (Figure (4.1)).

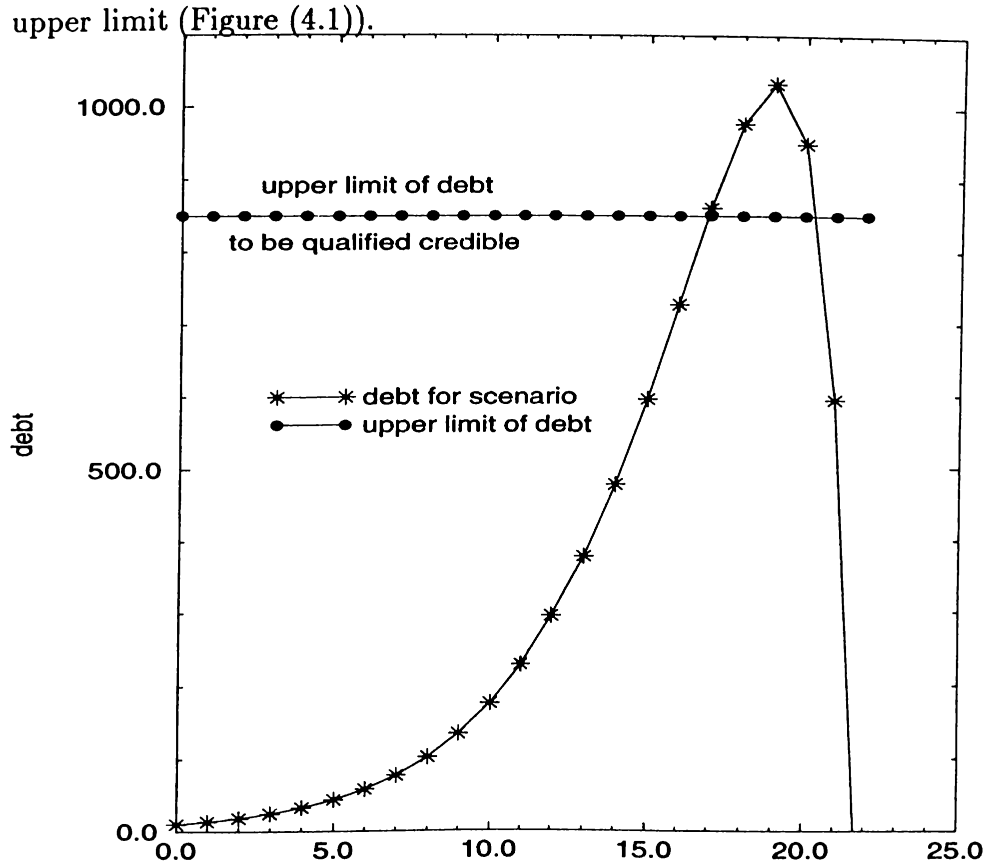


Figure 4.1: Scenario where max.level of debt is bounded

Even in this case, the model which is based on unlimited credibility, still provides a very useful (and reliable) information by indicating the period that the limit exceeded. This gives a warning to the DM to take action to overcome this critical situation. Thus, summing up, the model constructed on the assumption , which appear unrealistic at first sight, is still a reliaable and very useful instrument of information generation.

### 4.1.2 Mathematical Analysis of the Continuous Case

In this part, we will analyze the growth model which is presented above. As it is mentioned before, the power of the model is in its ability to enable information generation. In equation (4.3) we assumed $a(t)$ to be of any amount, other assumptions of the model were stated in page 52. In order to simplify the computations, we may make another assumption that the pay back rate increases exponentially at a unit rate $\beta$ ( as in the case of $\alpha$ ) :

$$a(t) = a_0 e^{\beta t} \tag{4.4}$$

where

$a_0$ : initial pay back rate

$\beta$ : unit growth rate of pay back rate $(\beta \geq 0)$

It is obvious that determination of $\beta$ is more difficult than $\alpha$. In fact, determination of $a(t)$ itself is difficult since it is affected by various factors. The equation (4.4) holds under the assumption that the firm is operating in steady state, that is real sales and efficiency does not change through time. We assume that the input and product prices increase at a constant rate of $\beta$ which was told to be equal to the inflation rate. This implies that the firm's self payment fund (SPF) also increases continuously at a rate of $\beta$. When (4.4) is substituted into (4.3), we get

$$B(T) = e^{\alpha T} \left[ B_0 - a_0 \int_0^T e^{(\beta-\alpha)t} dt \right] \tag{4.5}$$

and integration yields

$$B(T) = e^{\alpha T} \left[ B_0 + \frac{a_0}{\beta - \alpha} ( 1 - e^{(\beta-\alpha)T} ) \right] \tag{4.6}$$

This is the formula that will be used throughout the analysis as it is computationally more convenient.

The mathematical analysis of the model will be presented in three groups, which are found to give interesting and meaningful results, as well as very useful information.

*i)* The analysis of pay back time of debt

*ii)* Analysis of the first order derivative

*iii)* Analysis of the second order derivative

The model should be analyzed in three cases of relative position of $\alpha$ and $\beta$ to each other. Remembering that $\alpha$ and $\beta$ are both positive numbers, these three cases are given below.

- $\alpha < \beta$
- $\alpha = \beta$
- $\alpha > \beta$

However, we should mention that usually one would expect $\alpha$ to be greater than $\beta$ in a sound economic environment. One of the other two cases indicates a negative or zero RIR, and this of course is not meaningful. The rates in Turkey before 80's is a good example of such a situation.

<u>for $\alpha < \beta$ case :</u>

Debt ( $B(T)$ ) is monotone decreasing with $T$, since $(1 - e^{(\beta-\alpha)T}) < 0$ (see equation (4.6) ). So, it is sure to be liquidated very quickly. This is intuitively conceivable, since it means that pay back funds grow faster than reproduction of debt. This is the trivial but unusual case , and DPP is not of a concern.

<u>for $\alpha = \beta$ case :</u>

In this case (4.5) directly turns to

$$B(T) = e^{\alpha T} \left[ B_0 - a_0 T \right] \tag{4.7}$$

So, $B_0$ will be liquidated within finite time for sure, provided that $a_0 > 0$

for $\alpha > \beta$ case :

This is the case that reflects reality and hence liquidation of debt is not as obvious as in the above cases. We can rewrite equation (4.6) as

$$B(T) = e^{\alpha T} \left[ B_0 - \frac{a_0}{\alpha - \beta} \left( 1 - e^{-(\alpha-\beta)T} \right) \right] \tag{4.8}$$

in order to ensure liquidation, we shall find a finite $T^0$, called *Pay Back Time of Debt* for which $B(T) = 0$.

This is the most fundamental information obtained from the model. Pay Back Time (PBT) is the root of equation (4.6) with respect to $T$. When we equate (4.6) to 0 we get :

$$T^0 = \frac{1}{\beta - \alpha} \ln \left[ 1 + \frac{B_0}{a_0} (\beta - \alpha) \right] \tag{4.9}$$

In order to simplify the equation, we will introduce parameters $\Delta$ and $r$ , where:

$$\Delta = \alpha - \beta$$

$$r = \frac{B_0}{a_0}$$

so,

$$T^0 = -\frac{1}{\Delta} \ln[1 - r\Delta] \tag{4.10}$$

### Analysis of Pay Back Time

It is clear that we can analyze $\alpha > \beta$ and $\alpha < \beta$ cases together, when we correctly understand the meaning of the general equation (4.10). In fact the problem was in $\alpha > \beta$ case. It is different and relatively easier to analyze the $\alpha = \beta$ case.

We shall use (4.10) and derive PBT from this equation :

$$T^0 = \frac{1}{\alpha - \beta} \ln \left[ \frac{a_0}{a_0 - (\alpha - \beta) B_0} \right] \tag{4.11}$$

Obviously, $T^0$ exists if

$$\left( \frac{a_0}{a_0 - (\alpha - \beta) B_0} \right) > 0 \tag{4.12}$$

that is

$$a_0 - (\alpha - \beta) B_0 > 0$$

or

$$\frac{a_0}{B_0} > (\alpha - \beta)$$

this can be represented in terms of $r$ and $\Delta$ :

$$\frac{1}{r} > \Delta \qquad \text{or better} \qquad 1 - r\Delta > 0 \tag{4.13}$$

meaning that debt can be paid iff the difference between unit growth rate of debt and the unit growth rate of pay back fund is less than the ratio of initial pay back rate of fund to initial debt.

In fact this inequality (4.13) gives the survivability index ($SI$) (see [15]).

$$SI = 1 - r\Delta$$

By SI we check whether the debt can be paid with given parameters. This measure shows whether our debt of $B_0$ increasing at a rate of $\alpha$, can be paid with paybacks starting with $a_0$ and increasing at a rate of $\beta$.

Note that, it can be paid in all cases where the firm's pay back funds grow faster than its debts. So we do not need to deal with SI when $\alpha < \beta$, that is $\Delta < 0$. Under normal conditions , that is when $\alpha \geq \beta$ , $-\infty < SI \leq 1$ is satisfied. Our aim is to achieve $0 < SI \leq 1$ , which is the solvency range. Remember that this is theoretical solvency, since the firm is assumed to be credible to borrow as much cash as it needs.

Although it is very simple, equation (4.10) may not be understood by the decision maker , since there is the *"ln"* function in it. As our primary aim is to assist the DM, we shall find a better form to express payback time (PBT), $T_0$. It can be expanded into a formal Maclaurin series in powers of ( $r\Delta$ ) :

$$T^0 = -\frac{1}{\Delta}\left[-r\Delta - \frac{r^2\Delta^2}{2} - \frac{r^3\Delta^3}{3} - \frac{r^4\Delta^4}{4} + \ldots\right] \tag{4.14}$$

$$T^0 \simeq r\left[1 + \frac{r\Delta}{2}\right] \tag{4.15}$$

Obviously equation (4.15) gives an intuitive feeling about the situation. However, it is important to mention that the derivation of equation (4.15) from (4.10) is valid if $r\Delta \ll 1$. Otherwise, if $r\Delta < 1$, then we have to add a few higher ordered terms of the Maclaurin expansion in order to get a close approximation to the exact formula.

In $\alpha = \beta$ case, substituting $\Delta = \alpha - \beta = 0$ into (4.10) we get

$$T_0^0 = r \tag{4.16}$$

where $T_0^0$ is the PBT for $\alpha = \beta$.

