UNIVERSIDADE FEDERAL DE SANTA CATARINA

PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA DE PRODUÇÃO E SISTEMAS

Artificial Intelligence Techniques for Modeling Financial Analysis

Thesis submitted to the *Universidade Federal de Santa Catarina* in partial fulfillment of the requirements for the degree of Doctor of Engineering

Alejandro Martins Rodriguez

FLORIANÓPOLIS

SANTA CATARINA - BRASIL

MARÇO DE 1996

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ALEJANDRO MARTINS RODRIGUEZ

THIS THESIS WAS JUDGED ADEQUATE FOR CONCEDING THE TITLE OF

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SPECIALTY PRODUCTION ENGINEERING AND APPROVED IN ITS FINAL FORM BY THE POS-GRADUATE PROGRAM

_____

Prof. Ricardo Miranda Barcia, Ph.D.

Coordinator,

PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA DE PRODUÇÃO E SISTEMAS

COMITEE:

_____

Prof. Ricardo Miranda Barcia, Ph.D.

Advisor

_____

Prof. Suresh Khator, Ph.D.

Co-Advisor

_____

Prof. Abraham Kandel , Ph.D.

_____

Prof. Alvaro Lezana, Dr.

_____

Prof. Rogério Cid Bastos, Dr.

Mediator

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Abstract

Although monitoring financial health of small firms is decisive to their success, these firms commonly presents difficulties in order to analyze their operational financial condition. In order to overcome this fact, the present thesis propose a **financial knowledge representation** that is capable to propose alternatives of action whenever a deviation could be detected.

The knowledge representation developed recognizes the existence of two different phases of analysis: one that looks for some *clues* about possible financial problems and another one that focus on with more detail the potential problems detected by the prior phase.

The vagueness presented in many *semantic* rules was implemented by using the theory of fuzzy sets. The uncertainty about the future behavior of some *key* financial variables is incorporated by the meaning of managers' *perceptions* about trends and events.

A practical formulation of this proposal is done considering the retail business sector.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Problem to be Focused on

The ability of a firm to use the information and knowledge has turned a vital aspect which can determine the success or failure of a organization. This is particularly true to the so called “small business” due to its size and the increasingly expansion of the international trade.

On this context, many small businesses have experienced difficulties in their management due to a lack of expertise knowledge in some of the main management areas. According to data published by CEBRAE[1] [CHER90], the small business activity is responsible of 40 % of the total Brazilian Gross National Product (GNP). In particular in the Santa Catarina region, a research done by the Production Engineering Department [BAT90] reported that financial mgmt. is considered as one of most problematical areas to the small industries. The direct consequences of such difficulties is translated in **liquidity** problems, low assets **turnover**, high risk due to a **debt** position and **unstructured** growth among other cases. These aspects affect later on the firm’s operational costs and revenues, and cause, depending on the timing of a correction, a firm’s failure.

Systems architecture based on AI techniques could turn the knowledge of a financial expert accessible to a large number of firms. If correctly implemented, such systems could save millions of dollars to a country due to a more efficient use of the overall financial instruments and internal decisions.

[1] CEBRAE: Centro de Apoio à Pequena e Média Empresa (*Brazilian Center for Small Business Support)*

Monitoring financial health of the small firms is a critical factor to their success. Although these firms generally have substantial requirements of capital, their access to credit is more restricted. In addition, in most cases small firms may not afford financial consultancy.

A central technique for addressing problematic financial situations is Financial Statement Analysis, a process in which the expert reorganizes information from the firm and other sources, creates auxiliary variables (*e.g.*, financial ratios and trend figures), and makes a comparison with standards in order to identify and understand deviations. Aiming to achieve a conclusion without getting lost in such a complex process, the expert looks for financial symptoms based on his/her experience in perceiving deviations. This process is essentially unstructured. On a further analysis, the expert focuses in more particular aspects in order to verify potential causes, understand the deviations and finally reach a conclusion. This process is much more structured than the first one, because at this point the expert has more specific symptoms to analyze.

In order to overcome the absence of a specialist, by including expert knowledge into a computational model we developed a *hybrid intelligent system* integrating Neural Network and Fuzzy Expert System technologies. The Neural Network models the first stage in which the expert looks for financial deviations. The Fuzzy Expert System models the expert's process of checking, understanding and giving a diagnostic. Figure 1 is a schematic view of the traditional and proposed methods of financial statement analysis .

Traditional financial statement analysis includes various techniques such as cross sectional (common size and financial ratio analysis), time series and the combination of financial statement information with other types of data. The general process of extracting valuable information to support decisions in a firm is not plain. It depends on the economic sector, the firm size, standards of comparison and it is dynamic. Therefore, the financial statement analysis is a process that requires expertise and a great deal of experience from the financial analyst.

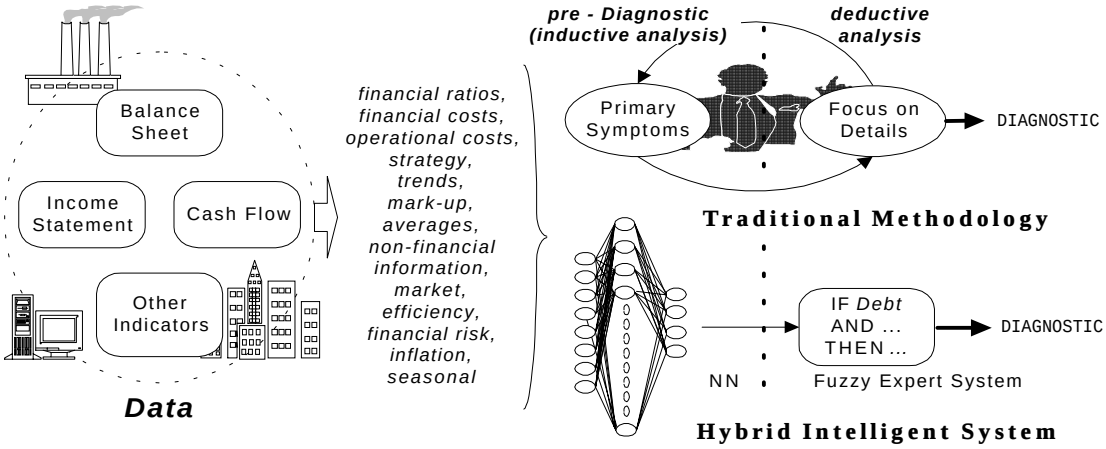


Figure 1: Analyzing Financial Health: Traditional Methodology vs. the Hybrid System Technology

1.2 General Objective

The general goal of this work is give financial support to small firms by diagnosing their situation and propose alternatives of action to their managers.

1.3 Specific Objective

The specific objective of the present thesis is to model the required knowledge to make a financial diagnosis and to indicate solutions whenever the any deviation is detected.

In order to satisfy the specific objective, a system proposed in the present work must handle the following requisites:

- model the normative and practical knowledge from a financial expert.
- have flexibility in order to be adapted to different economic sectors and environmental conditions.
- the system's output may be more specific than a general diagnostic. As an example, is the pre- diagnosis is a liquidity problem, then the system may determine is the cause is a low inventory turnover, the debt structure or high operational costs. By this way, the system will guide the manager to different alternatives of decision.
- it basic structure must be possible to implement in order to analyze other financial topics like the investments decisions.

1.4 Major Contributions

The implementation of a hybrid intelligent technology to fulfill the general objective of financial advise represents an important test in relation to the potential capabilities of the integration between different AI techniques. Such integration may be capable to model *sensible* outcomes in relation to the suppositions adopted in conjunction with knowledge that is no structured by nature.

In relation to the theory of finance, the application proposed presents the following potential contributions:

- clear out the use of financial ratios as a thermometer of the financial health of the company.
- establish a relationship between the theory of financial statement analysis and the influence of different financial scenarios (e.g., information available, economic sector, firm size).
- establish a formal representation of the financial knowledge acquired from experience and the knowledge that is based on the normative theory of finance. The referred representation must be a contribution to the development of hybrid intelligent system applications in order to satisfy the general objective mention on section 1.2.

1.5 Organization of the Different Chapters

The rest of the thesis is organized as follows. Chapter 2 discusses the use of financial statement information and financial ratios as financial indicators for a diagnosis. Chapter 3 introduces the financial categories in which the present diagnostic is divided, giving an overview of the very concepts of liquidity, profitability, activity and debt. An analysis of the advantages and disadvantages of the Expert System and Artificial Neural Networks technologies is presented in Chapter 4. This chapter discuss the potentiality of the combination of the referred technologies in order to reach the general objective of this thesis. The description of the financial knowledge representation is given in Chapter 5. Finally, Chapter 6 refers to concluding remarks and further developments proposed.

2. CROSS SECTIONAL ANALYSIS OF FINANCIAL STATEMENT INFORMATION

This Chapter addresses a review of the use of financial statement analysis with comparative purposes. Due to its importance in the present work, the ratio analysis technique is considered separately form the other basic financial statement techniques. The main limitations of financial statement analysis are considered in section 6[2]. Finally, a summary of the topics addressed is presented in Section 7.

2.1 The Principal Statements

The accounting based principal statements are the Income Statement, Balance Sheet, and the Statement of Cash Flows. Each one of these statements was originated for different specific purposes [SMI96].

The Income Statement (Figure 2) main purpose is to report the profitability of a business over a specific period. Basically, the income statement goes through four steps in the process of evaluating the business performance. The first step corresponds to the gross profit evaluation; the term *gross* means that only the operating costs were discounted at this stage. In the second stage, all the operating expenses are discounted; at the end of this stage, the evaluation of the profit before interest and taxes is completed. Finally, in the third and four stages the interest expense and the income taxes are deduced and the *net income* of a period is evaluated.

[2] ;A further discussion about how to operate with them is considered in Chapter 5

HOOVER RETAIL

INCOME STATEMENT

		S (%)	Dt-1 (%)
Net Sales	$ 224,834.2	100.00	5.02
Cost of goods sold	$ 184,363.2	82.00	0.15
Gross profit	**$ 40,471.0**	18.00	-0.15
Mark. & sales expenses	$ 8,911.8	3.96	-2.69
Adm. & research expenses	$ 22,172.5	9.86	2.44
Depreciation expense	$ 1,482.7	0.66	0.66
EBIT	**$ 6,421.2**	2.86	-0.52
Interest expense	$ 1,912.0	0.85	0.16
Profit before income tax	**$ 4,509.2**	2.01	-0.69
Income tax expense	$ 1,578.2	0.70	-0.24
Net Income	**$ 2,931.0**	1.30	-0.45

Figure 2: Income Statement

The Balance Sheet (Figure 3) shows the business' financial position[3] on a particular date. The left side of the balance sheet (assets) represents what the firm owns. The right side represents what the firm owes to the owner (equity) and to third parties (liabilities). The difference between current and fixed assets is that the first ones are supposed to be converted into cash during the operating cycle[4] (Figure 4). The term fixed assets is not correct and responds to an historical aspect. More precisely, fixed assets is composed by the assets which the firm keep over several periods in order to run the business. Current liabilities are composed by short term debt that in most cases its payment is related to the conversion of current assets into cash. Long term liabilities is composed by debts whose maturity dates are more than one year form the date of the current balance sheet. The equity category represents how much of the assets is financed by the firm's owners.

[3] I.e., what the firm owns and what the firm owes.

[4] Assets like marketable securities, which are not related directly to the operating cycle are considered *current* if they are will be converted into cash during the coming period.

HOOVER RETAIL

BALANCE SHEET:

Assets		**(%)**	**d*(%)**	**Liabilities & Equity**		**(%)**	**d*(%)**
Cash	$ 13,777.8	3.2	7.5	Accounts Payable (1)	$ 38,240.0	8.9	2.1
Accounts Receivable	$ 33,456.0	7.8	3.8	Accounts Payable (2)	$ 6,758.3	1.6	21.4
Inventory	$ 113,456.8	26.3	18.0	Accrued Expenses (1)	$ 6,256.3	1.5	0.2
Prepaid Expenses	$ 1,134.0	0.3	-46.8	Accrued Expenses (2)	$ 1,689.2	0.4	1.1
Temporary Investments		0.0		Income Tax Payable	$ 586.2	0.1	-21.8
				Short - Term Notes	$ 33,678.0	7.8	57.8
				Other		0.0	
Total Current Assets	$ 161,824.6	37.6	12.9	Total Current Liabilities	$ 87,208.0	20.2	19.4
Other Assets				Long Term Notes	$ 12,987.0	3.0	-0.6
Fixed	$ 274,890.0	63.8	0.0	Other Liabilities	$ -	0.0	
Depreciation	$ (5,931)	-1.4	33.3	Deferred Income Taxes	$ -	0.0	
Book Value	$ 268,959.1	62.4	-0.5	Total Liabilities	$ 100,195.0	23.3	16.4
				Equity	$313,237.4	72.7	0.0
				Retained Earnings	$ 17,351.3	4.0	20.3
				Total Equity	$ 330,588.7	76.7	0.9
Total Assets	$ 430,783.7	100.0	4.1	Total Liabilities and Equity	$430,783.7	100.0	4.1

*: difference from previous period (%)

Figure 3: Balance Sheet

The Statement of Cash Flows (Figure 5) relates the cash receipts and payments to the operating, investing and financing activities. Is not uncommon that a firm with *positive* balance sheet and income statement figures could go bankrupt the next period. This type of *incompatibility* is due that the statement of cash flows shows more detailed information regarding the firm's operation. For example, one may check if the firm primary sources of cash provide from the operating cycle or from another *temporary* source. Another example could be the following: the income statement may be reporting a positive income when the cash from the operations is negative. This case occurs frequently in fast growing firms whose sales depends heavily on credit. In resume, the statement of cash flows provides unique information hoe the firm's pool of cash flows.

2.2 Financial Statement Techniques of Comparison (I)

2.2.1 Common Size Statements

The common size technique consists in express the financial reports of different firms in a common base of comparison in order to overcome the size effects [SMI96], [FOS87], [BRI90], [GIB89]. The most common techniques consists in express the balance sheet figures in terms of percentage of total assets and the income statement figures as percentage of sales. This technique is known as *vertical* when the comparison is done within a same period and as *horizontal* when comparing any item at different periods.

It is common that many industries associations gather the financial statement data form its members in order to produce common size financial statements for business of similar size. Another useful application of the common size analysis is the analysis of business trends, which signal many times some particular deviations of the firm that appears to be independent of the sector.

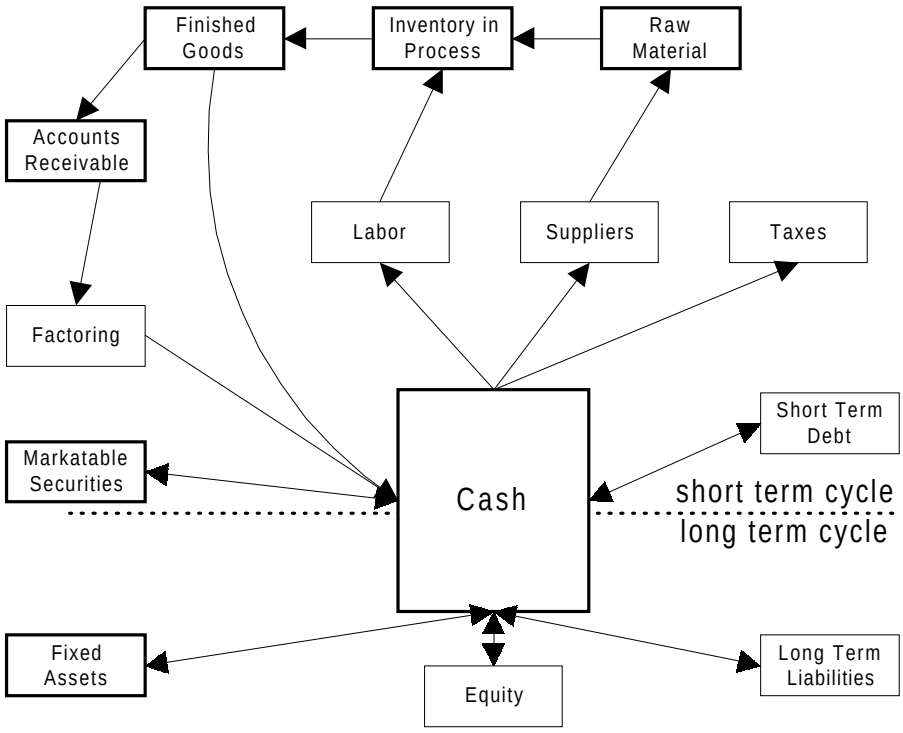


Figure 4: Operational Cycle

HOOVER RETAIL

Statement of Cash Flows

Cash Flow from Operating Activities:	
Net Income (from Income Statement)	$ 2,931.0
Plus charges to income not affecting Cash Flows	
Depreciation & Amortization	$ 1,482.7
Increased in deferred federal taxes	
Decrease in other liabilities	
	$ 1,482.7
Changes in Operating Assets (affecting Cash Flow):	
Accounts Receivable	$ 1,221.2
Inventory	$ 17,322.2
Prepaid Expenses	$ (996.0)
Changes in Operating Liabilities:	
Accounts Payables	$ 1,975.3
Accrued Expenses	$ 30.5
Income Tax Payable	$ (163.2)
Net Cash Flow from Operations:	$ (11,291.1)
Other Cash Sources:	
Cash Flow from Investing Activities:	
Increase in investment in properties	$
Increase in investment in other current assets	
Decrease <increase> in other assets (fixed assets purch.)	
Net Cash Flow from Investing:	$ -
Cash Flow from Financing Activities	
Increase Stock Issues	$ -
Increase in notes payables to bank	$ -
Increase in Short Term Debt	$ 12,333.0
Increase Long Term Debt	$ (79.8)
Net Cash Flow from Financing Activities	$ 12,253.2
Net increase (decrease) in cash and cash equivalents	**$ 962.1**
Cash & cash equivalents, begining of the year	**$ 12,815.7**
Cash & cash equivalents, end of the year	**$ 13,777.8**

Figure 5: Statement of Cash Flows

Since the meaning of the size deflectors depends on the industry, this technique is appropriate for comparisons among different firms of *similar* economic activities. A cross-sectional common size comparison between firms may be taken with care, since there are various other factors that affect the comparison.

2.2.2 Trend Statements and Variability Measures

Trend analysis is another type of horizontal examination of the financial reports in which the changes of different items over time are analyzed. The purpose of this type of analysis is to find specific *areas* that may require a more detailed analysis.

An important topic regarding the analysis of trends by the analyst is trend *forecasting.* In order to analyze the data to make decisions, the analyst must consider the expectations regarding some specific trends. As an example, one could consider the following decision rule:

"If liquidity is medium and sales trend is decreasing, it may be wise to reduce the inventory"

In the case of that decision, what do the financial analyst has already in mind could be the evaluation of the trend by the historical data or a personal forecast that is not taken from the *historical* data form the financial reports. That is, one may keep in mind that any forecast of specific trends from historical data are based on the assumption of the continuity of the present. If that supposition is no longer valid, the use of past trend to forecast futures trends could be done in a better way by other methods.

2.3 Financial Statement Techniques of Comparison (II): Financial Ratio Analysis

The use of financial ratios obtained from the main financial statement reports is the main tool of financial statement analysis [BAR87] [FOS86] [FRI95]. Ratio analysis was first used as instruments of failure detection as it is shown in the pioneer work of Beaver [BEA66].

Multivariate models that are based on financial ratios have been widely applied to bankruptcy prediction, since the precursor work of Altman [ALT68]. Recently the forecasting fundamental used by Altman have been modeled by ANN with better results in terms of forecasting and the additional advantage that they do not require the multiple-discriminant analysis [LAR95], [ODO90], [OHL80].

The financial analysis through financial ratios signal different financial areas within a firm that may be further analyzed to diagnostic their *efficiency*. Additionally, various researches in the cognitive area conclude that the financial analysis through ratios improves the quality of the decisions by reducing the information overload [CAS80], [ISE88], [ISE93].

Any financial analysis system that is based on the use of financial ratios may take into consideration many other indicators such as general economic situation, strategy of the firm, business sector and accounting principles that are affecting the firm. This *set* of requirements determine the validation of the input data and the confidence on the analysis.

When the different financial ratios are analyzed, one must consider the possible (and common) correlation between the different ratios. Another important aspects to be considered are the following:

a) it is not necessary to consider a great number of financial ratios in order to analyze an specific situation due to the fact that many indexes have variables in common.

b) the relevance of the different ratios depends entirely on the comparison of the ratios with similar data from the same economic activity [BER89].

In relation to the distributional form of the ratios and their statistical behavior, there is no consensus in the literature. The different distributional forms of the ratios depend basically on the type of ratio and the economic activity of the firm [BAR87], [EZZ90], [FOS87]. In relation to the behavior of the financial ratios along the time, in most cases the financial ratios have a non randomic behavior and their adjustment is dependent of the environmental conditions of the sector, the overall strategic goals and the information available [EZZ90], [CHU92], [LEE88].

The main areas of financial ratio research are:

- functionality form of financial ratios
- statistical properties over the time
- categorization of financial problems

Due to the importance ratio analysis on this research, the later research areas are overview in the next sections.

2.3.1 Theoretical Aspects

2.3.1.1 Functionality Form of Financial Ratios

This area of research gives the support for the use of financial ratios as an instrument of comparison between the different firms, economic sectors and time.

The precursor work in this area of research is the work done by Lev and Sunder[LEV79]. In order to validate the hypothesis proportionality, there must be taken some assumptions in relation to the firm size and economic sector. The functional

form of the ratio denominator is very important in relation to the validity of the referred hypothesis.

Some researches [BAR82] have shown that the non normal characteristic of various financial ratios can be deducted from the analysis of proportionality of the index. It turns necessary to highlight that one may focus on the practical meaning of the ratio rather than the significance of the ratios as size deflectors [HOR83].

Donald and Morris [MCD84], [MCD85] were the first to research the statistical fundamental of the use of financial ratios. The referred authors have studied heterocasticity hypothesis of the model Y/X where Y= Y= a + b X(i) + e(i). Their research gave support to the use of financial ratios within similar economic activities; in inter-industry comparisons, proportionality is not supported. Some authors like Berry and Nix [BER91] put in doubt the conclusions of that work in relation to its generality. By comparing value and equal weighted aggregate financial ratios, McLey e Fieldsend [MCL87] concluded that the non proportional behavior of some financial ratios varies is different for each ratio, firm's size and the economic activity. supposed to be converted into cash during the operating cycle[5] (Figure 4). The term fixed assets is not correct and responds to an historical aspect. More precisely, fixed assets is composed by the assets which the firm keep over several periods in order to run the business. Current liabilities are composed by short term debt that in most cases its payment is related to the conversion of current assets into cash. Long term liabilities is composed by debts whose maturity dates are more than one year form the date of the current balance sheet. The equity category represents how much of the assets is financed by the firm's owners.

It is worthy to be mentioned that the deviation from the proportionality is indeed connected with the distributional hypothesis. For example, Fieldsend, Longford and McLeay [FIELD87] have signaled that some ratios are expected to be lognormally distributed due technical zero lower bounds. Other works are in correspondence with the researchers mentioned: the proportionality hypothesis have theoretical support only if the effects of the specific economic activity are considered.

Another important aspect in relation to the functionality form of the financial ratios is the existence of market based ratios; these ratios are not going to be considered in

[5] Assets like marketable securities, which are not related directly to the operating cycle are considered *current* if they are will be converted into cash during the coming period.

the present work due to the assumption in relation to the firms' size ("small business"). But otherwise is important to mention that this type of ratios also present deviations from the proportionality hypothesis as it was shown in an analysis of the E/P ratio by Booth, Martikainen, Perttunen and Yli-Olli [BOO94].

2.3.1.2 Distributional Characteristics of Financial Ratios

There was an *extra* motivation at the beginning of the practical applications of financial to consider the assume that several ratios were normally distributed. The main reason of that approach was that significance tests of parametric methods like linear regression and discriminant analysis are based on the normal distribution assumption.

One of the pioneer work in this area was done by Mecimore [MEC68]. Using descriptive statistical measures he found cross-sectional non-normality and positive skewness in a sample of randomly selected Fortune 500 firms.

Several posterior researches [DEA76], [BIR77] have confirmed the non -normality hypothesis. These evidences guided many researchers to look for some methods that could restore the normality hypothesis. The most common methods used are the use of functional transformations and to remove outliers [FRE83], SO87], [FOS78].

Finally, it is worthy to mention the research conducted by Watson [WAT90] who analyzed the distributional properties of four ratios from a four hundred sample of firms. The main result was that the multivariate normal distribution is rejected if the outliers are not removed.

2.3.1.3 Classification of Financial Ratios

There exists four approaches in the literature in relation to the classification of financial ratios. A basic description of each approach is shown on Table 1.

Table 1: Different approaches to classify the financial categories

Approach	Main characteristic	References
Pragmatic	Based on practical experience	[LEV74], [FOS78], [BER89], [WHI94}
Deductive	Based on the Dupont ratio	[COU78], [LAI83]
Inductive	Emphasis on statistical methods	[PIN73], [CHEN81], [AHO80], [YLI86], [YLI89], [YLI90]
Confirmatory	A priori categorization; posterior checking	[LAU79], [LUO91], [KAN92]

The pragmatic approach is going to be used in the present work due to the necessity of a practical pre-diagnostic categorization of the financial problem to be analyzed by the expert system.

2.3.2 Common Used Financial Ratios

A list of common used financial ratios is presented on Table 2. A discussion of the financial ratios used by the system is presented in more detail in Chapter 5.