### Maxima Analysis (Analysis of First Order Derivative of Debt)

When appropriately defined, the function $B(T)$ must satisfy the following conditions in order to have a maximum at a specific point $T$ :

$$\frac{dB}{dT} = 0 \quad \text{and} \quad \frac{d^2B}{dT^2} < 0$$

The first order derivative of (4.6) is :

$$\frac{dB}{dT} = e^{\alpha T}\left[\alpha B_0 - \frac{\alpha a_0}{\Delta} + a_0 e^{-\Delta T}\left(\frac{\alpha - \Delta}{\Delta}\right)\right] \tag{4.17}$$

and solution of $\frac{dB}{dT} = 0$ gives :

$$T = -\frac{1}{\Delta}\ln\left[\frac{\alpha}{\beta}(1 - r\Delta)\right] \tag{4.18}$$

Since $\frac{d^2B}{dT^2} < 0$ is also satisfied , we will call $T$ in (4.18) as "$T^m$", representing *time of the maximum value of debt*, i.e. the time where debt reaches its maximum value. This value is very important too. Assuming realistic values for the parameters, it is seldom possible to reduce debts sharply; generally, there is a warm-up period for the policy to be effective. After $T^m$, cumulative debt begins to fall.

We can write (4.18) as :

$$T^m = -\frac{1}{\Delta} \ln \frac{\alpha}{\beta} - \frac{1}{\Delta} \ln (1 - r\Delta) \tag{4.19}$$

A comparison of (4.19) with (4.10) gives :

$$T^m = T^0 - \frac{1}{\Delta} \ln \frac{\alpha}{\beta} \tag{4.20}$$

and

$$T^0 - T^m = \frac{1}{\Delta} \ln \frac{\alpha}{\beta} \tag{4.21}$$

This interesting relationship between two terms is very important for the decision maker, as it simplifies and shortens the time required for the analysis. Once $T^0$ is found, it is very easy to calculate $T^m$, or vice versa. The spread between two time points is only affected by changes in $\alpha$ and $\beta$ and is independent of the initial situation. Here, you can easily see that, the DM cannot determine the spread in the beginning, since $\alpha$ and $\beta$ are deterministic and are not constant as we have assumed. The relation between $T^0$ and $T^m$, which is obtained through the model, enables the DM to adapt the values according to the environmental changes. That is, since $T^m$ is observed before $T^0$; in case of a deviation in actual and planned values the analyst may modify $T^0$ using actual $T^m$ and current $\alpha$ and $\beta$ values according to the formula given in (4.21). This is an example of the system's power to support learning and hence performance. The decision maker is able to use his experience and updated information to evaluate the situation and increase the performance.

For the $\alpha = \beta$ case, we take the limit of (4.18) when $x \longrightarrow 0$, and obtain :

$$T_0^m = r - \frac{1}{\alpha} \tag{4.22}$$

The relation between $T_0^m$ and $T_0$ , where $T_0^m$ is time of maximum value of debt for $\alpha = \beta$ is :

$$T_0 - T_0^m = \frac{1}{\alpha} \tag{4.23}$$

This equation is much simpler than equation (4.21) and similarly important for the decision maker. It can be observed from both equations that the spread between time of complete liquidation and time of maximum debt is independent of the initial situation and is only dependent on the rate of growth of the payback fund or equivalently on the rate of growth of debt.

Now, since we know $T^m$ for each case we can find $B^m$ values which represent maximum value of debt. This information is also important for the DM, although it is not as critical as $T^0$ or $T^m$ for DPP purposes. By $B^m$ the firm knows the limits to its debt and it is able to take the precautionary actions, if necessary. This is more related with the 'cash management' concept of FM. The finance manager must ensure the availability of adequate funds and must be ready to defend the company against any questions, complaints that can come from the creditors. The formulas for *maximum amount of debt* are given below for the three cases. The variables $B^m$ , $B_0^m$ are used corresponding to $T^m$ and $T_0^m$ i.e.

$B^m$ : Level of debt at $T^m$

$B_0^m$ : Level of debt at $T_0^m$

Since $B^m$ represents debt when time is $T^m$, we can state the formula for $B^m$ by substituting $T^m$ in equation(4.6) as :

$$B^m = e^{\alpha T^m} \left[ B_0 - \frac{a_0}{\Delta} ( 1 - e^{-\Delta T^m} ) \right] \tag{4.24}$$

By substituting $T^m$ , which was given in equation (4.19) we get:

$$B^m = \frac{a_0}{\beta} [ \frac{\alpha}{\beta} ( 1 - r\Delta ) ]^{-\frac{\alpha}{\Delta}} ( 1 - r\Delta )$$

or

$$B^m = \frac{a_0}{\beta} u^{-\frac{\alpha}{\Delta}} \left( 1 - r\Delta \right) \tag{4.25}$$

where $u = \frac{\alpha}{\beta} \left( 1 - r\Delta \right)$

In the case of $\Delta = 0$, eq. (4.6) returns to :

$$B_0^m = e^{\alpha T_0^m} \left( r - T_0^m \right) \tag{4.26}$$

Substituting (4.22) into (4.26) $B_0^m$ is obtained as :

$$B_0^m = \frac{a_0}{\alpha} e^{\left(\alpha r - 1\right)} \tag{4.27}$$

Both $B^m$ and $B_0^m$ which are given by equations (4.25) and (4.27) respectively, have complex formulas for the DM. The important contribution of these formulas are that, they eliminate the need for calculation of $T^m$ and $T_0^m$ first. Therefore, it is useful in controlling the credit limits. In addition to knowing $T^m$ and $B^m$ for the given parameters exactly, various $B^m$ values may be found by sensitivity analysis. This additional information may be very useful since there is uncertainty in the problem. The decision maker can get an insight about the possible cases and can easily and quickly adapt to changes.

### Analysis of the Second Derivative

So far, we have analyzed $T^0$ and $T^m$ ; two points in time where debt is fully paid in the former and reaches its maximum in the latter. Another useful information is $T^i$ , the inflection time of debt curve. We know when debt reaches its maximum its second derivative is negative, but we do not know where it turns from positive to negative. $T^i$ is obtained by the root of second derivative of the growth model of debt. In fact, the point where the second derivative changes its sign that is, it equals zero may not mean too much to a manager. We find it important since we think that, the elapsed time until the sign changes, which is $T^i$ can be used as a measure of riskiness. $T^i$

is like the turning point for the faith of the firm. Rate of rate of change of debt becomes negative after this point. So, creditors will prefer shorter $T^i$ values, since this means quicker liquidation of debts. Before $T^i$ , most of the SPF will be allocated for interest payments, while after inflection point the situation will change in favor of capital payments. Once we pass $T^i$ we can be comfortable thinking that we have guaranteed to pay debts fully provided that the parameters do not get worse.

The second derivative of equation (4.6) is as follows :

$$\frac{d^2B}{dT^2} = e^{\alpha T} \left[ \alpha^2 B_0 - \frac{\alpha^2 a_0}{\Delta} + \frac{a_0}{\Delta} e^{-\Delta T} ( \alpha - \Delta )^2 \right] \tag{4.28}$$

*Inflection time*, $T^i$ is the time when the second derivative is equal to zero. So, by equating (4.28) to zero we get :

$$e^{-\Delta T^i} = \frac{\alpha^2}{\beta^2} ( 1 - r\Delta ) \tag{4.29}$$

and by taking the natural logarithm of both sides, we obtain $T^i$ as:

$$T^i = -\frac{1}{\Delta} \ln \left[ \frac{\alpha^2}{\beta^2} ( 1 - r\Delta ) \right] \tag{4.30}$$

Again, the analysis continues as done before. By further modifications on (4.30) we may write :

$$T^i = -\frac{1}{\Delta} \ln \alpha^2 \beta^2 - \frac{1}{\Delta} \ln ( 1 - r\Delta ) \tag{4.31}$$

Note that the condition for the existence of a finite $T_0$ which was given in equation (4.13) is necessary here also; since $T^i \longrightarrow \infty$ , in case of $SI = 1 - r\Delta < 0$ , which means that the sign of the second derivative never changes and always remains positive. In such a case, a finite time of inflection does not exist and debt cannot be paid.

Recall that the second term of the right-hand side of (4.31) was given in (4.10) representing $T^0$ . So,

$$T^0 - T^i = 2\frac{1}{\Delta} \ln \frac{\alpha}{\beta} \tag{4.32}$$

This last equation shows the elapsed time between payment time and inflection time of debt. A very interesting relation arises from here. Remember equation (4.21) which was the elapsed time between payment time of debt and time of maximum debt :

$$T^0 - T^m = \frac{1}{\Delta} \ln \frac{\alpha}{\beta}$$

So, when we combine these two equations we get :

$$\begin{aligned} T^0 - T^i &= 2(T^0 - T^m) = 2(T^m - T^i) \\ T^0 - T^m &= T^m - T^i = \frac{1}{\Delta} \ln \frac{\alpha}{\beta} \end{aligned} \tag{4.33}$$

In $\alpha = \beta$ case, the following expression is found again by equation (4.30) and by limit when $x \longrightarrow 0$ :

$$T_0^i = r - \frac{2}{\alpha} \tag{4.34}$$

Similarly by (4.16) we get :

$$T_0^i = T_0^0 - \frac{2}{\alpha} \tag{4.35}$$

and by (4.23)

$$T_0^i = T_0^m - \frac{1}{\alpha} \tag{4.36}$$

Again the same relation that was given in equation 4.33 is observed between $T_0^0$ , $T_0^m$ *and* $T_0^i$ , i.e. :

$$\begin{aligned} T_0^0 - T_0^i &= 2(T_0^0 - T_0^m) = 2(T_0^m - T_0^i) \\ T_0^0 - T_0^m &= T_0^m - T_0^i = \frac{1}{\alpha} \end{aligned} \tag{4.37}$$

Table 4.1 gives all of the equations that are given up to now for the continuous case.

| | $\alpha <> \beta$ |
|---|---|
| 1. Payment Time | $T^0 = -\frac{1}{\Delta} \ln[\,1 - r\Delta\,]$ |
| 2. Time of Maximum Debt | $T^m = -\frac{1}{\Delta} \ln \left[ \frac{\alpha}{\beta} (\,1 - r\Delta) \right]$ |
| 3. Inflection Time | $T^i = -\frac{1}{\Delta} \ln \left[ \frac{\alpha^2}{\beta^2} (\,1 - r\Delta) \right]$ |
| 4. Amount of Debt at$T^m$ | $B^m = e^{\alpha T^m} \left[ B_0 - \frac{a_0}{\Delta} (\,1 - e^{-\Delta T^m}) \right]$ |

| | $\alpha = \beta$ |
|---|---|
| 1. Payment Time | $T_0^0 = \frac{1}{r}$ |
| 2. Time of Maximum Debt | $T_0^m = r - \frac{1}{\alpha}$ |
| 3. Inflection Time | $T_0^i = r - \frac{2}{\alpha}$ |
| 4. Amount of Debt at $T_0^m$ | $B_0^m = \frac{a_0}{\alpha} e(\alpha r - 1)$ |

$\Delta = \alpha - \beta \qquad r = \frac{B_0}{a_0}$

Table 4.1: Summary of equations derived by continuous GMD

## 4.2 Discrete Growth Model of Debt

In the discrete case,the fundamental equation is a "difference" equation rather than a "differential" equation. Difference equations are often used in business analysis, as they are easier to understand and data are usually recorded periodically. In DPP we also pay or borrow at discrete points in time. So use of a discrete model seems to be more appropriate.

The assumptions that were used for the continuous case are also valid in discrete model except that, 'continuous' compounding and payment is replaced with 'discrete'. That is, pay back of debt is made annually ( or at any selected period) and interest on debt is charged by discrete compounding.

The notation is slightly different to prevent any confusion :

$B_t$ : amount of debt at end of period t

$a_t$ : annual pay back fund for year t

$\bar{\alpha}$ : annual unit reproductive growth rate of debt

$\bar{\beta}$ : annual unit growth rate of pay back fund

$\bar{a_0}$ : initial value of pay back fund

The following difference equation represents the annual growth of debt :

$$\Delta B_t = \bar{\alpha} B_{t-1} - a_t$$

or equivalently,

$$B_t = (1 + \bar{\alpha}) B_{t-1} - a_t \tag{4.38}$$

Note that $(\bar{\alpha})$ is the reproductive rate of growth and the solution of (4.38) gives

$$B_T = (1 + \bar{\alpha})^T \left[ B_0 - \sum_{t=1}^{T} a_t (1 + \bar{\alpha})^{-t} \right] \tag{4.39}$$

which is the **Discrete Growth Model of Debt.**

When we substitute the annual pay back fund $a_t$ $(a_t = \bar{a_0}(1 + \bar{\beta})^t)$ in (4.39) , we get

$$B_T = (1 + \bar{\alpha})^T \left[ B_0 - \bar{a_0} \sum_{t=1}^{T} \left( \frac{1 + \bar{\beta}}{1 + \bar{\alpha}} \right)^t \right]$$

and

$$B_T = (1 + \bar{\alpha})^T \left[ B_0 - \bar{a_0} \sum_{t=1}^{T} e^{-\Delta t} \right] \tag{4.40}$$

as the final form of the model. The details of the computation can be found in the appendix.

## 4.3 Discussion on Continuous and Discrete Cases

It is clear that the continuous version of the model does not represent real life exactly. This is due to the discrete nature of the financial processes. First, the firm does not pay and borrow money continuously. Second, business data are recorded in discrete points in time even if the time between transactions is short.

Therefore, continuous model may be regarded as unrealistic; while discrete version of the model reflects the real situation better. However , we do not prefer to use the discrete version because of its relatively higher complexity and longer computation time. It is relatively more difficult to find $T^i$ *and* $T^m$ values in discrete case.

So we try to achieve a balance between the computational easiness and appropriateness to reality. The solution is in constructing a continuous model equivalent to the discrete model. Given the parameters $\bar{a_0}$ , $\bar{\alpha}$ and $\bar{\beta}$ of discrete model, one can calculate corresponding continuous model parameters $a_0$ , $\alpha$ and $\beta$ ; so the two models become equivalent [22]; i.e. they both give the same values for discrete time.

The relations between the parameters can be shown as:

$$\alpha = ln(1 + \bar{\alpha})$$

$$\beta = ln(1 + \bar{\beta})$$

$$a_0 = \bar{a_0} \frac{\Delta}{e^{\Delta} - 1}$$

recall that $\Delta = \alpha - \beta$ so, $\Delta = \ln \frac{1+\bar{\alpha}}{1+\bar{\beta}}$ .

Hence, we will use the equivalent continuous model to generate more meaningful information in an easier manner. Since the decision maker may get confused with the continuous model, he will be allowed to enter the data in discrete terms and then, the parameters will be converted to continuous equivalents and the analysis will continue with the equivalent continuous model to generate information.

# Chapter 5

# DPPSS DESIGN

In this chapter, we will show and explain the specific details of the DPPSS. The purpose is to integrate and apply elements of the methodology discussed in Chapter 3. We will discuss the steps of design and operation which will help the system to achieve the objectives and to acquire the properties that we desire. First, we will briefly remind these properties, although they were previously discussed in Chapter 3, then will describe and demonstrate the operation of the proposed system by an example session.Examples are always a good way for learning, so this sample will clarify the details of design. In the design process, agreement of the user and the designer is an important objective. Chapter 5 will serve this purpose. With this chapter, it is hoped that the designer and the user of the DPPSS will understand the power and limitations of the system in concrete terms.

## 5.1 Properties Restated

We say that, we are designing the DPPSS which is " a DSS to assist decision making for the DPP problem". Success of such a design can be determined by how often and efficiently it is used. In order to use it, Decision Maker must be confident that s/he can make better decisions by using the DPPSS.

In other words, *the system must prove that it will increase the effectiveness of the use of judgment and intuition of DM.* So in the design stage, we will try to achieve two main objectives which will cover the properties that are necessary to satisfy the user. These are restated briefly in the following, though they were discussed in detail in Chapter 3.

- **To provide understandable and digestible information to the user:** The user, first of all wants easy and quick access to information. This implies that either the user should know where s/he can get information from, or the information should be directly given to the user. In both cases, there is the risk of information overflow. The user may get more information than s/he really needs and may get confused. The second case, where information is directly given, is more critical since it also has the risk of insufficient information. That is, we may still give too much information but the user may need different and perhaps less information. It is very hard to assess the user's need since level and content of information differs from user to user, according to the capability and skills of the user. Therefore it should not be standardized. A typical decision maker is assumed to know and be able to analyze the long run goals and strategies of the firm. He is not expected to know all the details, although details are very important in most cases. Thus, the system will serve the user to get information on details. Remember that data and information are two different things; and a DM requires information, which can be described as 'processed data'. For example, historical records of sales figures are data and we can calculate their average or variability as information. Representation of data in current figures may also be conceived as information. It is obvious that the effectiveness of the decisions would decrease, if the user loses time and energy to analyze the data. Specific to our case; we will need past data and forecasts for our decision parameters (which are $\alpha$ , $\beta$ , $B_0$ and $a_0$). After that, current information, which should be adjusted for inflation, may be retrieved from financial statements. The effect of inflation was discussed before, so it is obvious that inflation adjustment is vital for obtaining true information. Finally, we should add that format and presentation of information, which is the subject of user interaction, has a great effect in making it understandable and digestible.

- **To enable and enhance learning:** The achievement of this objective may be regarded as the core of our system and has two dimensions. In this context, both the system and the user will learn in a cyclic process. The two dimensions of learning are; *(1) learning how the main system functions* and *(2) developing and improving the decision making skill by evaluating past performances.* The former is especially important for diagnosing the problems, deciding for their solutions, and implementability of decisions. The most critical element of a decision is insight and judgment of the decision maker. There are too many organizational and environmental factors that may change the state of the problem and insight, which is gained through experience is necessary to identify system's behavior under different conditions. By making analyses after making the decision in different conditions, the decision maker can compare the expectations behind the decision with actual results attained after implementation. Thus, s/he can find mistakes in her/his decision making style and improve it. This is an obvious example of learning. Recording these analyses is especially important if there are other decision makers in the system. Decision maker must transfer his experience to the computer in a predefined format so that other decision makers may reach this information later. This process is called 'organizational learning' and is necessary to achieve **participative management**, which was claimed to be one of the objectives of the system. This procedure enables the decision maker to evaluate and improve his/her performance in making decisions. Performance of DSS in terms of modelbase and database may also be measured in this way. If the DM is misled by the DSS, then it should be modified as necessary.

## 5.2 Operational Design of the DPPSS

A successful design depends on good understanding of user's decision process. So, we must realize and understand the steps in DM's mind and design the system according to that process. For that purpose we need an operational procedure which is essential to see the details. We have tried to think like the manager in view would, and identified the following questions of significance.

- What's the current situation?
- What's the problem, if there is any?
- What are the alternative solutions?
- Which one of them is more appropriate?
- What would be the results of a 'selected' alternative?

We tried to form a systematic procedure which can answer the above questions and specified the steps that we will use in the forthcoming development.

- Analysis of the Situation
- Problem Diagnosis and Formulation
- Alternative Scenario Generation
- Selection Among Alternatives
- Evaluation of the Decision

These are the steps that were thought to be useful in making a decision for the Debt Payment Planning Problem. We assume that any decision maker would possibly follow these steps in a complete analysis. By the term *completeness* we mean an analysis in which the above procedure is followed exactly. However, DM may want to ignore some steps of the procedure due to various reasons.In fact, decision process is different for every person, problem and environment. So, this procedure must be flexible enough to allow selection of any combination of the steps specified above, which will be determined according to user's needs and priorities. Otherwise, if we had forced the user for a 'complete' analysis; the system is no longer a DSS but an Expert System. The above listed steps of analysis will be explained with examples in the forthcoming sections of this chapter. In order to prevent any confusion, from now on we will call each of these analyses as a *subanalysis* of DPPSS. Now, before discussing subanalyses, we will briefly explain details of DPPSS components.

The discussion of Growth Model of Debt in Chapter 4 may be regarded as an introduction to the system design.The motivation in that early discussion was to make the user familiar with the problem, since Growth Model of Debt (GMD) constitutes the largest part of the **modelbase**, and it also affects other components. It would be very difficult to discuss the design of components or system operation before introducing the model. GMD derives its power of usefulness from the fact that it can generate meaningful information through use of differential calculus, which is probably very difficult for the DM to understand. The results that are obtained via the model are self-explanatory, such that DM does not need to understand the mathematical analysis that they are generated from. The model can not however ensure the truth of this information , since some of its parameters have to be determined by the user and wrong estimation may lead to failure. $B_0$ may be obtained directly from the information system as a recorded factual datum, but others must be assessed and estimated by the DM. Here, the DM requires assistance during his/her analysis and while making forecasts. Forecasting is one of the tasks that a decision maker can use a DSS effectively, since it is an estimation of future value based on past-data and requires a high level of expert judgment. We will not use sophisticated forecasting techniques, since selection of those require additional effort and as we cannot guarantee that a specific technique will be applicable in every case. We have found AVERAGE and TREND functions of EXCEL to be sufficient for our purposes.