Table 2: Common Used Financial Ratios

Ratio	What Does it Measure
Current Ratio	liquidity evaluation; poor ;liquidity indicator but is traditionally used.
Quick Ratio	liquidity evaluation; its purpose is to measure the liquidity in the most liquid way.
Cash Turnover	average rate at which sales are generated in relation to the cash assets
Working Capital Turnover	how efficiently working capital is used
Payables to Current Liabilities	extent to which trade credit is used to provide short term financing
Bad Debt to Receivables	credit granting performance
Average Collection Period	average time required to receive the payment due to a sales on credit
Accounts Receivable Turnover	financial cost of carrying Receivables
Inventory Sales Turnover	financial cost of carrying Inventories
Cost of Goods Sold to Sales	1 - gross margin
Depreciation to Sales	the consumption of fixed assets in relation to sales
Variable Cost to Sales	firm's cost structure; 1- contribution margin
Operating Margin	profitability of production and operations
Cash Flow to Sales	critical indicator of the firm's productivity and creditworthiness
Earning Power	net return on tangible assets
Before Tax Return on Equity	productivity of a firm's total capital and asset base
Sustainable Growth Rate	annual growth rate that a firm can sustain given its financial performance
Net Income to Working Capital	after tax profitability of working capital assets
Fixed Asset Turnover	efficiency of the firm on managing fixed assets
Total Asset Turnover	efficiency of the firm on managing all assets
Net Profit Margin	profit generated after considering all expenses and revenues
Return on Investment	overall efficiency of the firm on managing its assets and generating profit
Earnings per Common Share	return to common stock shareholder for each share owned
Price / Earnings Ratio	expresses multiple that stock market places on a firm's earnings
Dividend Payout Ratio	percentage of earnings paid to shareholders
Dividend Yield	rate earned by shareholders from dividend relative to current

	price of stock
Return from Leverage	value of leverage to the equity investor
STDebt to Total Debt	financial risk
LT Debt to Tangible Assets	financial risk
Current Liabilities to Tangible Worth	amount of debt which must be retired within one year using the tangible net worth of the firm
Cash Flow Coverage	how many times the current cash flows will cover the firm's interest obligations
ST Debt to Working Capital	risk exposure of the suppliers of short term debt
LTDebt to Working Capital	risk exposure of the suppliers of long term debt for operational purposes
Fixed Charged Coverage	coverage capability more broadly than times interest earned by including lease payments as a fix expense
Debt Ratio	proportion of all assets that are managed with debt
Long Term Debt to Total Capitalization	extent to which long term debt is used for permanent financing
Debt to equity	relative proportion of funds provided by creditors
Times Interest Earned	how many times interest expense is covered by operating earnings

2.4 Limitations

2.4.1 Inflation

Traditional financial statements were not designed to cope with the effect of inflation over their figures. Inflation affects the market through three different ways: increase of the general price index, distortion of the relative prices and effects over the demand and cost of capital. The combination of the three effects over the firm are translated into a distortion of its financial statements. The degree of this distortion depends on the level of inflation, business activity, accounting methodology and period on consideration.

The issue of correct the effects of inflation over the financial statements is still on discussion. The most accepted technique consists in expose the information in constant purchasing power. Another methodology, the current cost accounting, displays the financial statement figures related to the current cost of the firm. This methodology is more precise but it contradicts the objectivity problem, since each firm would based its correction on *particular* indexes.

Another important consideration is related to the concept of *monetary* and *non monetary* accounts of the Balance Sheet. The monetary accounts do not need to be corrected, since they are already expressed in terms of constant purchasing power; what is computed over the monetary assets are the *gain* or *loss* with inflation due to keep a monetary liability or asset respectively. The non monetary accounts do need

to be corrected by a inflation index, since their value is not automatically renewed by current money terms. An example of different assets and liabilities and their distortion due to inflation is shown on Table 3.

Table 3: Balance Sheet accounts classified in relation to the inflation effect

Type of account	Account
Monetary assets	Cash, Accounts Receivable, Advances to employees,
Monetary liabilities	Accrued taxes, Notes payable, Bonds payable, Accrued wages, Accounts Payable
Non monetary assets	Inventory, Property Plant and Equipment, Patents,
Non monetary	Deferred Income, Owner's Equity

In general the validity of a cross firm comparison *increase* with the following assumptions:

a) the comparison is done between firms of similar economic activity and size;

b) the comparison is done over the same period;

c) the trends are not evaluated explicitly by historical data[6];

2.4.2 Averages, Firm Size and Seasonal Factors

The problem of gathering meaningful industry averages for comparatives purposes is quite difficult for large firms because they usually have multiple products and various divisions. In this sense the comparison with industry averages tends to be more meaningful as the size reduce its size and as a consequence, the number of market sectors that it operates with.

Another issue is that most firms try to perform *better than* the average instead of attain an average performance [BRI90]. This makes more useful in many cases, a comparison with industry leaders instead of a virtual average firm.

Another issue that needs the attention of the financial analyst are the seasonal factors. For example, a high accounts receivable turnover could be consider a problematic situation in *normal* conditions but no problematic if seasonal factors are involved. In other words, the seasonal factors have the effect of changing the standards of comparison and financial *rules* that an analyst works with.

[6] instead, in the present work the system will ask the manager to give his/her insights in relation to key expectations

2.4.3 Accounting Methods

The use of different accounting methods distort some of the Balance and Income Statement figures. An example of this effect is the inventory account. Depending if the methodology used to evaluate the inventory is LIFO or FIFO, the figures and financial ratios derived from the inventory and cost of goods sold accounts are different. Since most firms in a given industry use similar accounting procedures [BRI90], this point reinforce the fact that the conclusions derived financial statements comparisons are more conclusive within similar industry sectors.

2.4.4 Window Dressing

Sometimes, firms employ *window dressing* techniques in order to present their financial condition better than it actually is. This type of practice is not easy to detect. Examples of windows dressing techniques are:

- deliberate misstatement of inventories and cost of sales in order to improve profits
- recording written checks that are still not cleared by the banking system as current liabilities instead of deducting them from reported cash balances.
- borrow from a financial institution, holding the loan for a few weeks in order to improve the current and quick ratios.

In summary, financial statement analysis is very useful if the analysis is not taken *mechanically.* Usually the analysis requires adjustments, understanding, and experience from the analyst.

2.5 Conclusion

Financial Statement Analysis had been widely use for comparative purposes. Different factors like size, accounting methodology, inflation, and particular characteristics of an industry or service sector may affect the output of an expert analysis.

Ratio analysis is the most common used technique of financial statement comparison. Research topics regarding functional form and distributional properties of the different ratios are far from being concluded but in general they point out the same assumptions of the other techniques; i.e., the conclusions tend to be more decisive with similar firm size and activity, and shorter periods of analysis.

3. EVALUATING FINANCIAL PERFORMANCE

3.1 Purpose of the Current Diagnosis

The general process of extracting valuable information to support decisions in a firm is not plain. It depends on the economic sector, the firm size, standards of comparison and it is dynamic. Therefore, the financial statement analysis is a process that requires expertise and a great deal of experience from the financial analyst.

A primary issue in financial analysis is the categorization of problems. It is important to know how the expert aggregates financial deviations into categories. The better is the categorization the easier might be the problem identification. A financial expert has several alternatives to combine similar financial problems, including theoretical and practical frameworks.

In this work it is adopted a *modified* classification respect to the pragmatical empiricism approach[7]. In general, the pragmatical empiricism classifies the firm's financial aspects into five categories:

I) Short Term Liquidity

II) Asset Management

III) Debt Management

IV) Profitability

V) Market Value

[7] See for example [LEV74], [WES72], [FOS78], [WHI94], [BEA77], [HOL90], [TAM78].

These five categories represent the main *focuses* of the financial manager. In relation to the problem categorization, it is important to notice that the *boundaries* between each of these categories is not rigid. The main reason is due to the fact that any of these categories overlap dynamically over time; e.g., a debt problem may turn a profitability problem in the future and vice-versa. This turns out that any financial figures (e.g., ratios) does not belong strictly to *one* category; what indeed is present are different degrees of relationship between each of the pragmatical categories.

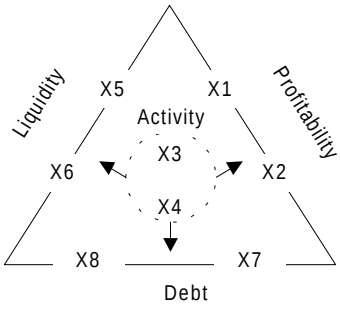


Figure 6: Financial Problem Categorization.

As it was stated above this work considers a modification from the pragmatical categorization. First, since the present work is devoted to analyze the financial health of small firms, the Market Value category is no longer to be consider. Second, the Activity category (i.e., Asset Management.) is not going to be present, in terms of *problem,* independently from profit, liquidity and debt. This is equivalent to the following assumption: regarding a financial health problem any *activity* problem translates into a profit, liquidity or debt problem; these are considered *immediate* consequences[8]. Figure 6 and Figure 7 represent graphically the pragmatical categorization assumed in this work.

In relation to Figure 7, it is worthy to explain the abstract conceptualization. First, there are two concepts of Profitability represented: a first one makes reference to the profit concept associated to the *operational cash flow*. That is, from this point of view, profitability represents the firm *economic* capacity to generate cash flows; it analyses the cash flows generated from the *economic cycle* of the business, without considering explicitly the influence of the *financial* cycle (i.e., assets turnover and debt). The second use of the Profitability term is broader than the first one: it considers the overall profitability of the firm, which is related with economic, financial

[8] See Chapter 5 for a further explanation about this point.

and debt management aspects. This concept is correctly called by some authors of "Liquidity", because the very concept of liquidity is related to both the short and long term. In other words, an *overall liquidity analysis* is not separate from an *overall profitability analysis* and vice-versa. Each financial category shown in Figure 7 is going to be further analyzed in Chapter 5.

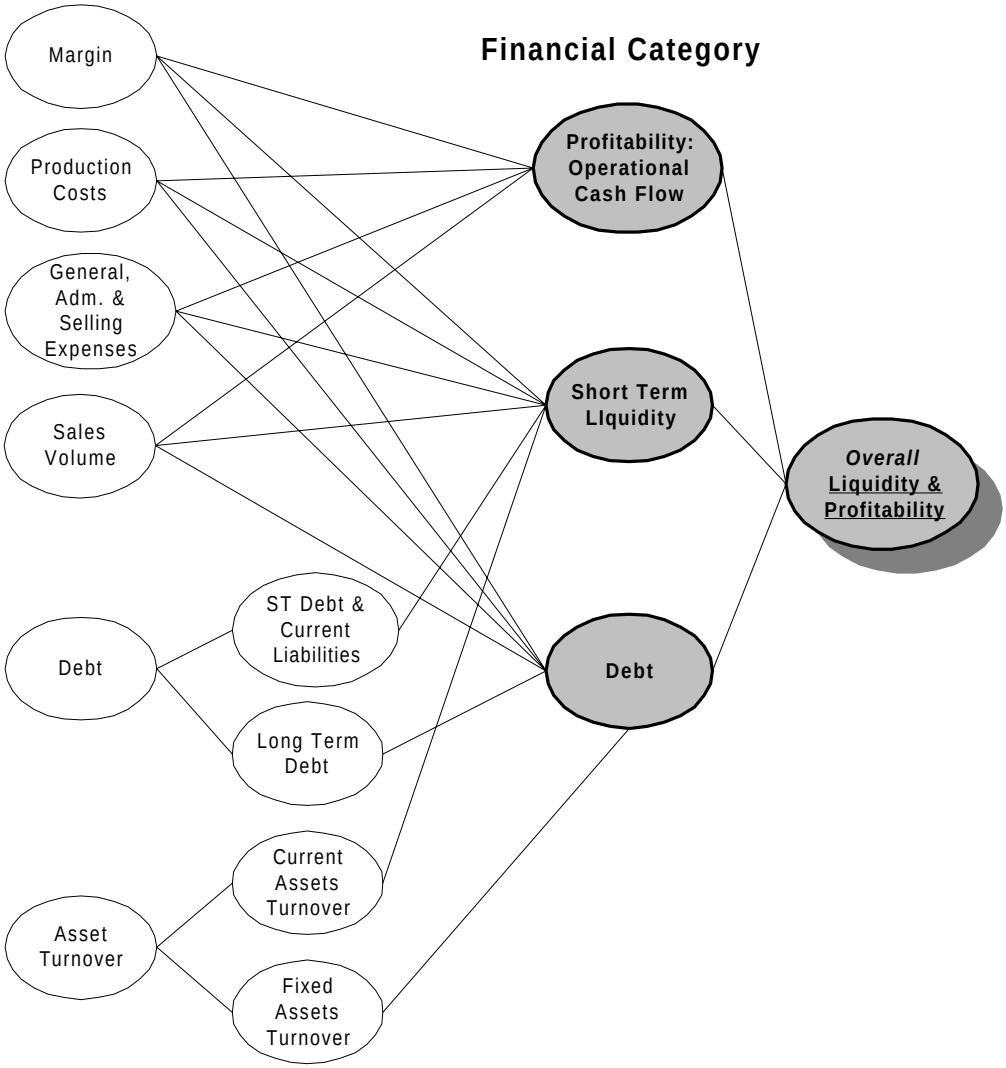


Figure 7: The Conceptualization of the Financial Diagnostic of Small Firms

These Chapter discuss the main focuses points of a profitability, debt and short term liquidity analysis. *Theoretical* focuses of activity are considered along with any of these categories. As an introduction, an example of some of the factors to be checked in each category is shown in Table 4.