In general terms, **database** is collection of all the data and information that is required by DM or modelbase to perform the tasks that are explained in this study. Specific examples of data stored in database are financial statements, historical values of model parameters and performance measures, and records of past decisions. The subanalyses could be done periodically in predetermined time intervals. But here the problem and its environment is very dynamic and unstable so it should be used whenever needed and the DSS should be ready to use at any time. Therefore, proper adaptation of the database is very important. Of course, we would not expect the decision maker to update the database, some other people in the organization must be responsible for adaptation, however this person must be in close contact with DMs . The user should not be allowed to change the database since s/he may change the content of the database either by mistake or on purpose. A decision maker should only be allowed to enter his/her decisions with associated reasons. Such a differentiation is necessary for system security. The content of database cannot be specified at the beginning of the design since it will evolve according to the requirements of the modelbase and the user. Ideally, we should be able to keep every transaction in the organization and retrieve them whenever needed.

While discussing DSSs, in Chapter 3 we have mentioned that they are user interactive information systems. So, we tried to design database and modelbase such that they would provide a good computer-user interaction. That's why we stressed the fact that GMD's main strength is its ability to generate meaningful information. Our purpose is simply to help the decision maker in doing his/her analyses easily. In addition to it, a good DSS shall assist even an unexperienced user. We claim that we achieved this in our DPPSS, provided that the user has some knowledge on the DPP and FM. The user may learn the rest, i.e issues specific to the system , by HELP subroutines. The user will be able to get sufficient help from the system whenever s/he wants. The quality of user interface is determined by the format and presentation of information. So, the information will be given in an easily understandable format; with tables, graphs and figures. Colors will be used to guide the user especially when there are too many numbers together. These may be observed during the operation of sample session .

## 5.3 Performance Measures

In Chapter 3, we discussed that we need performance measures to help in learning and problem diagnosis and gave the categorization of classical financial ratios as *liquidity, activity, coverage* and *profitability* ratios. Liquidity and coverage ratios are the ones that are closer to the DPP problem. Liquidity ratios indicate the level of firm's funds that can be used for operations or for debt payment in the short-run, so these may be conceived as measures of solvency. It is probable that these will give unacceptable or critical results in our case, since the firm is assumed to be credible. In such a case, the firm is not obliged to hold excess cash or other liquid assets. Coverage ratios are measures which show the level of assets with respect to existing liabilities.

In this study however, we will make and follow a different classification while measuring performance. By this classification we have tried to develop adequate measures that can indicate the capacity and ability of the firm to plan cash flows efficiently and liquidate them while keeping solvent. These measures can be classified as:

1. Measures of organizational efficiency
2. Measures of liabilities management
    - measures on finding resources
        - finding from external resources
        - generation of funds from internal resources
    - measures on use of funds
3. Measures of working capital management

The first one includes general efficiency measures about the operation of the organization, which are probably indirectly related to the problem. The second category is directly related to DPP problem. *Measures on finding resources* determine the credibility of the firm, and may indicate the degree of solvency. Because, generally the organizations which are found to be credible, are the ones that can find loans easily. A distinction between external and internal resources is necessary, because the cost of these two are different. In addition to that, the ability to generate funds from internal resources may indicate a success in operations of the firm. But it must be analyzed and ensured that such funds are not obtained through sale of productive assets. The measures on use of funds have also been designed for the same reason.

Namely, the following performance measures are thought to be appropriate to be included in DPPSS. Again the DM is free to omit some of them or add new measures to the list. To make a distinction, we found some of them to be indirectly related to the solution of the DPP problem. For that reason those which have direct relation will be used in the DSS design, and others will be ignored, i.e., it will be assumed that the DM can obtain this information in the company but not necessarily via our computer system. This is due to the idea that user should be saved from burdening with irrelevant or remotely relevant information. Now we will simply list the measures by their names and later define the ones that will be used intensively.

- Profit
- Sales
  - Nominal (NOMSALES)
  - in real prices (REALSALES)
- Capital
  - Nominal (Currentized Capital) (CURCAP)
  - Real
- Debt

  - Nominal
  - Real

- Total Investments
  - Nominal (Currentized Total Investments) (CURTINV)
  - Real

- Self Payment Fund (SPF)

- Cost of Capital (CC)
  - Cumulative
  - Marginal

- Total Working Capital (TWC)

- Working Capital Financing
  - with external resources
  - with internal resources

- Cost of Working Capital (CWC)

- Market Share

- Price Indices
  - Wholesale Price Index
  - Output Price Index
  - Input Price Index

Among these measures, profit, sales, Self Payment Fund, debt, Cost of Capital and price indices are directly related to our problem. Capital and investment figures are not used during the analysis or problem diagnosis stages, but they may be useful while generating alternative courses of action. So, they are also included. TWC (Total Working Capital) and CWC (Cost of Working

Capital) have been described although they will not be used in any part of the design. These measures are designed for future decisions. If the DPP problem is solved and a payment plan has been constructed, then planing of cash flows becomes a problem to be solved to increase the efficiency of the plan. TWC and CWC may be used in such FM decisions. Self Payment Fund (SPF) is the most important one among these measures. This is obvious by the fact that the Growth Model of Debt (GMD) constitutes the most important part of the modelbase and SPF is determined by parameters of GMD which are $\alpha$, $\beta$, $a_0$ and $B_0$. All of the parameters are related to the above measures. $\alpha$ is CC (Cost of Capital), in fact we will use CC as $\tilde{\alpha}$ and later convert to $\alpha$. $\beta$ is rate of growth in SPF so it is affected by growth in sales, profits and market share. $B_0$ is directly obtained from the Balance Sheet and SPF is the amount of funds that can be reserved from profit for debts.

In the following subsection definitions and discussion on these measures will be given; but first, in order to complete the list, we will give the ratios as relative values that will be derived from these measures:

- Profit / Sales
- SPF / Sales
- Debt / Sales
- SPF / Debt
- Debt / CURCAP
- Profit / CURCAP

Ratios may be categorized into three as ratios that indicate profitability, liquidity and ability to SPF generation. Of course the most important one for DPP problem is the third category. In fact SPF/Sales is an important indicator for SPF generation ability and can be a determinant of $\beta$, which we assumed it to be constant in the Growth Model of Debt, for simplicity. In our analyses we have observed Debt/Sales which, in our opinion, indicates the situation better.

It is a kind of composite measure which is affected by SPF generation, growth and increases in cost of debt at the same time.

### 5.3.1 Definitions and Clarification of Performance Measures

Now, we will define some of the above listed performance measures, the ones that are selected are either new or derived through modification of classical measures. The measures which were developed by Feşel and Doğrusöz are found to be useful in our analyses, too. [15], [22] First, we will give a brief verbal definition of the measure and then give the operational definition, i.e. formula to calculate the value of the performance measure :

1. **Sales in real terms:** Amount of sales in a base year's prices (in fixed prices).

$$REALSALES = NOMSALES * DEFLATOR$$

$$DEFLATOR = \frac{1}{I(t_0, t)}$$

   where $I(t_0, t)$ = price index for year $t$ based on $t_0$.
   As discussed before, calculation of real sales eliminates the effect of inflation from NOMSALES and shows the "real" situation of the volume of the business and the firm's operations.

2. **Currentized Capital (CURCAP):** Value of total capital in nominal terms (current monetary units). We assume that the firm has no capital relations in other firms, i.e. it has no subsidiaries. Here also note that, currentized value of a measure represents the value defined in current monetary unit (TL). In practice, balance sheets are prepared with nominal figures and are not updated with current indices. This may cause problems since they do not reflect the real value of assets or real debt. Currentizing is reevaluation of figures according to rate of change in units.

$$CURCAP_t = CURCAP_{t-1}(1+i_t)t + RETEAR_t - LOSS_t$$

$CURCAP_t$ : CURCAP at the end of year t.
$i_t$ : rate of inflation in year t.
$RETEAR_t$ : retained earnings in year t (undistributed profit).
$LOSS_t$ : loss in year t.
This measure is obtained by currentizing the prior year's amount and adding any earnings or losses occured during the year.

3. **Currentized Total Investments (CURTINV):** Value of total investments up to year t, in terms of current monetary unit.

$$CURTINV_t = CURTINV_{t-1}(1+i_t) + INV_t$$

$CURTINV_t$ : total currentized investments in year t.
$INV_t$ : total investments in year t.

$$NET\,CURTINV = CURTINV_t - CURDEPR_t$$

$$CURDEPR_t = CURDEPR_{t-1}(1+i_t) + DEPR_t$$

by NET CURTINV, we can make comparison with other currentized measures, where $CURDEPR_t$ is accumulated depreciation in nominal terms and $DEPR_t$ is the accrued depreciation expense in year t.

4. **Self Payment Fund (SPF):** SPF is the measure which indicates the firm's ability to pay its debts or to make new investments, so it has a very important role in the analysis; remember that it is one of the parameters of the survivability index. It can be briefly described as the annual fund that is left for payment of debts and investments after all operational expenses are deducted. In other words, it is the fund that is generated by the company and is ready to be distributed over debts and investment alternatives.

There are two ways to calculate SPF each of them using different financial statements:

- Using Cash Flow Statements :

$$SPF = CASH\ INFLOWS - CASH\ OUTFLOWS$$

$$(LOANS\ ,\ PAYMENTS\ OF\ LOANS\ WITH\ INTEREST$$
$$AND\ INVESTMENTS\ EXCLUDED)$$

- Using Balance Sheet:

$$SPF = \underbrace{PROFIT + DEPREC + INT\ EXP}_{SPF_1}$$
$$\underbrace{-\Delta\ (\ CUR.ASSETS - CUR.LIABILITIES\ )}_{SPF_2}$$

In this formula $SPF_1$ is the amount that is created through operations and $SPF_2$ is the amount that is obtained through reduction in net current assets or that is lost through increase. Usually, $SPF_2$ is negative in an inflationary environment, so a portion of funds created through operations is lost to financing the increase in net current assets (due to inflation).

5. **Cost of Capital:** Annual per-unit-cost of total debt (which is $\alpha$ in GMD). Cost of capital can be calculated for the debts that are obtained during the last year ( period) as well as it could be done for total debts. The former will be called 'marginal cost of capital' (MCC) and the latter will be called 'cumulative cost of capital'(CCC). They can be calculated by the same formula:

$$CC = \frac{\sum f_i k_i}{\sum k_i}$$

where, $k_i$ : total amount of debt of type $i$ and $f_i$ : annual unit cost of debt of type $i$. Cumulative CC is a good measure of performance of credit procurement as it gives the average cost of loans that are taken up to the current time. On the other hand, Marginal CC indicates the differences between years, so it is helpful to observe the trend in CC, and to evaluate the past performance in obtaining funds. The need for such a distinction arises from a case of inconsistency between these. We would not need such a distinction if always both of them happened to be high or low,but there may be cases where they are not in the same direction. The most important contribution of the Marginal CC will be in case of increases in the interest rates in latest times.

6. **Total Working Capital (TWC):** Total resources tied up in operations. It is found by adding

    - Cash + Bank accounts
    - Receivables
    - Inventories
    - Other Current Assets

    This measure indicates the efficiency of working capital usage. Of course in order to have a better understanding we shall follow the net Working Capital, which is found by subtracting Total Short Term Liabilities from the above summation. It may be followed through the ratio of this measure to annual sales.
    Cost of Working Capital (CWC) is relatively complex and it is not almost irrelevant to our problem so we will not describe it in detail, it can briefly be stated as the cost of resources tied up in total working capital. This measure is helpful since it indicates the importance of efficient management of working capital.

## 5.4 Operation of the System

In this section we will describe the operation of DPPSS, in general and by the help of example demos. We must, however, first justify the use of EXCEL as the basic program package that we selected as the foundation of the operating system of DPPSS. The design must begin with selection of one (or more) software package(s), since we have to know whether we can implement what we have designed. As we intend to build an interactive system, the decision maker should be guided by menus and dialog boxes, etc. It was mentioned in Chapter 2 that advanced data access and retrieval functions are necessary for designing a good DSS. Spreadsheets are very powerful tools in this respect. Especially in financial modeling, the use of integrated spreadsheet packages is very beneficial. Integrated packages (Lotus 123, Quattro, Excel, etc.) are superior to others since they can combine several general-purpose applications in one program. In this study we will use Excel for Windows which includes spreadsheet, database management, forecasting and graphic programs. Using integrated packages is superior to using different packages for each task; since it is guaranteed that there will be no problems in data access in the former alternative. Such packages, especially Excel are widely used in the business environment and this motivates the software companies to increase the number of applications that can be used via these packages. The motivation behind designing the system based on Excel for Windows can be understood by describing its properties briefly as follows.

*i)* It is very easy to store and manipulate data, which is essential for a good database management. The package can link different sheets and allows data transactions among these. So, we can retrieve necessary information from other subsystems.

*ii)* There are too many built-in functions that can be used in operating the system. In addition to that, we can easily assign custom commands and functions which are necessary for representing the formulas that we obtain through the model and finally we can write macros to automate repetitive tasks.

*iii)* It is already mentioned that it is superior to others in terms of user interaction with its excellent graphic capabilities. Moreover, we are able to give both numerical and graphical information at the same time, since it operates in windows environment.

Now we turn to describing the system operation in which we go through the problem solving steps as described in Section (5.2). During the description, we will give the names of files that we operate. It will be seen that there are two type of file; worksheets and macrosheets. Worksheets are conceived as a part of the database, since they are used to enter (store) and view (retrieve) data. Macrosheets, on the other hand are in the modelbase. They include the commands and functions which automate tasks and perform necessary calculations. Also note that there are two types of macros : local macros which are actioned when their sheets are opened ; and global macros that are actioned as soon as EXCEL is started.

### 5.4.1 Analysis of the Current Situation

As the first step of problem solving process, we shall begin with the analysis of the main system and its environment in order to have a clear understanding of the current situation. A decision maker would probably want to have general information about the market conditions (inflation and interest rates, exchange rates, etc.) and the firm's situation (sales, profitability, market share, average or marginal cost of debt, etc.). So, the system will allow the user to retrieve selected information directly from financial statements and reports. Examples are current assets and liabilities from the balance sheet; latest period's sales and profit figures from the income statement; and economic indicators that are publicly available, like last month's price indices, current interest rates, etc. The user will have an option to observe the realized values of above listed indicators in the last 10 periods. This is especially helpful if the decision maker is not experienced and wants to see the previous situation. Although we know that we need at least $\alpha$, $\beta$, *Self Payment Fund* and *Sales* in a sound analysis, we will show the operation only for $\alpha$ in our sample session. Then the procedure will be the same for all of the measures. The data will be stored in a worksheet called DATABASE.XLS and the user will be able to get information when s/he clicks a user-defined button named <Forecast>. The output will contain data for the past 10 periods; a forecast for the next period, which is simply the average of those 10 periods, with a chart to provide graphical presentation of information. The user is free to use the forecast value in further analyses. The system could directly use it, however this would decrease the use of judgment; so we preferred to give it only as information. In addition to historical data;

DM, especially if s/he is not experienced, would want to learn, or remember what had happened in the past; that is s/he would want to observe the previous decisions and their consequences. By these records, the decision maker can analyze the decisions that are made in the past and tries to improve his/her knowledge and skill in order to prevent repetition of any failure. These records are like patients' health records which are used by the doctor who wants to know (or remember) the history of the patient, before making a decision. S/He needs to know whether the treatment that s/he is about to decide has been applied before; and how the patient responded to that. By that analysis the doctor learns how the system (body of the patient) functions, whether it is allergic to anything, etc.

It is obvious by the example that was given above that problem solving in financial management is almost analogous to decision making in medical sciences; where the doctor is the decision maker and the patient replaces the system (firm) that s/he is responsible from. Therefore, in order to provide a better understanding, during the discussion on system operation, we will use similar terminology and give examples from medical sciences. Note that, similar to our case, new problems (e.g. AIDS) are more difficult than old and known problems, since we do not know how new problems affect functions of the body. Sometimes even a proper treatment may have side-effects and may be harmful to the system, i.e., patient. So, it is very hard to achieve absolute "correctness". In that sense, this step, in which we analyze the situation, may be thought as taking the body temperature and blood pressure of a patient.

Another important thing to examine in this stage is past experience on the problem. The DM may not require such an examination if s/he was the DM in past decisions too. In such a case s/he will obviously know what s/he has done before, which makes him/her 'experienced'. But if there is a different DM then s/he should better observe what had happened in the past and check the past performance of the former one with the stated reasons. Details of data that will be entered for this purpose will be given while discussing the last subanalysis of operation, which is 'evaluation of decisions'. In that part of the analysis DM may search for certain values of $SI$ or $T_0$ and learn the logic behind that decision. Other things are the environmental factors that may affect the system behavior. The system will probably adapt itself to the new conditions but the DM must be aware of these changes in order to be comfortable in his/her decisions. The DM may be affected by the past and may change his/her opinion even though s/he is sure about it. Also note that, a decision maker should also be very careful in assessing information regarding the past. System would give different responses to different actions and deviations would probably be observed. The important thing is that these deviations should be small both in quantity and frequency, and be in different directions so that their average is closest to 0. Otherwise , it implies that the system is biased and this requires a different procedure for analysis and treatment and DM may go further by looking for some indicators for the existence of a problem.

### 5.4.2 Problem Diagnosis and Formulation

Analysis of a problem begins with problem diagnosis, which depends on identification of symptoms. Symptoms can simply be defined as observations that deviate from expected values. In our case we need to find out the symptoms that may indicate a risk of insolvency. This is important since problem can be solved with regulation of the symptom. Decision maker has to find some indicators that should be observed immediately, as potential symptoms. We have called these indicators as 'performance measures', and *'survivability index'* (SI) as the most important one. Remember that this measure shows whether our debt $B_0$ reproducing at a rate $\alpha$ can be paid with periodic pay back rates, $a_0$ at time $t_0$ and growing exponentially at the unit rate $\beta$. This measure is important, because it indicates whether there is any use in continuing the analysis. If the index gives a negative value then the existence of a serious problem is obvious and we should be more careful than ever in the analysis. On the other hand, when the index is found positive and above a critical value, we have to search for other clues that should be regarded as symptoms of a problem. Therefore, when trying to treat, i.e. increase, the survivability index; we should either decrease $\alpha$ or $B_0$ or increase $\beta$ or $a_0$. $\alpha$ may be reduced if market conditions has changed. We may find new debt to replace existing debt with lower cost and decrease the average cost of debt. It is hard to decrease $B_0$, since existing debt is a result of past transactions. Actions that would lead to a decrease in $B_0$, as selling assets or issuing new shares were already stated as alternatives. Increasing $a_0$ or $\beta$ may be analyzed together as increasing $a(t)$, which is annual pay back fund. Increasing $\beta$, which is the rate of change in self payment fund, is related with productivity improvement. $a_0$ is more critical than others since increasing only $a_0$, without a change in $\beta$ may decrease debt and increase $SI$. Increasing $a_0$, which is funds that are generated from operations and are ready for use in debt payment, is not easy since we have to interrupt the firm at the operational level. That is, we must decrease costs and increase marginal return. As we can calculate $a_0$ as $inflows - outflows$, every action that increases inflows and decreases outflows contribute to increasing $a(t)$. Of course, we should carefully observe the effects of these actions over others. Examples are; increasing sales, decreasing costs, and reducing the number of employees. Of course, number of employees should be reduced after a marginal cost analysis, otherwise such a reduction might end up with a decrease in production and sales, if there are no inventories. Therefore ,the management should pay attention to make its decisions according to the long run strategies of the firm. As a final remark, we should say that when $\beta$ and $a_0$ are analyzed together, we can see that reducing $\beta$ decreases financial expenses which leads to a increase in $a(t)$, provided that all other parameters have been the same.

In case of positive SI, the analysis will follow with what we call the Debt Payment Schedule (DPS), which is the first original output that is presented to the user. DPS is a table that shows the level of debt and other related measures by time until it is fully liquidated. This schedule is useful to decide on the long range goals of the firm. The collection of parameters required to operate the Growth Model of Debt (GMD) is called a *scenario* and when we say *summary of information* we will refer to those parameters and a selection of outcomes. In the upper part of the sheet, summary of information will be given to give an insight about the situation. We have created a scenario and called it *reference scenario*, which is in Table (5.1), to use in the design of operation. The user

| Reference Scenario | | | |
|---|---|---|---|
| Parameters | | Basic Information | |
| $B_0$ | 10.33 | $SI$ | 0.05 |
| $\bar{a}_0$ | 1.61 | $T^0$ | 21.76 |
| $\bar{\alpha}$ | 55 % | $T^m$ | 19.02 |
| $\bar{\beta}$ | 35 % | $T^i$ | 16.28 |