Table 4: Causes to be checked according to the financial problem.

Problem	Some Potential Causes
Liquidity	purchases, production process, sales, credit terms, fixed assets, turnover, etc.
Debt	maturity, financial risk, lease payments, interest charges, long term investments, etc.
Profitability	operational cost, pricing, opportunity costs, administrative expenses, market share, etc.

3.2 Profitability Focuses

Profitability represent the ability of the firm of generating earnings. When analyzing profit, the manager focuses more on relative terms than on absolute values due . The most common *bases* of analysis to express the relative terms are the productive assets, owner's and creditors capital employed, and the sales from which earnings are the residual . In general the analysis of profit ratios should include only income that is expected to occur in subsequent periods[GIB89]. This translates into the exclusion of unusual or extraordinary items, discontinued operations and cumulative effects of changes in accounting principle.

A self contained profitability analysis may address the following questions [BER89]:

- what is the relevant net income and its quality ?
- what elements of the income statement can be used for a forecasting purpose?
- how stable are the elements of the income statement and what about their trends?
- what is the earning power of the firm?

The main topics regarding these questions are addressed briefly in the following sections by analyzing the main profitability measures and the information that is not present in the financial statements.

3.2.1 Profitability Ratios

a) Net Profit Margin: Net Income / Sales

The importance of this measure comes from that fact that is a consequence of the inclusion of all operating costs and expenses in relation to the basic source of income.

This measures provide a useful figure providing that the main sources of income and expenses are from operating activities. When this is not the case, one alternative

methodology consists in remove from both numerator and denominator the main non-operating activities, the ones that are labeled as “other income” or “other expenses”.

In analysis of the net profit margin *changes* between different periods, it is useful to separate the items that contribute to an increase of net income from those that did not.

b) Total Asset Turnover: Sales /Assets

This ratio measures profitability from an *activity* point of view. Basically, this ratio measures the productivity of capital. The higher is the value of this ratio, the better is the firm position. A low value of this ratio may represent problems in technology, marketing, or inadequate business strategy.

The refinement that may be done to this ratio is concerned to the variables involved in both numerator and denominator. One may take into consideration the proportion of assets that are not related to sales, which may decrease the ratio and consequently its relevance as indicator.

c) Operating Income Margin

This ratio is calculated directly from the Income Statement Sheet. It is not so relevant to measure the firm’s profitability because it does not consider the effect of interest paid on its evaluation.

c) Gross Profit Margin

This ratio measures the average margin of the firm. It is useful as an indicator of the overall business margin but in some cases, specially in the retail business, it tends to be quite homogenous, restricting in consequence its usefulness as an indicator between profitable and no profitable firms.

d) Return on Equity

This ratio is useful as a profitability indicator from the owner’s point of view. It usefulness as a financial indicator of the firm’s health is restricted due to different capital structures between different firms.

e) Sales to Fixed Assets

This ratio intends to separate the efficiency of the total assets between current and fixed assets. Specially in the industrial sector, the fixed assets are *supposed* to be

the most profitable assets of a firm. Its usefulness as a financial indicator of the firm's profitability depends on the period into consideration and the firm strategy. As an example one may consider the auto industry sector: it is possible that some firms decide to invest heavily in automation, even in periods of slight recession, in order to be more competitive in the period of economic recovery. The later strategy may traduce into a low fixed assets turnover but it doesn't necessarily means that a firm has a profitability distress.

e) Cash Flow / Sales

This ratio is an efficient profitability indicator since it look for the cash flow side of the operating cycle. The Cash Flow is computed as EBIT[9] plus depreciation expense, amortization expense and depletion expense. It is clear that this ratio measures the capacity of a firm to generate cash; that is, if for a specific firm this ratio is constantly low if compared to the average standards, the profitability problem of the firm, resides n its very bases and the potential problems turn to be hard to solve

3.2.2 Quality of Earnings

As it is stated by Gallinger [GAL91], *"failure to detect low earnings quality makes any form of ratio analysis suspect as a management tool"*. The concept of quality of earnings refers to the relationship between accrual income and cash flow, the degree of conservatism in calculating earnings, and the variability of the firm earnings.

The most relevant topics regarding the quality of the earnings are shown in Table 5. Each of the specified items may contribute to distort the profits figures of a firm.

[9] Earnings Before Interest and Taxes

Table 5: Factors that Contribute Negatively to the Quality of Earnings Figures;

(adapted from [GAL91])

Factors	Example
Fraudulent Actions	Deliberate misstatement of inventories of cost of sales
Above-Average Financial Risk	Fixed interest payments
Less-Than Conservative Accounting	Difference between reported income and inflation-adjusted income, leasing capitalization
one-time transactions	Sales of subsidiaries; debt restructuring gains
Borrowing from the Future	Acceleration of sales
Riding the Depreciation Curve and Other Factors	Management fail to invest in the future
Top Management	People on the boarding directory
Deferred Taxes	Deferred tax liability
Reaching Into the Past	reducing contingency reserves

3.2.3 IRR vs. ARR

There is a tradition of divergence regarding how to evaluate the *Internal* Rate of Return (IRR) from the *Accounting* Rate of Return [HAR65]. Several discussions can be find in the literature regarding this topic (e.g., [LIV70], [RUU82], [LUC84]); The methodology used to the referred purpose consists basically to make assumptions about a firm's growth, economic sector, depreciation, asset valuation, etc.. Most critics about the different methodologies rely on the assumptions that the different model considerate.

The main trends that emerge form the discussion are the following [SAL94]:

- IRR is a well-founded profitability concept; the ARR have relevance from a practical point of view.
- whether to evaluate the IRR from the ARR remains unsolved because most methodologies proposed relied heavily on various questionable assumptions.
- the estimation of the IRR from published financial data is an important direction for measuring the long-run profitability of the firm.

3.3 Short Term Liquidity

Short Term Liquidity measures the firm's capacity to meet its short term financial obligations. As it is shown in Figure 7, the referred capacity is the result of the conjunction between economic and financial aspects that which are related to short term debt and current assets turnover management.

The different types of liquidity problems are described in Table 6. Further explanations must be done in relation to each type:

Working Investment refers to the operational working capital, i.e., it is evaluated as a difference between the operational currents assets and liabilities:

WI: Operational Current Assets - Operational Current Liabilities =

Accounts & Notes Receivable + Inventory - (Accounts Payable + Accrued Taxes + Accrued Wages) =

Working Capital + (Cash + Marketable Securities - Short Term Debt[10]) = Working Capital - "Treasury"

➔ **WI= WC +"Treasury" ,**

where "Treasury" = Cash + Marketable Securities - Short Term Debt

As it can be appreciated form the above definition, if WI <WC, then Treasury is negative, which means that <u>at least momentarily</u> a firm is relying on short term debt to finance its WC necessities. That situation, *depending on how long it persists*, makes pressure over the short term liquidity position of a firm. If the particular situation no longer persists than for a couple of months, probably it was generated by *seasonal* factors of the business cycle or by "normal" growth of the business. On the other hand, if the situation persists over a several months as if it were *permanent,* then probably the resources that the firm generates and uses for the short term (represented by WC) are not sufficient to cover the short term obligations; that is, the short term liquidity position of the firm is "poor".

As an example, a short term maturity matching type of ST liquidity problem is present when a firm finances its fixed assets with short term debt. This type of financial movement may pressure the firm's ST liquidity position and it is generally very risky.

[10] i.e., Notes Payable

The Cash Balance type of ST liquidity problem appears when a firm allocates (or retires from the ST) an insufficient amount of money to the ST that doesn't cover the WC necessities. As a result, a firm needs to borrow to recompose its ST cash position.

Table 6: Different Type of Liquidity Problems

Liquidity Problems	Description
Working Investment	*Excessive* capital tied up to the short term for an specific level of Sales
Short term debt maturity matching	There is an imbalance between the period needed to return the investment and the period used to finance the assets
Cash Balance	Insufficient resources allocated to support the short term position
Overtrading	The resources that the firm can used for support the short term are insufficient to support such a volume of Sales; in general, the later is due to the fact that the firm is growing besides its financial available capacity
Overall Short Term Risk Position	The liquidity position of the firm depends heavily on how stable are either the current environmental situation or the correspondent forecasts

A problem of *overtrading* exists when a firm is doing business beyond its financial capacity in such a sense that the necessity of capital due to growth is bigger than the financial capacity. As a consequence of overtrading, a firm increases its short term risk position due to a constant shortage of cash.

Finally, the overall short term risk position refers to a short term financial position that is *risky* if it is considered with different scenarios. An example of this case is a ST financial position characterized by investing heavily in inventories; even if the inventory doesn't make pressure over the ST liquidity, it can be *risky* if the figures of the estimated sales are unreliable. This is not necessarily a *bad situation,* but it does need to be point out in order to be analyzed in further detail by the financial analyst.

3.3.1 Different Short Term Liquidity Ratios

In Table 7 is presented a summary of the most common used financial ratios used to analyze the firm short term liquidity position. In most cases, the relevance of each ratio depends on the type of SIC activity to be evaluated.

Table 7: Different ST Liquidity Ratios

Ratio	Formula	Comment
Quick Ratio	Current Assets/ Current Liabilities	Poor indicator for internal used; used by many financial institutions.
Acid Ratio	(Current Assets - Inventories) / Current Liabilities	Better indicator than the Quick Ratio; used by many financial institutions.
Cash Turnover	Sales / (Cash + Marketable Securities)	Measures the efficiency of the cash balance.
Treasury to Working Investment	T / | WI |	Well founded indicator of liquidity if considered in conjunction with its *trend*
Inventory Turnover	Sales / Inventory	Measures the inventory management efficiency
Days Sales Outstanding (DSO)	Receivables / (Sales of the period)/ period (days)	Associated with the financial cost of holding receivables
Working Capital Turnover	Sales / Working Capital	Indicates the impact of current operations over profit
Days Payable	Accounts Payable / (Cost of Sales & Operations of the period)/ period (days)	Measures how long does an average payable takes to be paid.
Cash Conversion Cycle	Days Receivable + Days Inventory - Days Payable	Precise indicator of the ST management efficiency.

3.4 (Long Term) Debt

In this section and generally speaking in this work, the term *LT Debt* refers to the firm's capacity to meet its long term obligations (principal plus interest). There are two approaches in the literature to investigate the Debt position of a firm[11]. A first one analyses a firm's debt position from the income statement point of view, and the second one analyses the debt position from the balance sheet. Each of these different approaches is evidenced by the main financial ratios used to evaluate *LT Debt.* A list of the most representative LT Debt ratios is shown in Table 8.

[11] *See* for example [GIB89], [BER89].

Table 8: LTDebt Indicators

Ratio	Formula	Comment
Income Statement point of View		
Times Interest Earned	Earnings Before Interest and Taxes (EBIT) / Interest Expense, including capitalized interest	Measures the capacity of a firm to give coverage to the interest expense; temporary positive cash flows items may be excluded from EBIT in the computation. “Earning Power” indicator.
Fixed Charge Coverage	EBIT + Lease Payments / (Interest Charges + Lease Payments + Sinking Fund Payments / (1 - marginal tax rate)	Include the effect of leasing and taxes to measure the coverage capacity of fixed charges expenses
Balance Sheet Point of View		
Debt Ratio	Total Liabilities / Total Assets	Measures the financial risk of the creditors; there is no agreement in practice in relation to whether or not consider the short term liabilities. It must be checked if the *book value* of the assets corresponds to the *market value*.
Financial Leverage Ratio	Total Assets / Common Equity Capital	Measures the capital structure.
Debt to Equity	Total Liabilities /Equity	Indicator of the leverage position
Debt to Tangible Net Worth	Total Liabilities / (Equity - Intangible Assets)	Conservative index if compared to the *Debt to Equity* ratio.

3.5 Du Pont Analysis

The Du Pont analysis dates from 1919; originally it was known as the triangle system (Profits / Total Assets), (Profit / Sales), (Sales / Total Assets). Its usefulness consists on the graphical representation of asset management and profit ratios. The Du Pont Analysis corresponds to the *deductive approach* of financial ratios. This approach was returned to the theoretical analysis by several authors [COU78], [LAI83], [BAY84]. In particular, Bayldon, Woods, and Zafaris [BAY84] developed a pyramid scheme of

financial ratios but in some applications it did not function as expected. This approach is now mixed with the confirmatory approach[12].