Table 5.1: Summary Information on scenario 1

will see the summary of information as soon as s/he enters the data and s/he can prepare the DPS (Debt Payment Schedule) for his/her scenario by clicking <Prepare DPS Table> button. Then s/he has two buttons which are <Clear Table> and <Draw Chart>. Clearing the table will be appreciated before switching to another subanalysis or to another table for a different scenario. The chart is a debt-versus-time graph; i.e. it will show amount of debt by period. The DPS for reference scenario, also called scenario 1, is in Table (5.2) and its associated graph is in Figure (5.1). We found *Sales, Payback* and *Debt* as the performance measures that are related to DPP; so, these are included in the standard DPS. In addition to that *Debt/Sales* and *Real Debt* will be given to enable the DM to make comparisons using real figures. Since $\alpha$ is greater than $\beta$ in general, Debt increases until a certain time (which is $T_{max}$) and then reduces sharply. However, DM or people who evaluate the decisions may feel uncomfortable with continuously rising debt, unless they see real debt which begins decreasing right from the start. Observe in Table (5.2) and in Figure (5.1), that the *real debt* is decreasing at an increasing rate, although nominal debt seems to be increasing. While preparing the DPS, the system uses the formulas that are obtained through the Growth Model of Debt. So, values for parameters $a_0$ , $B_0$ , $\alpha$ *and* $\beta$ are needed. These may be obtained directly through historical records, or the user may enter his/her choice. Since there is high uncertainty and since we believe in the benefit of using judgment we will prefer to enter data manually. Remember that, we use continuous version of GMD so the parameters that must be entered are $\bar{\alpha}$ , $\bar{\beta}$ and $\bar{a}_0$; then these will be converted to their continuous equivalents. Also, note that by entering data the user is not modifying database but simply creating a new scenario. Finally

| YEAR | PBACK | DEBT | SALES | DBT/SLS | R.DEBT | RqLoan |
|---|---|---|---|---|---|---|
| 1 | 2.03 | 13.84 | 26.66 | 0.52 | 10.25 | 6.81 |
| 2 | 2.74 | 18.51 | 35.99 | 0.51 | 10.16 | 9.08 |
| 3 | 3.69 | 24.74 | 48.59 | 0.51 | 10.05 | 12.09 |
| 4 | 4.99 | 32.99 | 65.59 | 0.50 | 9.93 | 16.07 |
| 5 | 6.73 | 43.92 | 88.55 | 0.50 | 9.80 | 21.30 |
| 6 | 9.09 | 58.33 | 119.54 | 0.49 | 9.64 | 28.14 |
| 7 | 12.27 | 77.26 | 161.38 | 0.48 | 9.45 | 37.04 |
| 8 | 16.56 | 101.99 | 217.87 | 0.47 | 9.24 | 48.53 |
| 9 | 22.36 | 134.10 | 294.12 | 0.46 | 9.00 | 63.23 |
| 10 | 30.19 | 175.49 | 397.07 | 0.44 | 8.73 | 81.82 |
| 11 | 40.75 | 228.30 | 536.04 | 0.43 | 8.41 | 104.96 |
| 12 | 55.02 | 294.87 | 723.66 | 0.42 | 8.05 | 133.19 |
| 13 | 74.27 | 377.40 | 976.93 | 0.39 | 7.63 | 166.61 |
| 14 | 100.27 | 477.45 | 1318.86 | 0.36 | 7.15 | 204.47 |
| 15 | 135.36 | 594.89 | 1780.46 | 0.33 | 6.60 | 244.33 |
| 16 | 182.74 | 726.12 | 2403.62 | 0.30 | 5.97 | 280.72 |
| 17 | 246.69 | 860.95 | 3244.89 | 0.27 | 5.24 | 302.81 |
| 18 | 333.03 | 977.33 | 4380.61 | 0.22 | 4.41 | 290.75 |
| 19 | 449.60 | 1032.73 | 5913.82 | 0.17 | 3.45 | 209.55 |
| 20 | 606.96 | 949.85 | 7983.65 | 0.12 | 2.35 | -0.71 |
| 21 | 819.39 | 593.57 | 10777.93 | 0.06 | 1.09 | -440.54 |
| 22 | 1106.18 | -266.19 | 14550.21 | -0.02 | -0.36 | |

Table 5.2: Debt Payment Schedule for scenario 1

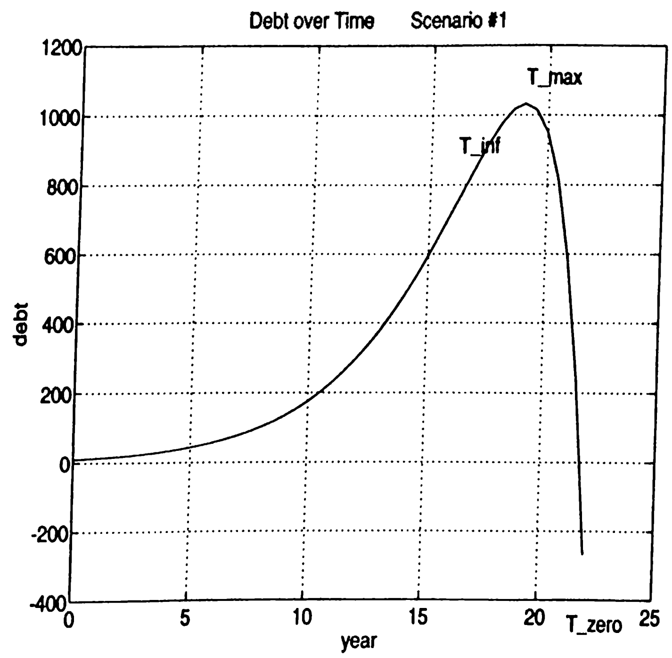


Figure 5.1: Debt vs Time Graph for Scenario 1

we will discuss the *required loan*, which is another type of information that is obtained through the growth model of debt. Required loan shows the amount of funds that the firm must obtain to arrive 0-debt state at the mentioned period, assuming that average maturity can be determined. In order to calculate this measure, the modelbase needs the average maturity of loans; so this is an input parameter and is called *'year'*. We have also added *sales*, *debt/sales* and *real debt* in order to overcome the deceptive effect of inflation over figures. By this ratio we can evaluate the pattern that debt follows relative to sales, and use it as an indicator of the reason of debt financing.

If the problem can be diagnosed and formulated at this point, then the DM may start to create alternative courses of action to find a solution. However, if s/he cannot decide on the existence of a problem, then we have to use more sophisticated analyses. Even if the current situation, which is observed through "summary information", does not indicate any problem for now, we must look for the possibility of a problem in the future, especially near future. For example, in the reference scenario, the survivability index is positive and the debt can be paid. However, the value of SI is so small that needs special attention. It can suddenly become negative with a slight change in market conditions. Moreover, when we analyze the debt schedule and the associated chart we can see that debt increases for 19 periods and then begins to reduce sharply and drops below 0 in 4 periods. This may be regarded as a symptom by itself, if there is no good explanation for it. So, we may have problems in case of positive SI, too. The DM may identify the changes that will force critical measures to their acceptable limits . These limits may be either lower or upper limits depending on the type and meaning of the measure. We may look for the value that provides achievement of an upper limit or guarantees satisfaction of a lower boundary. These are like optimal values of an optimization problem as they are values that are on the boundary of a feasibility region. We may also give another example, turning back to the analogy that we have made before. In most laboratory analysis patients are loaded or given certain amount of substances and then their responses are observed in order to decide on the level and type of the treatment. We will call this type of subanalyses as "Threshold Analysis" and mentioned values as "Threshold Values". We can perform this analysis for any parameter provided that it is dependent on the parameter whose limit is set by us. However, selecting uncontrollable parameters does not lead to effective and realistic analyses. For example trying to decrease $\alpha$ while inflation is rising will not be an effective analysis; that is, the decision maker should make realistic analyses for effectiveness. The most useful ones for our problem will be values of $B_0$ and $\alpha$ separately for a certain value of *SI*, e.g. 0.1. So, we can know our critical cost of debt or our maximum debt capacity given these market conditions. During the session, we have especially observed threshold values for all model parameters,i.e. ( $\alpha$ , $\beta$ , $B_0$ , $a_0$ ) forcing $SI = 0, 0.1, 0.2$ and $T^0 = 5, 10, 15$ , respectively. It is possible to prepare tables for selected measures, but we let the user free to analyze any pair for any value. EXCEL has a function called GOAL.SEEK, which is designed for this purpose so we used it directly in our analyses. Values that are obtained from a batch of analyses are given in the above mentioned table format in Table (5.3).

| Threshold Values | | | | | | |
|---|---|---|---|---|---|---|
| **Parameters** | **SI** | | | $T^0$ | | |
| | SI=0 | SI=0.10 | SI=0.20 | $T^0$=15 | $T^0$=10 | $T^0$=5 |
| $\alpha$ | 0.56 | 0.54 | 0.52 | 0.53 | 0.47 | 0.25 |
| $\beta$ | 0.34 | 0.36 | 0.38 | 0.37 | 0.42 | 0.68 |
| $B_0$ | 10.87 | 9.78 | 8.69 | 9.50 | 8.14 | 5.42 |
| $a_0$ | 1.53 | 1.70 | 1.91 | 1.75 | 2.04 | 3.07 |

Table 5.3: Threshold values for selected measures

| $\alpha$ / $\beta$ | 0.29 | 0.31 | 0.33 | 0.35 | 0.37 | 0.39 | 0.41 |
|---|---|---|---|---|---|---|---|
| 0.49 | 36.42 | 16.57 | 13.01 | 11.09 | 9.83 | 8.91 | 8.20 |
| 0.51 | $\infty$ | 27.38 | 15.97 | 12.76 | 10.96 | 9.75 | 8.86 |
| 0.53 | $\infty$ | $\infty$ | 23.90 | 15.45 | 12.53 | 10.83 | 9.67 |
| 0.55 | $\infty$ | $\infty$ | $\infty$ | 21.76 | 15.00 | 12.31 | 10.71 |
| 0.57 | $\infty$ | $\infty$ | $\infty$ | $\infty$ | 20.25 | 14.59 | 12.12 |
| 0.59 | $\infty$ | $\infty$ | $\infty$ | $\infty$ | $\infty$ | 19.09 | 14.23 |
| 0.61 | $\infty$ | $\infty$ | $\infty$ | $\infty$ | $\infty$ | $\infty$ | 18.16 |

Table 5.4: Sensitivity Analysis of $T_0$ for $\alpha$ vs. $\beta$

By adding Threshold Value Analysis, we can have an understanding of the situation, but still we have to determine how changes in parameters affect the problem. Parameters change due to probable modifications in problem environment, and we have to take precautionary actions against these, or we should be aware of the modifications and have an idea of its effect on critical performance measures. We know that the most critical performance measure is the survivability index. We have also decided that the decision maker should follow what happens to the time of liquidation in case of a change in parameters, since time span of the analysis is important due to psychological factors. The management might feel that they would not be able to apply the liquidation plan for longer periods. The following analysis will determine sensitivity of results ($SI$, $T_0$, $B_{max}$, etc.) to changes in model parameters ($\alpha$ & $\beta$, $B_0$, etc.) ; and the name of worksheet that will be used in Sensitivity Analysis is SENSITIV.XLS. In our sample, we have analyzed sensitivity of $T^0$ to changes in $\alpha$ and $\beta$. We have selected current $\alpha$ and $\beta$ from the summary information as the reference values and allowed the user to choose increments that will determine the ranges of parameters. Other possible selections might be $SI$ vs $\alpha$ and $\beta$ or $T_0$ vs $a_0$ and $\beta$. The results of our analysis is in Table (5.4). We can see that survivivability depends on the value of $\Delta$, debt can not be paid for any $\Delta > 0.22$. It can also be seen that $T^0$ is more sensitive to changes in $\beta$ than in $\alpha$.