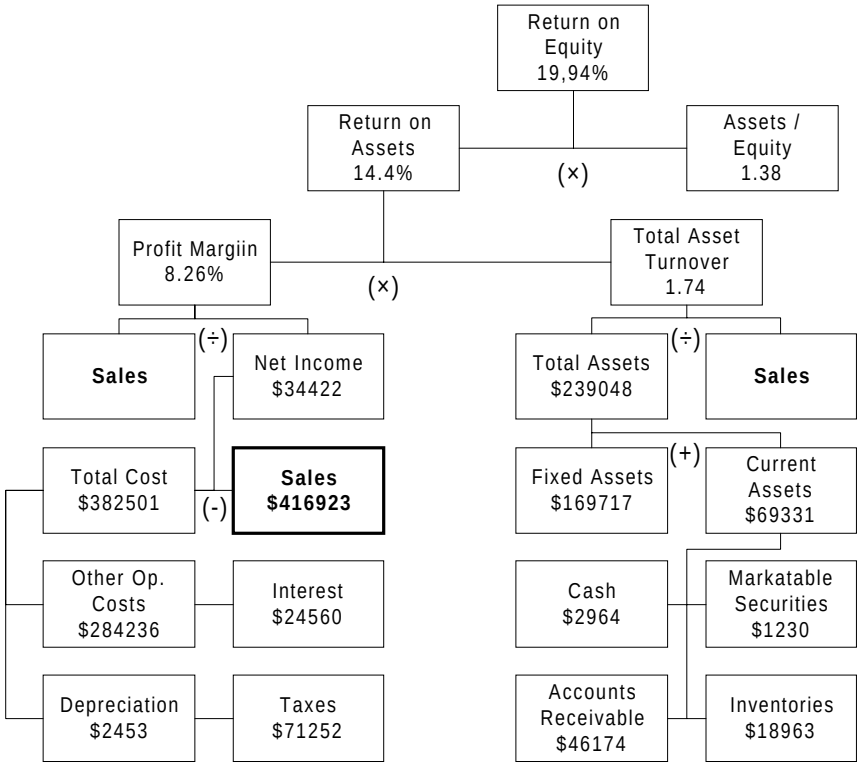


Figure 8: An Example of the Du Pont Deductive Scheme to Analyze Profitability.

3.6 Overall Risk Consideration

In a complete analysis of a firm, the financial expert may take care of the basic risk assumptions and considerations. The main types of risk are of *financial* and *business* nature. The financial risks are associated with the debt position and are in general *particular* to the firm. The business risks, on the other hand, are associated to the business' economic activity and are particular to the sector. Both financial and economic risks interact with each other in a complex way to signal the overall risk of a firm.

It is difficult to measure either the financial or the business risks from the analysis of ratio figures since most of the ratios are static or historical. In order to evaluate the overall risk of a firm when signals are present on some financial ratios, it is

[12] *See* Chapter 2.

necessary to know *additionally* information about different aspects; that is, one must answer questions like the following:

- Are the effects that contribute to an increase of the financial (business) risks temporarily or permanent?
- What about the financial (business) trends? Could they be measure by some financial ratios trends?

This questions are addressed in the present application proposed through an explicit consideration of non-financial statement information related to trends perceptions in the fuzzy expert system rules.

3.7 Conclusion

There is no a unique way to make a categorization of the financial aspects of a firm with diagnostic purposes. The current categorization proposed is derived from the pragmatical approach. Its main target is the small firms since no explicit consideration are made to market value variables. The division of the aspects in profitability, short term liquidity and debt categories has the aim of ease the detection of *warning* signal to focus on in the analysis. In order to be precise in relation to the use of financial terms, one must have ever present that the concepts of liquidity and profitability represent an overall financial and economic condition. That is *liquidity* and *profitability* are the consequence of the complex interaction of short term and long term financial and economic events, decisions and trends. These concepts correspond to the general diagnostic of a firm as the one done by investors and credit lenders.

The purpose of this work is to focus on how to give a financial support to small businesses, giving *operational* alternatives whenever a warning signal is detected and confirmed; with such a purpose, it is necessary to make a categorization in a narrower sense than the one that could be derived from the general concepts of *liquidity* and *profitability.*

The evaluation of the different types of categories can be done as a first trial by the selection of proper financial ratios. Although the financial ratios give information about a firm situation, additional information is required in order to evaluate the risks involved. Similar premises may conduct to different decisions if specific consideration of risks involved are considered. Thus, any system that aims to model the financial diagnosis process done by an expert needs to consider additional information than the one offered by the financial statements. The later represents the actual necessity

to model the knowledge using the theory of fuzzy sets, which can handle in a practical way the imprecision present in many financial perceptions and concepts.

4. THE USE OF EXPERT SYSTEMS AND NEURAL NETWORKS IN FINANCE

This Chapter analyses the advantages and limitations of Expert Systems and Neural Networks technologies in order to represent the knowledge required in the process of financial diagnosis.

4.1 Expert Systems

A ES is a system a computer application that solves complex problems that require extensive human expertise. The ES captures the knowledge and heuristics that an expert uses in order to take decisions.

The main characteristics of the ES within the different AI technologies may be summarized in four basic concepts. In first place, the ES is capable to explain why did the system reached a specific conclusion. In second place, the vast majority of ES are capable to work with imprecision and uncertainty. The main techniques used to model such knowledge characteristics, are fuzzy logic [ZAD65], bayesian probability [PEA86], and certainty factors [ADF76]. In third place, in the ES technology the inference control is separated from the system's data and knowledge; this later characteristic make possible to implement an ES in an incremental way, refined and easily tested. Finally, another characteristic of the ES consists on the use of symbolic reasoning (in opposition to numeric processes of reasoning).

In order to evaluate if an specific application is appropriate or not to be model by an ES, one may analyze the following topics [MED94]:

a) the problem has not immediate resolution, it is performed periodically and involves symbolic reasoning;

b) there exists some form of consensus in relation to its resolution;

c) there is available at least one expert in relation to the problem;

d) there exists cases available in order to perform different type of tests;

e) there exists a real necessity to capture the expert knowledge involved;

4.1.1 ES Components

The basics components of an ES are described in Figure 9: a) user interface: dialog structure, b) control structure: inference machine, and c) knowledge base.

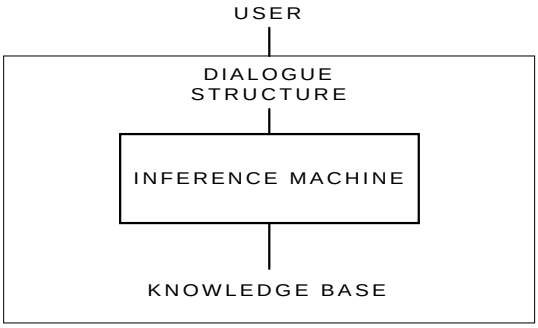


Figure 9: ES components

The dialogue structure represents the interface by which the user can access the ES. The three different methods of access are: a)user as client, b) knowledge base refinement and c) use of the knowledge. The inference machine is the structure that uses the ,knowledge base in order to reach a conclusion. The main inference methods are: forward chaining, backward chaining, and the combination of both methods. The knowledge base id the main component of an ES. The *power* of an ES is relate din most cases with the volume of information stored[DUD81].

4.1.2 Advantages and Limitations of the ES

The main advantages of the ES are:

a) easy maintenance of the knowledge base; this is consequence of the EDS architecture which separates the knowledge base form the inference machine

b) the capability to explain its conclusions.

c) the number of commercial applications already developed that in turn facilitate the development of new applications

In relation to the main ES limitations, one may mention:

a) An important limitation of the ES technology is the fact that the expert doesn't ever think in terms of structured knowledge. In consequence, for a variety of applications, the ES can not model the process of problem solving. In relation to this later deficiency and the problem to be solved, other techniques can be used in order to overcome such limitation;

the main basic technologies to be considered are Neural Networks, Case Based Reasoning and Genetic Algorithms.

b) ESs do not learn directly from their experience. This fact highlights the crucial importance of the constant maintenance of the ES knowledge base.

4.1.3 Applications of ES in Finance

Finance had been broadcast as one of the major areas outside medicine that has a great potential of Expert Systems Applications [WAT88].

The applications of ES in Finance can be divided into the areas of Corporate Finance, Financial Institutions, Securities and Financial Markets.

An example of financial applications of ES that have been developed with success are:

- fraud control of credit cards [NEW87]
- analysis of financial indicators [PAU91]
- credit granting [ENR91] , [WEB92]
- financial planning [BRO90]
- accounting [BRO90]
- portfolio analysis [RAM90]
- risk evaluation [RAD91]
- marketing [COO88]

Two financial ES that are devoted to Financial Analysis are *Answers* [BLO90] and *Financial Statement Analyzer (FSA)* [MUI90].

Answers is an ES that consists of two modules, one who performs a ratio analysis and the other one performs an analysis of projections. The function of the ratio analysis is to trigger comments from observed variations in *key* financial ratios used by the system. The purpose of the comments is to suggest to the managers further questions to be addressed or topics to be analyzed. Originally, this system was conceived for audit purposes but later on it was used for training and advice. It is important to notice that the advice performed by the *Answers* is not operational, in the sense that it describes some further topics to be addressed but it does not present an *specific course* of action.

The FSA is an ES commissioned by the U.S Securities and Exchange Commission (SEC) State to Arthur Andersen in order to extract *valuable* information from current financial statements. Originally, the FSA was goal was to process automatically ratio computations. The FSA system computes standard ratios from a company's financial statements. Further developments mentioned by the authors consist on the implementation of more sophisticated analysis that uses the results actually developed as its inputs.

4.2 Artificial Neural Networks (ANN)

The ANN technique have been widely used in commercial applications in the 90' decade. An *Artificial Neural Network* is a dynamic non-linear mathematical function that establishes a link between input and output variables. In such a model, there are some equilibrium states that may recognize an specific behavior or may solve a mathematical problem (Figure 10). In general terms, a ANN can be implemented in practical applications as an specific algorithm, a software or directly thorough a hardware device. The common point in most applications is the motivation to simulate the human brain behavior.

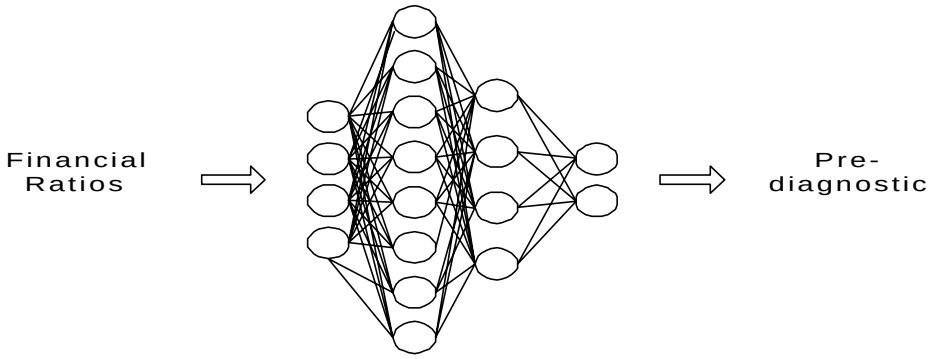


Figure 10: ANN technique applied to analyze the financial health of a firm.

It is important to highlight, from a practical point of view, the concept of *training* of an ANN. Any ANN has a rule based on an algorithm that adjusts the different weights of the neurons, in correspondence to a training data set. For each new set of training data, the different weights between the connections are adjusted . This fact makes possible the ANN capability to learn directly from the experience and at the same time *generalize.* The main difference between the methodologies of ANN learning are in terms of a supervised learning or unsupervised learning. In the first case, the training data consists of a set of known inputs and outputs. In the second case, the

ANN *infers* the behavioral properties from the input data. The selection of the training methodology depends on the data available and the nature of the application.

In general, the ANN technology is used in problems which there is a considerable number of data available and when the nature of the reasoning is *connectionist.*

Among the current applications already developed using the ANN technology are:

- applications related to physics: movement detection for military use, data transmission, voice and language recognition, robot learning, automation of operations in dangerous places, diagnosis of defects, etc..
- data analysis from a variety of sources: financial services, creditor evaluation, diagnostic of engines, medical diagnosis, demand forecasting, employee evaluation, etc..
- mathematical optimization: minimal distance, maximum capacity, etc..

4.2.1 Advantages and Disadvantages of ANN

The main advantages of the ANN technology were considered implicitly on the previous section:

a) ANN have learning capabilities directly form the experience

b) ANN can be applied to specific situations where the correspondent knowledge is not available or is not modeled in terms of rules.

In relation to the ANN limitations, one can mention the following:

a) ANN do not use straightforward symbolic reasoning; this fact mean that in many cases the numeric weight of the different neurons is not significant to the human expert. The translation of the acquired knowledge by an ANN in terms of rules in one of the main research areas at the present moment [CAR95], [CRA94], [FU94], THR95]. Additionally, this will let to have a better knowledge in relation to the ANN process of training.

b) ANN is not capable of *chaining* reasoning, necessary to model many financial applications.

4.2.2 Factor Analysis: an Alternative Technique to ANN Regarding Financial Problem Classification

The main objectives of the discriminant analysis are [LEE85]: a) to test the differences between different groups of data and to describe the intersection between the different groups, and b) to construct a classification system based on a sample set of m-variables in order to classify samples that were not classified previously.

The factor analysis technique consists on a linear combination of different *originals* variables; it can be defined through the following equation:

$f_i = b_1 Y_1 + b_2 Y_2 + ... + b_p Y_p$, where f_i represents the i-th. factor, Y_j the original variables and b_i are the coefficients to be estimated.

The existent correlation between a set of different factors with the original variables represents the *factor load*. Different factor loads in relation to a same variable makes possible to associate each variable to the different factors.

As an example of applications of factor analysis in finance, one can mention the following:

- discriminant analysis in groups of bankruptcy, non-bankruptcy [ALT68].
- credit analysis: accounts receivable classification in good or bad accounts [MEH74], [VANH80].
- classification and test of different financial aspects from a sample set of financial ratios [JOH69].

In relation to the efficiency of this methodology in practical applications, there exists in the literature different comparisons between discriminant analysis and ANN, mainly in relation to bankruptcy forecasting [ODOM93], [TAM93]. The reported results indicates a relative advantage of the ANN approach (in general, the ANN percentage of success is at least 10 % higher than the percentage obtained with discriminant analysis).

The factor analysis technique may be used in this problem to find the different financial categories from a set of different financial ratios. Besides this fact, this technique is not going to be considered in this work because the general purpose of dividing the potential financial problems in different categories[13] will be approached by a practical classification, following the classical criteria of Lev [LEV74].

4.2.3 Applications of ANN in Finance

In recent years, the research and implementations of the ANN technology grew steadily. The main financial areas in which the ANN technology concentrated are: .

- bankruptcy forecasting [LAR93] [REF95]: the models based on the ANN for that purpose generally performs better than the classification methodologies based on discriminant analysis.

[13] These categories represent a pre-diagnostic input to the ES.

- stock market analysis and forecasting [BARR94], [LIN93], [OBR93] , [MEN93], [MAR92]
- macroeconomic and foreign exchange applications [REF95]
- knowledge extraction from accounting data [BER93]: this ANN consists on the construction of valuable relationships (such as financial ratios) from the financial statement reports.

It is important to notice that the application of the ANN proposed aims to give a financial diagnosis regarding different financial aspects (profitability, ST liquidity and debt). It is goal is not bankruptcy prediction, in which case the mapping is trained in order to classify the output in bankruptcy, non- bankruptcy category; consequently, the proposed use of the ANN technology is very different from mentioned application, both in terms of the financial ratios employed and the ANN architecture.

4.2.4 Why to Use ANN?

The relationship between the financial ratios and the problem categories depends on the firm size, economic sector, seasonally, and business cycle [OST92], [HAW86]. Depending on these variables, similar factors could lead to different financial problems. This situation is very common when the financial analysis is done by an expert; he considers different weights for similar ratios if he is working in different economic sectors. It is important to notice that each of the chosen ratios have connotations on more than one categorization.

An example of a financial categorization of retail grocery firms[14] is presented on Table 9. From this table, one can consider the cases number 2, 6, 7 and 11. These cases are different from each other regarding their financial categorization, as it can be easily verified from columns **P, L, D and FA[15].** Although different in nature, cases 2 and 6 can be viewed as *Profitability* problems; similarly, cases 7 and 11 can be viewed as *non-Profitability* ones. If a technique of categorization is employed, this technique must be capable to separate firms 2 and 6 from firms 7 and 11 in a mathematical space of representation.

Two cases of mathematical spaces of representation are considered. One case correspond to a space of functions defined by two Gaussian functions of the form $G(x)= \exp\{(x_1- t_2) + (x_2 - t_6)\}$, where t_1 and t_2 represent the coordinates of firms # 2

[14] SIC code 5140

[15] Profitability, Short Term Liquidity, Debt and Further Analysis categories; 1= Problem.

and 6 regarding the financial ratios C/S and NI/S[16] respectively; this type of functions are frequently used by the Radial Basis Function mapping. The other case considered corresponds to the functional space of Polynomial functions of the form $a(x_1- t_2)+b(x_2- t_6)$. The graphic representation of the referred firms is presented in Figure 11. As it can be shown, the Gaussian functions are capable of better differentiation between the firms considered; **similar results could be appreciated using nth. grade polynomials instead of linear functions**. These result suggest that better results could be obtained with ANN instead of Factor Analysis as a methodology of classification.

Table 9: Financial Categorization of 18 Firms; An Example

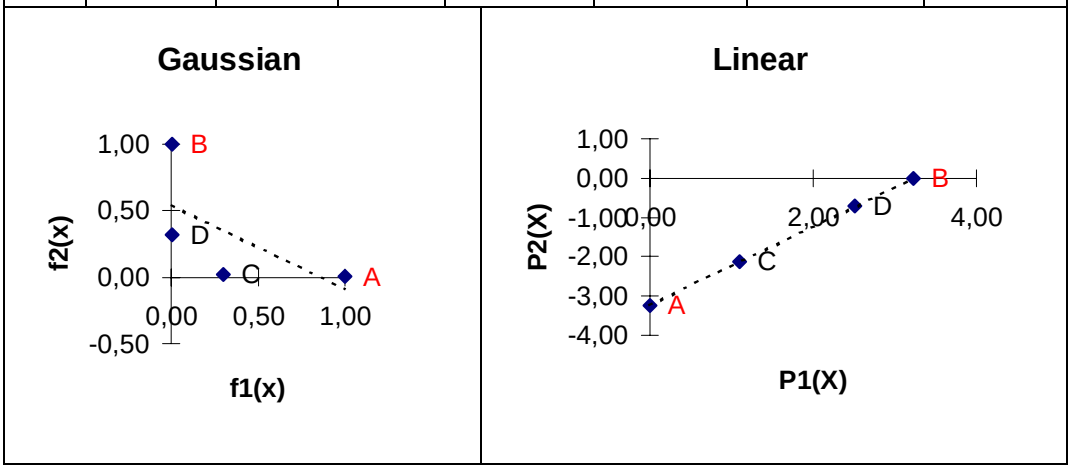
#	C/S	NI/S	WC/S	CCC	T/|WI|	t*	EBIT/I	D/E	P	L	D	FA
1.	5,35	2,05	17,79	28,25	0,43	0,00	5,26	-2,05	0,00	0,00	1,00	0,00
2.	**1,06**	**-1,14**	**12,80**	**36,62**	**0,30**	**1,00**	**2,04**	**4,98**	**1,00**	**0,00**	**1,00**	**0,00**
3.	3,24	1,23	5,71	31,96	-1,52	-1,00	3,80	-3,18	0,00	1,00	1,00	0,00
4.	4,35	1,50	17,23	23,52	-2,42	1,00	4,52	-4,47	0,00	1,00	1,00	0,00
5.	3,60	-0,60	7,95	32,01	0,78	0,00	1,84	-9,94	0,00	0,00	1,00	0,00
6.	**3,03**	**0,12**	**8,15**	**14,50**	**0,63**	**0,00**	**4,65**	**2,95**	**1,00**	**0,00**	**0,00**	**0,00**
7.	**3,34**	**-0,91**	**21,67**	**34,18**	**0,59**	**0,00**	**-3,18**	**-5,60**	**0,00**	**0,00**	**1,00**	**0,00**
8.	2,37	1,11	10,05	40,83	-0,78	-1,00	5,70	-2,82	0,00	1,00	1,00	0,00
9.	1,07	-0,15	9,84	19,08	-0,15	0,00	1,12	3,96	1,00	0,00	1,00	0,00
10.	3,65	1,58	9,86	20,69	-1,33	0,00	3,22	-1,70	0,00	1,00	1,00	0,00
11.	**1,06**	**-0,04**	**13,09**	**2,26**	**-1,11**	**0,00**	**2,11**	**-5,70**	**0,00**	**1,00**	**1,00**	**0,00**
12.	2,99	1,75	15,48	4,01	-1,53	0,00	4,23	2,27	0,00	1,00	0,00	0,00
13.	5,47	2,78	20,01	72,34	0,65	0,00	7,20	0,28	0,00	0,00	0,00	1,00
14.	1,47	-1,60	32,10	10,92	-2,24	1,00	1,72	1,67	1,00	1,00	0,00	0,00
15.	2,31	-1,74	9,27	24,79	0,69	0,00	-2,21	-4,55	0,00	0,00	1,00	0,00
16.	2,34	1,24	7,08	28,32	-3,16	-1,00	5,63	4,81	0,00	1,00	1,00	0,00
17.	1,06	-1,36	24,21	5,13	-2,95	1,00	2,10	2,14	1,00	1,00	0,00	0,00
18.	2,01	-1,12	7,60	34,62	0,40	0,00	-2,39	-1,45	0,00	0,00	1,00	0,00

*: t =trend T/|WI|

[16] C/S: Cash Flow / Sales; NI/S: Net Income / Sales; both ratios are the *main* profitability indicators.

Figure 11: An Example of Gaussian Functions and Linear Functions Used As Separators of Different Financial Situations

point	x	y	output	f1(X)	f2(X)	P1(X)	P2(X)
A	1.06	-1.14	1	1	0.0042	0	-3.23
B	3.03	0.12	1	0.0042	1	3.23	0
C	1.06	-0.04	0	0.2981	0.0201	1.1	-2.13
D	3.34	-0.91	0	0.0052	0.3144	2.51	-0.72



In summary, the causes that justify the use of an ANN in the current problem are the following:

- there is no *linear* relationship between the financial ratios and the and the categorization.
- the behavior relationship between the ratio and the financial problem is dynamic; the capability to adapt to new situations and learning is a desirable characteristic that the ANN posses.

4.3 Hybrid Intelligent Systems: The Expert Networks Technology

In general terms, hybrid intelligent systems are architectures that use different AI basic techniques. In this work, the hybrid intelligent system proposed is composed by the integration of a Expert System (ES) and an ANN. Such systems that are composed by these two basic technologies are also known as *Expert Networks* [CAU91].

The main goal in the expert networks research is to create a synergy by the combination of the advantages of each basic technology. Table 10 presents the main

characteristics of each technology that compose an expert network. In particle terms, the focus point is to analyze the possible advantages of an integration and to establish *how* such an integration is going to be done.

Table 10: Characteristics of ANN and ES

	Expert Systems	ANN
reasoning	symbolic	numeric
learning	requires an external source	directly form the source
deduction	logical	associative
explanation	direct	doesn't explain
reference	mechanic	biological
process	sequential	parallel
tolerance to faults	closed	self - organizing

4.3.1 Different Approaches to Compose the Expert Network Architecture

There are several alternatives to integrate ANN and ES. These alternatives have been classified either in relation to the function that each module performs [RIC90] or on the architecture of the system implementation [MED93], [MED94]. Table 11 presents the categorization suggested by Medsker and Bailey [MED92], which goes from a total independence between the ANN and ES modules to a total integration.

Table 11: Expert Networks: different types of integration [MED93]

Architecture	Description
Full integration	Unique structure that shares data and knowledge representation.
Tight coupling	Separate modules that communicate with each other through a data structure resident in the memory .
Loose coupling	Separate modules that communicate with each other through files.
Transformational	Independent modules that do not interact with each other; the system starts at one module and ends at the other.
Stand alone	There is no integration; the modules act independent from each other.

In most cases, the practical application determines the system architecture to be used. As a general rule, the integration between ES and ANN is worthy to be analyzed whenever the practical application requires to model both deductive and inductive reasoning.

4.3.2 Expert Networks in Finance

The financial area maybe is one of the areas that AI had been widely applied. The financial applications have been considered one of the reason of the success of commercial applications of AI. The commercial AI systems were developed on the mid 70's. On the 90's one can verify the introduction of a variety of AI techniques in finance.

It is very difficult nowadays to review a complete state of the art of financial applications in AI [PAU91]. The number of financial applications of AI is constantly increasing. Yiu and Kong asseverate that the percentage of financial institutions that were planning to implement AI applications was 50 % in 1992 [YIU92]. This could be appreciated by the introduction of new AI techniques to solve financial problems. In the recent years, the applications of Genetic Algorithms [KLIM93] and Case Based Reasoning [BUT94] have been developed in many financial areas.

There exists several applications of hybrid systems in many areas such as medical diagnosis [GAL88], transport planning [HAN88], production planning in manufacturing systems [RAB92], corrosion [ROS92] and fault diagnosis and performance control in telecommunications systems [SEN93].