### 5.4.3 Generation of Alternative Scenarios

Solution begins with the generation of alternative scenarios. We may think that the decision maker has identified the symptoms and decided on the existence of a problem. The problem would probably be formulated at this stage, at least roughly. In this subanalysis we will analyze new scenarios that we have generated to be an alternative to the problematic situation that we are dealing within. We may make changes only on $\alpha$, $\beta$, $a_0$ and $B_0$; in order to use the model. This, however does not prevent us from modifying other variables that affect or determine these parameters. But in that case we should exactly know how such a modification affects the system. For example we may create a scenario where we decrease the number of employees; if we can calculate the new value of the self payment fund, which is totally changed due to the modification. It is suggested that only one parameter should be changed at a time in order to observe its effect better. Sometimes however, we may need to change two parameters at the same time to get realistic results. For example, $\beta$ must decrease when $B_0$ decreases by sale of a productive asset; or issuing new shares implies that more dividends have to be distributed in the following year. There's no restriction on number of parameters to be changed in scenario generation; however user must follow some rules and limits in order to be realistic. For example, s/he should not evaluate a scenario where $\alpha < \beta$, since we have set $\beta$ to be equal to the inflation rate. It is not impossible, but very unlikely that the cost of debt will be less than the inflation rate. Scenarios may be prepared with reference to the discussion in Chapter 2. Below

| Scenario 2 | | | |
|---|---|---|---|
| **Parameters** | | **Basic Information** | |
| $B_0$ | 10.33 | $SI$ | 0.14 |
| $\bar{a}_0$ | 1.61 | $T^0$ | 15.45 |
| $\bar{\alpha}$ | 53 % | $T^m$ | 12.67 |
| $\beta$ | 35 % | $T^i$ | 9.88 |

Table 5.5: Summary Information on scenario 2

we present our examples with their explanation. In each of the alternative scenarios we have modified one parameter and prepared separate Debt Payment Schedules. We have compared these scenarios with the reference scenario and below we will explain the differences. The scenario (Scenario 2), which is in Table (5.5) is produced by reducing $\alpha$ from 0.55 to 0.53, which represents a 3.6 % reduction. Summary information and DPS of the associated scenario which are in Tables (5.5 and (5.6), show the effect of such a modification. See that the survivability index has grown up to 0.14 from 0.05 ,which implies a 180 % increase. Time of liquidation has reduced to 15.45, that is by 29 %. It is clear that this scenario represents a situation where the management has been able to find new resources with 2 % less interest rate.

We should increase $\beta$ for a scenario in which we simulate higher production rate for self payment fund, which can be achieved by productivity improvement. Again we changed the parameter by 0.02 basis points, which corresponds to a 5.7 % increase.In this scenario, the value of the Survivability Index is 0.16, i.e. it has increased by 220 % and liquidation time has decreased by 31 %, to 15.00. The results can be seen in Tables (5.7) and (5.8). Finally, we have changed initial debt, say by a capital injection by owners. We did not simulate it as selling a facility or issuing shares ,since such scenarios require deeper analyses. We entered the new debt as 10.00, i.e we have supposed that the owners transfered 330 million TL to the company. This corresponds to a 3.2 % reduction in initial debt and increased SI to 0.08, by 60 %. The new value of $T_0$ is 18.30, i.e.. it has reduced by 16 % (see Tables (5.9) and (5.10)). After these arbitrary modifications we have also analyzed other scenarios where we

| YEAR | PBACK | DEBT | SALES | DBT/SLS | R.DEBT | RqLoan |
|---|---|---|---|---|---|---|
| 1 | 2.04 | 13.63 | 26.66 | 0.51 | 10.10 | 6.48 |
| 2 | 2.75 | 17.92 | 35.99 | 0.50 | 9.83 | 8.45 |
| 3 | 3.72 | 23.46 | 48.59 | 0.48 | 9.53 | 10.95 |
| 4 | 5.02 | 30.54 | 65.59 | 0.47 | 9.20 | 14.08 |
| 5 | 6.78 | 39.51 | 88.55 | 0.45 | 8.81 | 17.93 |
| 6 | 9.15 | 50.71 | 119.54 | 0.42 | 8.38 | 22.56 |
| 7 | 12.35 | 64.43 | 161.38 | 0.40 | 7.88 | 27.94 |
| 8 | 16.67 | 80.82 | 217.87 | 0.37 | 7.33 | 33.86 |
| 9 | 22.51 | 99.67 | 294.12 | 0.34 | 6.69 | 39.81 |
| 10 | 30.39 | 120.12 | 397.07 | 0.30 | 5.97 | 44.72 |
| 11 | 41.02 | 140.09 | 536.04 | 0.26 | 5.16 | 46.57 |
| 12 | 55.38 | 155.34 | 723.66 | 0.21 | 4.24 | 41.75 |
| 13 | 74.77 | 158.02 | 976.93 | 0.16 | 3.19 | 24.04 |
| 14 | 100.93 | 134.25 | 1318.86 | 0.10 | 2.01 | -16.99 |
| 15 | 136.26 | 60.25 | 1780.46 | 0.03 | 0.67 | -98.59 |
| 16 | 183.95 | -103.77 | 2403.62 | -0.04 | -0.85 | -248.84 |

Table 5.6: Debt Payment Schedule for scenario 2

| **Scenario 3** | | | |
|---|---|---|---|
| **Parameters** | | **Basic Information** | |
| $B_0$ | 10.33 | $SI$ | 0.16 |
| $\bar{a}_0$ | 1.61 | $T^0$ | 15.00 |
| $\bar{\alpha}$ | 55 % | $T^m$ | 12.32 |
| $\beta$ | 37 % | $T^i$ | 9.64 |

Table 5.7: Summary Information on scenario 3

| YEAR | PBACK | DEBT | SALES | DBT/SLS | R.DEBT | RqLoan |
|---|---|---|---|---|---|---|
| 1 | 2.07 | 13.81 | 26.66 | 0.52 | 10.08 | 6.74 |
| 2 | 2.84 | 18.38 | 36.52 | 0.50 | 9.79 | 8.89 |
| 3 | 3.89 | 24.34 | 50.04 | 0.49 | 9.47 | 11.65 |
| 4 | 5.33 | 32.06 | 68.55 | 0.47 | 9.10 | 15.14 |
| 5 | 7.30 | 41.93 | 93.92 | 0.45 | 8.69 | 19.46 |
| 6 | 10.00 | 54.34 | 128.67 | 0.42 | 8.22 | 24.68 |
| 7 | 13.70 | 69.65 | 176.27 | 0.40 | 7.69 | 30.75 |
| 8 | 18.77 | 87.97 | 241.49 | 0.36 | 7.09 | 37.38 |
| 9 | 25.72 | 108.98 | 330.85 | 0.33 | 6.41 | 43.84 |
| 10 | 35.23 | 131.43 | 425.26 | 0.29 | 5.64 | 48.65 |
| 11 | 48.27 | 152.33 | 620.96 | 0.25 | 4.77 | 48.96 |
| 12 | 66.13 | 165.73 | 850.72 | 0.19 | 3.79 | 39.65 |
| 13 | 90.60 | 160.46 | 1165.49 | 0.14 | 2.68 | 11.82 |
| 14 | 124.12 | 116.61 | 1596.72 | 0.07 | 1.42 | -49.69 |
| 15 | 170.14 | -0.23 | 2187.50 | 0.00 | 0.00 | -170.19 |

Table 5.8: Debt Payment Schedule for scenario 3

| Scenario 4 | | | |
|---|---|---|---|
| Parameters | | Basic Information | |
| $B_0$ | 10.00 | $SI$ | 0.08 |
| $\bar{a}_0$ | 1.61 | $T^0$ | 18.30 |
| $\bar{\alpha}$ | 55 % | $T^m$ | 15.56 |
| $\beta$ | 35 % | $T^i$ | 12.82 |

Table 5.9: Summary Information on scenario 4

| YEAR | PBACK | DEBT | SALES | DBT/SLS | R.DEBT | RqLoan |
|---|---|---|---|---|---|---|
| 1 | 2.03 | 13.33 | 26.66 | 0.50 | 9.87 | 6.48 |
| 2 | 2.74 | 17.72 | 35.99 | 0.49 | 9.72 | 8.57 |
| 3 | 3.69 | 23.51 | 48.59 | 0.48 | 9.55 | 11.31 |
| 4 | 4.99 | 31.09 | 65.59 | 0.47 | 9.36 | 14.86 |
| 5 | 6.73 | 40.97 | 88.55 | 0.46 | 9.14 | 19.42 |
| 6 | 9.09 | 53.76 | 119.54 | 0.45 | 8.88 | 25.22 |
| 7 | 12.27 | 70.16 | 161.38 | 0.43 | 8.59 | 32.51 |
| 8 | 16.56 | 90.99 | 217.87 | 0.42 | 8.25 | 41.51 |
| 9 | 22.36 | 117.06 | 294.12 | 0.40 | 7.86 | 52.35 |
| 10 | 30.19 | 149.07 | 397.07 | 0.38 | 7.41 | 64.96 |
| 11 | 40.75 | 187.36 | 536.04 | 0.35 | 6.90 | 78.83 |
| 12 | 55.02 | 231.41 | 723.66 | 0.32 | 6.32 | 92.68 |
| 13 | 74.27 | 279.04 | 976.93 | 0.29 | 5.64 | 103.83 |
| 14 | 100.27 | 324.99 | 1318.86 | 0.25 | 4.87 | 107.16 |
| 15 | 135.36 | 358.58 | 1780.46 | 0.20 | 3.98 | 93.50 |
| 16 | 182.74 | 359.84 | 2403.62 | 0.15 | 2.96 | 46.93 |
| 17 | 246.69 | 293.20 | 3244.89 | 0.09 | 1.78 | -59.56 |
| 18 | 333.03 | 97.33 | 4380.61 | 0.02 | 0.44 | -270.92 |
| 19 | 449.60 | -331.28 | 5913.82 | -0.06 | -1.11 | -661.04 |

Table 5.10: Debt Payment Schedule for scenario 4

| % change param.s | -10 % | -5 % | -2 % | Reference Scenario | +2 % | +5 % | +10 % |
|---|---|---|---|---|---|---|---|
| $\alpha$ | 0.4950 | 0.5225 | 0.5390 | **0.55** | 0.5610 | 0.5775 | 0.6050 |
| $\beta$ | 0.3150 | 0.3325 | 0.3430 | **0.35** | 0.357 | 0.3675 | 0.385 |
| $B_0$ | 9.2970 | 9.8135 | 10.1234 | **10.33** | 10.5366 | 10.8465 | 11.363 |