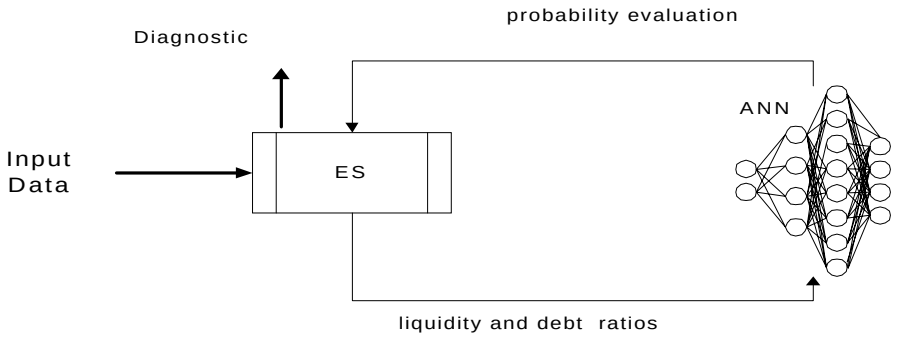


Figure 12: Hybrid system developed by Barker [BAR93]

In the financial area, there exists few applications of hybrid systems already implemented An example of such type of applications is an expert network that analyses the probability that a small business could obtain credit from a financial institution [BARK93]. This system evaluates financial indicators of liquidity and debt. This indicators are transferred to an ANN which returns to the ES a first estimation of the referred probability. Afterwards, the system compares the financial data from the firm with historic data from the same sector and then it reports the result of that comparison, indicating among other information, the probability value. Figure 12 represents the functionality of the system.

This system represents an advance in the financial engineering area but it is restricted in terms of practical applications. Another criticism to this system is related to the quality of the financial information: some of the financial ratios that this system works with are poor indicators; notably, this is the case of the quick ratio index when used as a liquidity indicator.

4.4 Conclusion

Expert Systems and Neural networks are powerful technologies in relation to model different types of knowledge representation. Both technologies had been widely applied in the financial area. In relation to the application proposed, the most similar implementations are related to bankruptcy classification (ANN) and the generation of comments and warning signals triggered by financial ratios.

Both technologies can interact in a synergetic way, combining their specific advantages. This is the aim of the proposed application when considering Expert Networks.

5. FINANCIAL DIAGNOSIS OF A FIRM

5.1 Introduction

The financial performance of a firm in most cases depends on a balance between liquidity and profitability. Even if a firm has an adequate profitability, it may experience liquidity problems in the near future; an example of this behavior is the problem of *overtrading* in which case the firm grows at a greater rate than it financial support capability [OLI87], [SIL88].The analysis of the financial health of a firm by an expert commonly shows non desirable trends that in turn may avoid a *reactive* behavior of the firm, which in many cases is a synonym of *tardy* behavior. The point is that many small business do not have either a financial expert permanently or *inside* information available in order to make their financial decisions.

The solution proposed in the present work is the development of an intelligent system which must be capable to reach a diagnostic and propose some alternatives. In order to reach the later goal such a system must have the capability of simulate both deductive and inductive reasoning; this in turn justifies the use of more than one AI basic technique. The proposed system integrates the ANN and ES techniques in order to model the financial expert behavior, and its purpose is to construct a synergy by the integration.

5.2 System Operation

The *potential* financial problems of a firm is classified in three basic categories: SHORT TERM LIQUIDITY, PROFITABILITY and DEBT. A desc

iption of how the system works is given in Figure 13. The ANN has a set of 8 financial ratios as it input and transfers to the ES a pre-diagnostic categorization of a potential financial problem. The ES analyzes the firm taken into consideration the financial pre-diagnosis given by the ANN; the ES output is a short report of the financial problem found, indicating *specific* actions in order to correct the deviations.

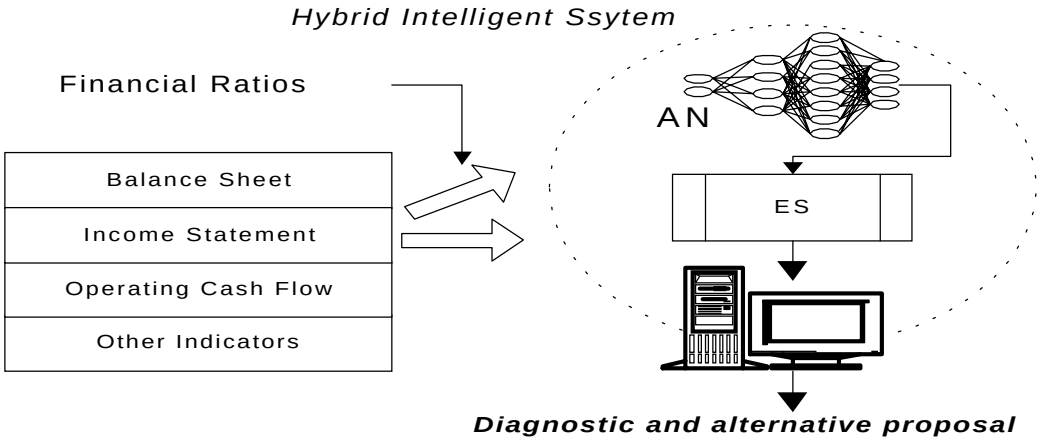


Figure 13: Hybrid intelligent system applied to financial statement analysis

5.3 On the Three Categories of Financial Ratios

As it was stated on Chapter 3, the three financial problem categories are Profitability, Debt and Short Term Liquidity. Each of these three categories represent the neural network output and compose the basis to the Expert System rules. In other words, the financial problem categorization is essential to establish a *synergy* between the Expert System and the Neural Network.

To understand why the financial categorization is essential to boost the quality of the system performance, one can the following observation: In a financial diagnosis, the rules are not independent from the *particular* context. That is, a chain of premises may have sense depending on the specific financial problem observed. For instance, "*if the interest is high, then reduce short term debt is high"* could be true in a context characterized by a liquidity problem; if the context is not so evident as a liquidity deviation, then the quality of the rule may be different, as for example "*if the interest is high, then reduce short term debt is medium".* Consequently, one may observe that it is necessary to know beforehand the financial problem category (categories) in order to fire the rules.

In relation to Figure 14 (Profitability category) it is worthy to notice that the profitability categorization used in order to fire *qualitative* rules corresponds actually

to a profitability pre-analysis if the concept is consider in a broader sense. That is, the *overall* concept of profit is wider than the use to model the ANN output and Expert System rules. The overall profit considers explicitly the short term liquidity and debt management situation. It is important to signal that the use of profitability done by the present work has the aim to *give alternatives of actions,* so it must focus on specific aspects that compose the profit *from an income statement* point of view. In other words, the aim of the expert system is to give alternatives to a profit problem characterized by deviations related to sales, cost of good sold and expenses; it is not the specific aim of the expert system to make a judgment about the overall profitability of a firm.

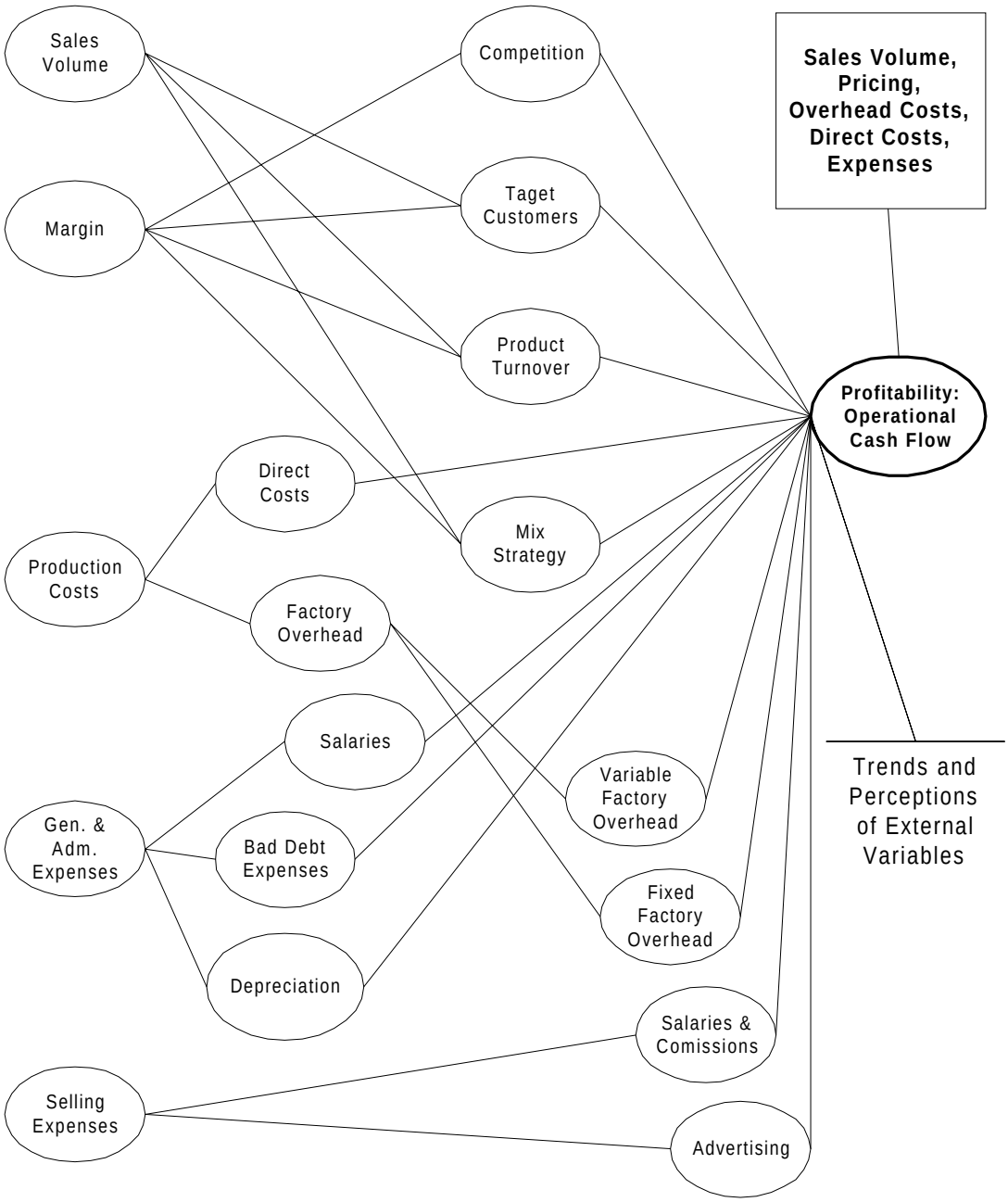


Figure 14: The Financial Aspects of the Profitability Category

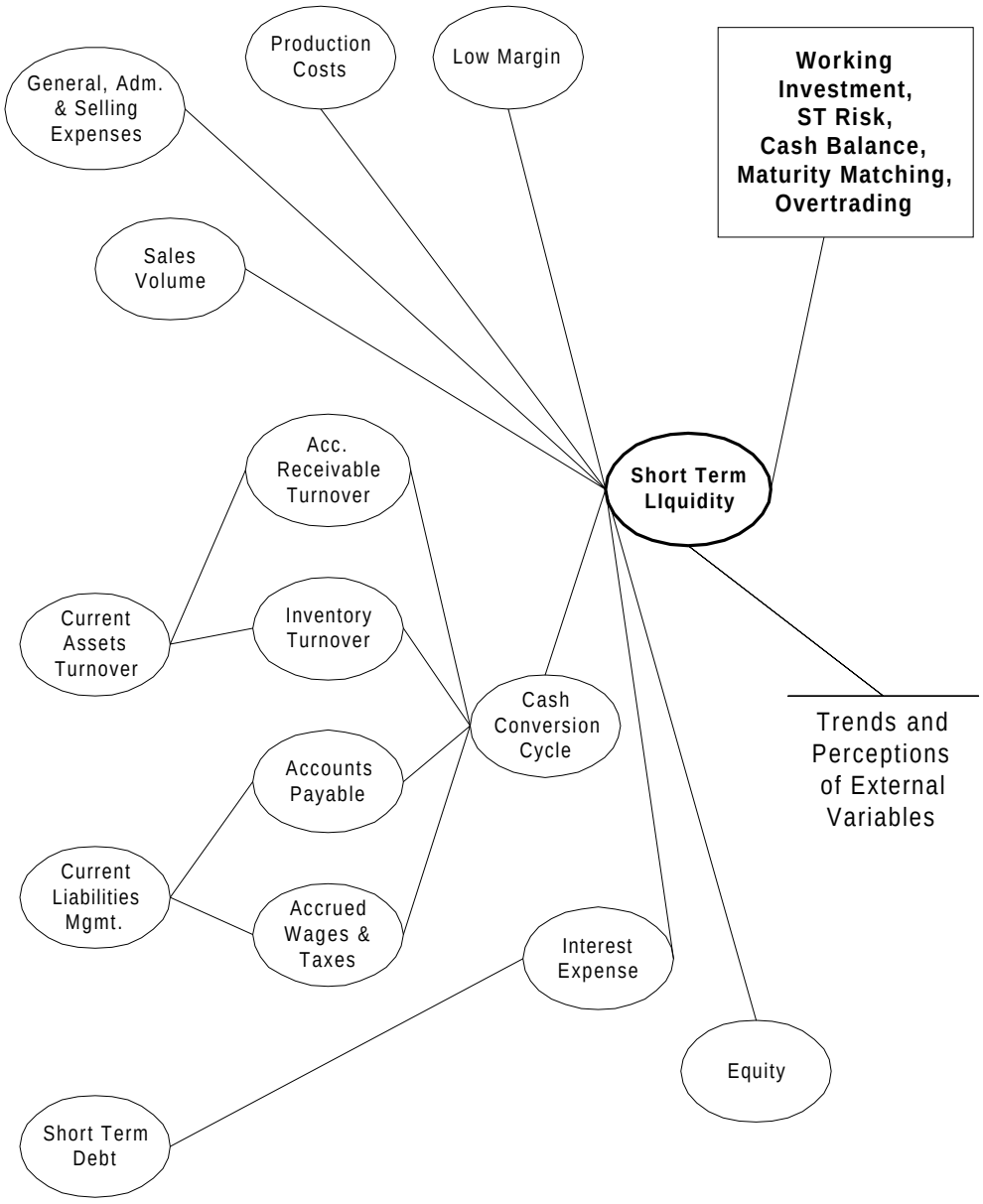


Figure 15: The Financial Aspects of the Short Term Liquidity Category

In relation to Figure 15, it is worthy to notice that the Short Term Liquidity Category is compose by the short term assets *turnover* mgmt., short term debt mgmt. and *profitability aspects from an income statement point of view.* As it was stated on the previous case, one may notice that the liquidity judgment is related to all the financial aspects of the firm: short term liquidity, profit, debt and asset turnover.