Values obtained for parameters with mentioned percent changes

| % change SI values | -10 % | -5 % | -2 % | Reference Scenario | +2 % | +5 % | +10 % |
|---|---|---|---|---|---|---|---|
| $\alpha$ | 0.31 | 0.18 | 0.10 | **0.05** | - | - | - |
| $\beta$ | - | - | 0.01 | **0.05** | 0.09 | 0.14 | 0.24 |
| $B_0$ | 0.14 | 0.10 | 0.07 | **0.05** | 0.03 | 0 | - |

Values of survivability index when above values are used one at a time

| % change $T^0$ values | -10 % | -5 % | -2 % | Reference Scenario | +2 % | +5 % | +10 % |
|---|---|---|---|---|---|---|---|
| $\alpha$ | 11.45 | 14.25 | 17.44 | **21.76** | $\infty$ | $\infty$ | $\infty$ |
| $\beta$ | $\infty$ | $\infty$ | 31.42 | **21.76** | 18.32 | 15.48 | 12.84 |
| $B_0$ | 14.00 | 16.89 | 19.41 | **21.76** | 25.27 | 45.23 | $\infty$ |

Values of $T^0$ when above values are used one at a time

Table 5.11: Analysis of $SI$ and $T^0$ vs changes in parameters

have changed the parameters by constant numbers. That is, we have observed the values of *survivability index (SI)* and *time of liquidation ($T^0$)* in scenarios where we have both increased and decreased the parameters $\alpha\,\beta$, and $B^0$ by 2 %, 5% and 10%. The results are in Table (5.11). The first table shows values of parameters that will be used in the second and third tables. we have changed one parameter each time. For example, the first entry (0.495) is found by reducing $\alpha$ by % while keeping other parameters constant. Then we have calculated SI and $T^0$ by changing one parameter at a time. Some SI values were fi=ound to be negative (represented by -) and some $T^0$ values were infinity ($\infty$). Values under the column heading 'reference scenario' indicate that none of the parameters have been changed.

### 5.4.4 Selection Among Alternatives

After creating scenarios, we have to evaluate them in order to see whether they are acceptable and select one of them. So, we need to apply the first two stages of the procedure to these scenarios. Summary Information and DPS (Debt Payment Schedule) tables were given above. In addition to that we decided to show them in the same table to allow comparison. Although it is nothing more than pasting the tables given above ; it will be very useful for DM, especially since we can produce graphs from that table. However, we have two problems in such analysis. First, we can not compare every pair of alternative and second we can not compare too much alternatives at the same time. The latter is related with format and presentation of data, we do not believe that it is useful to give too much information at the same time so we have restricted the user to compare at most 5 scenarios at a time. The summary information for up to 5 scenarios will be stored in a worksheet called COMPARE.XLS, and will be used by the user to make a selection among alternatives. We have also given a sample chart that shows debt over time for the reference scenario and the second scenario, in which we have reduced $\alpha$. The above mentioned problem is about these graphs;i.e. we can not draw every pair of scenario in one graph, since some of them are not appropriate by scale. An example graph which shows scenario-1 and scenario-2, is in Figure (5.2).

### 5.4.5 Evaluation of Decisions

After making a decision, the DM will enter the reason and expectations underlying that decision. Earlier, it was told that these records will help the user to recognize the weaknesses and strengths of the system. The data will be kept in free format, and will include date, data of Summary Information, and explanation. It may be sorted and kept by indexing on any parameter. $SI$ will be useful as an index, since we often used it in our analyses. The decision maker may observe the past decisions and does not repeat any mistake that was made before, as explained in the first section of this chapter. This

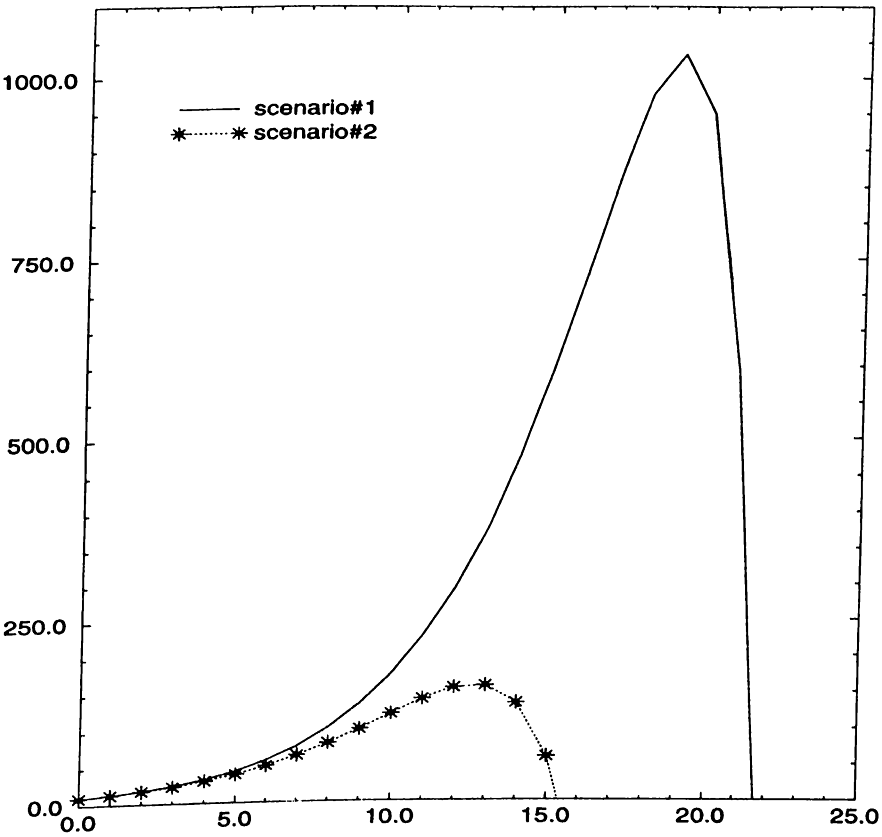


Figure 5.2: Comparison of Scenario 1 vs Scenario 2

subanalysis will help the DM to make effective decisions and therefore it will enhance organizational learning.

# Chapter 6

# SUMMARY and CONCLUSION

In this study we have designed a system to assist DM in DPP problem. We called our system the Debt Payment Planning Support System (DPPSS) since the properties that we intended to give to the system are similar to the properties that a typical DSS (Decision Support System) has. Our problem is a new one and does not exist in the finance literature, however it is in close interaction with other problems of financial management. Obviously there are interactions among objectives of DPP and of financial management in general. Thus clear definition of the interaction processes is vital for a good understanding of the problem. We have explained those dependencies and conflicts between objectives. The operational procedure of system design which is given in Chapter 5, is not specific to this problem or system; so, it may be used in any design task. The specific properties of the system that worth mentioning are described in Chapter 5 as: (1) the ability to generate meaningful and understandable information and (2) the ability to induce and enhance learning. Adaptation and flexibility were two requirements for such a system, so we have also tried to insert these properties into the system. We have conducted the study for the specific DPP problem, however, the study brings a new approach to decision making and can be used for other problems as well.

We have mentioned that, final decision must be made by the decision maker, regardless of the development and power of computer and software technology. Our understanding of the term 'expert' was given before and it was said that a classification based on expert skills distinguishes between "substantive experts" whose skill lies in analyzing large bodies of data and "assessment experts" whose skill lies in making judgment under uncertainty. We need a decision maker who has both of the above classified skills , the motivation in designing this system however, is to decrease the responsibility of DM in data analysis; and to increase his ability to make effective decisions. We achieved learning on personal & organizational basis, since we have guaranteed recording and transfer of information by our system.

Although we have said that we would not deal with implementational issues of the system; we have prepared a prototype of the system after explaining the components and properties of DPPSS,in Chapter 5. The real DPPSS must be developed by a capable programmer with the participation and guidance of an experienced decision maker. The prototype intends to help both the programmer and user while developing and implementing the DPPSS. The prototype was developed for an imaginary organization by making up numbers to generate scenarios. The needs and conditions of a specific firm may be different and our design may need adaptation. It can be easily adapted to any organization by following the methodology developed in our study. Moreover, a proper system may sometimes require modifications due to changes in environment. The proposed system is flexible enough to adopt to those modifications. In addition to implementing a properly operating system, this study may be improved by relaxing some of the assumptions or by inserting more complex objectives.

We have told before, during the description of modelbase that we had used AVERAGE and TREND functions while generating forecasts by using historical records of the firm. These functions are sufficient in the scope of this thesis, however there are sophisticated forecasting techniques that can be used. Effectiveness of the system and decisions may increase if an appropriate one is found and used among those sophisticated analysis. Of course, this technique must be user-friendly in order to be used in a DSS. That's the technique itself should not be too complicated as to decrease the power of interaction between the user and system. There are even DSSs on forecasting techniques, like the one for Box-Jenkins time series analysis, "which encompasses regeneration of possible time series models, the estimation of parameters and evaluation of them, followed by the selection and presentation of best of them based on best fit" [9].

With regard to credibility assumption used in developing GMD, one must be aware that this assumption may not always be very realistic. In section (2.3), we have discussed that credibility is in close interaction with other objectives and is very critical in determining solvency. So, we should try to give a quantifiable definition for credibility and then try to find ways of ensuring it, instead of assuming.

In the use of GMD we presumed the achievement of full-liquidation, which means reaching to a 0-debt state. In order to achieve this objective, we prefer to assume that there are no investments. In many cases, however, the firm has to make new investments to achieve growth and 0-debt is not desired or not necessary. There are studies on determining the optimal level of debt for the firm and these are called *leverage analyses.* Debt vs Equity choice is critical and depends on the nature of the firm and environment. Cost of capital is the factor that makes debt financing advantageous. Usually the firm does not have adequate funds and has to borrow from banks. There may be profitable investments that would bring higher returns when compared to cost of debt. In fact, a company decides to allocate or search for funds for new investments, that is it prefers debt financing, only if it expects to get a higher return from that investment. This does not, however, deny the usefulness of GMD. The model can be used equally well by simply specifying a safe (acceptable) level of debt. In that sense, instead of determining $T_0$, time to 0-debt state, we can determine $T^s$, time to safe-debt state. Debt/Sales ratio or Real Debt which were included in Debt Payment Schedule may be used as determinants of the safe-level of debt.

Another statement that we have made based on an assumption is about the survivability index. We have stated that the company can liquidate if the index is positive. However we should set a higher bound depending on the specific conditions of the system, especially when the way that system gives response forces us to take immediate actions. Such improvements, i.e. relaxation of assumptions, may complicate the analysis; however they are necessary for a realistic scenario.

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