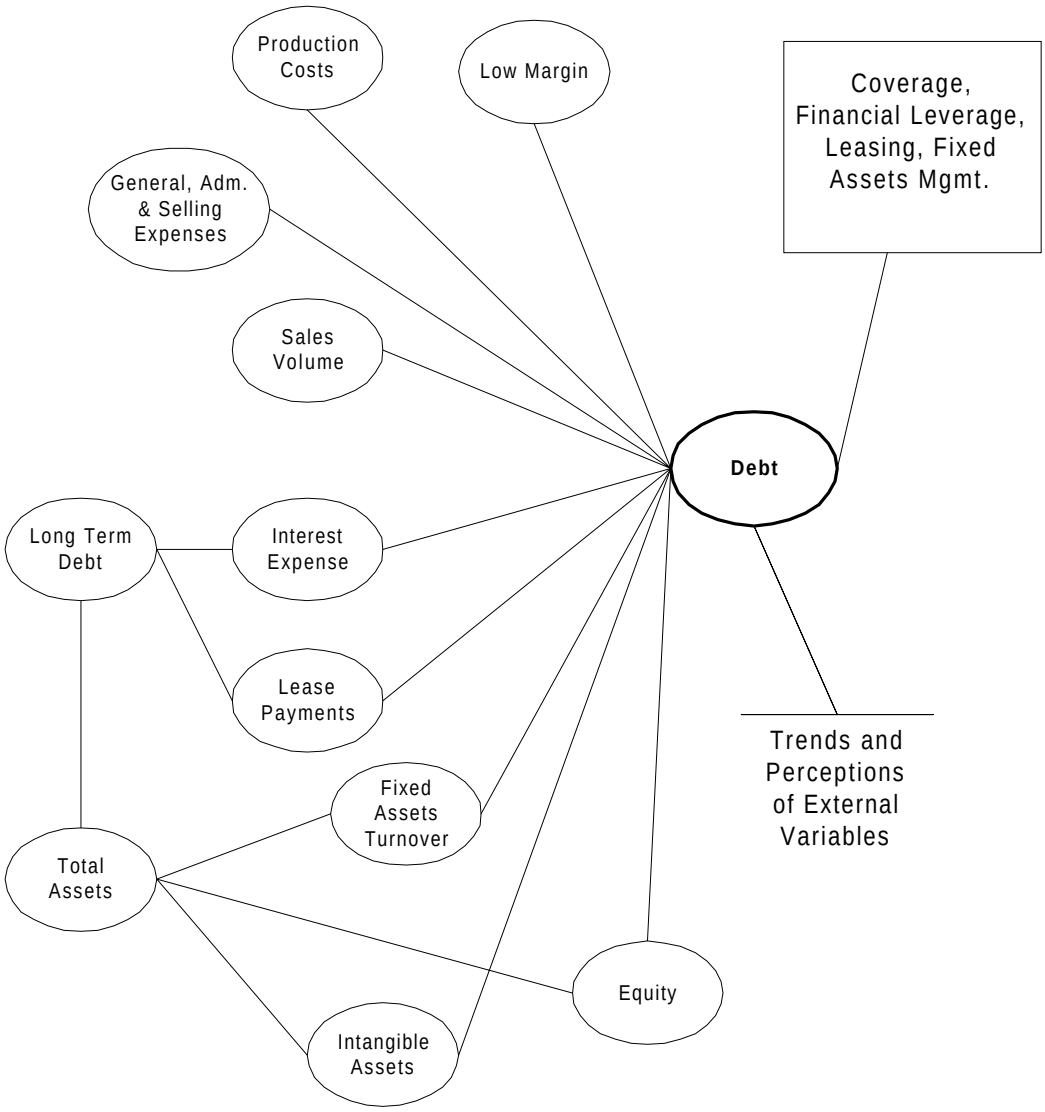


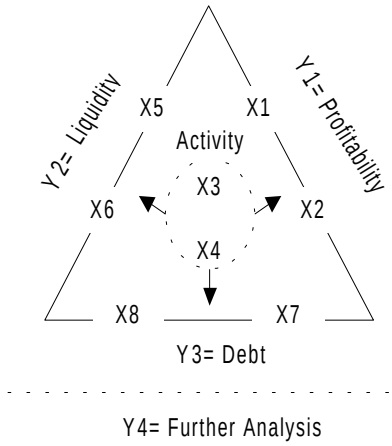
Figure 16: The Financial Aspects of the Debt Category

Figure 16 show the different financial aspects that are related to the Debt problem category. Similar to the liquidity categorization, even if the analysis is restricted to debt, one may look to profit consideration from an income statement point of view[17].

5.4 The ANN Operation

As it was stated before, the ANN output is a categorization of the potential problems. The eight financial ratios used by the ANN are presented in Figure 17.

[17] *See* Chapter 3.



Financial Ratios:

X_1 = Op. Cash Flows/Sales;
X_2 = Net Margin/Sales;
X_3 = Working Capital / Sales;
X_4 = Cash Conversion Cycle;
X_5 = T/ |W I|;
X_6 = T/ |W I| Trend;
X_7 = EBIT/Interest;
X_8 = Debt/Equity.

where: T = Cash - Short term Debt W: Working Investment = Working Capital - T

Financial Categorization:

Y_1 = Profitability;

Y_2 = Short Term Liquidity;

Y_3 = Debt;

Y_4 = Further Analysis

(there is no apparent reason for indicating a problem)

Ratio	Comment	Problem Related
X_1	Powerful indicator of the Cash Flow generation capability; main	**Profitability**, Debt
X_2	"Bottom edge" indicator of Profitability	**Profitability**, Debt
X_3	Indicator of financial efficiency	**Profitability,** Liquidity
X_4	Accurate indicator of liquidity	Profitability, **Liquidity**
X_5	Accurate indicator of liquidity	**Liquidity**
X_6	Accurate indicator of liquidity trend	**Liquidity**
X_7	Indicator of Coverage	Profitability, **Debt**
X_8	Indicator of Capital Structure	Profitability, **Debt**

Figure 17: Financial Ratios Used by the Neural Network.

It is important to highlight (again) that the activity problem is considered as an intermediary problem between ;liquidity, profitability and debt. In other words, the activity problem is considered as a cause of either short term liquidity, profitability or debt (depending on the firm).

5.4.1 Simulation of the ANN Sample

The ANN input data was obtained from a simulation of eight Beta distributions [MOO74]; 305 samples were taken for each of the eight financial ratios. The original data used to generate the different distributions is based on the financial ratios of the retail grocery sector (SIC 5140) for a size category of "sales revenue less than US$ 1.000.000" [IRS93].

The use of the Beta distribution is due to the flexibility of this function to represent several forms of skewness. There is no consensus in the literature in relation to the theoretical distribution of the different financial ratios but there exists agreement in relation to the deviation from the normal distribution through different grades of skewness [BUC84], [BAR82], [MEC68], [DEA76], [BIR77].

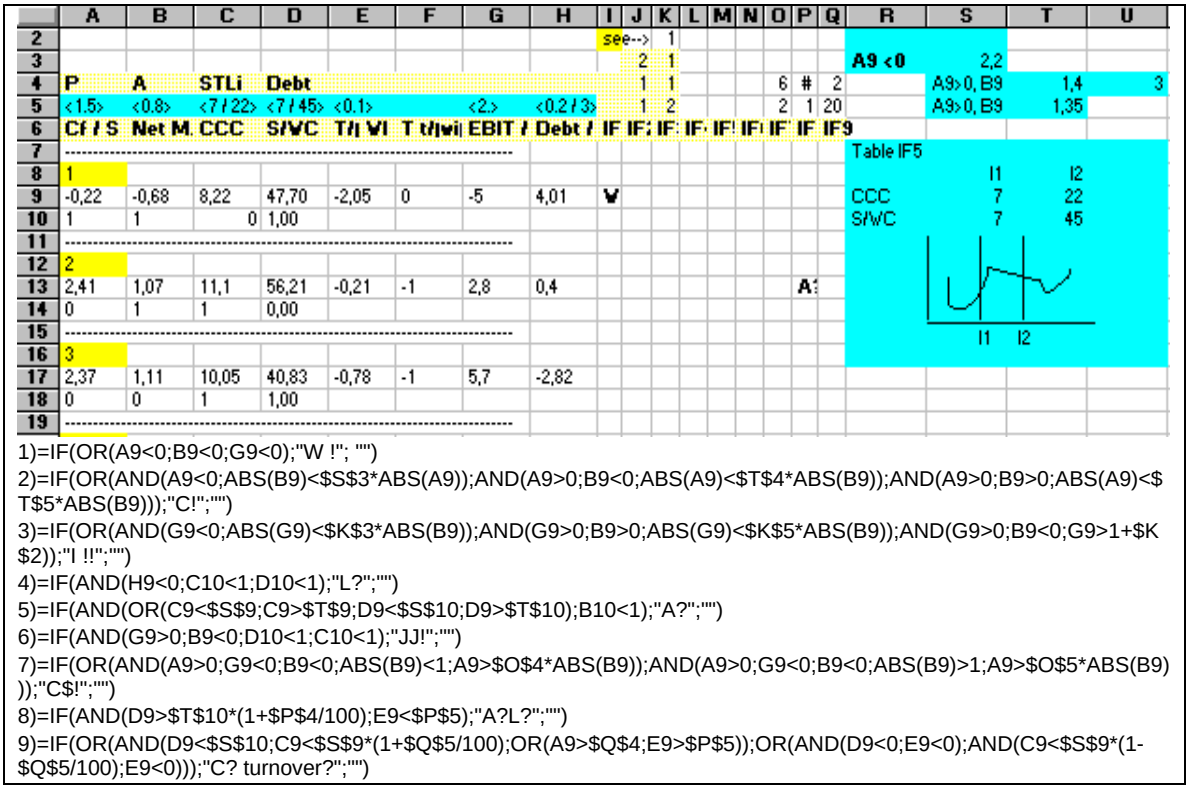


Figure 18: Checking Process of the ANN Sample

The simulation process is not the final stage of the data generation of the ANN inputs. After this process, there is a another one where each of the eight financial ratios is checked for inconsistencies among each the 305 samples. This stage consists in testing the ratios with nine if/or/and rules (Figure 18). The result of this process is a sample set that is coherent en terms of financial ratios sample of a *business entity*. The following is the financial *translation* of each checking rule shown in Figure 18:

1)
IF Cash Flow /Sales < 0
AND Net Margin < 0
AND EBIT / Interest < 0
THEN give a warning signal due to consistency.

2)
IF { Cash Flow / Sales > 0
and |Net Margin | < 2.2 * | Cash Flow | }
OR { Cash Flow / Sales > 0
and Net Margin < 0
and | Cash Flow / Sales | < 1,4 * | Net Margin |
and | Cash Flow / Sales | > 3 * | Net Margin | }
OR { Cash Flow / Sales > 0
and Net Margin > 0
and | Cash Flow / Sales | < 1,35 * | Net Margin |
}
THEN give a warning signal due to consistency of the relationship between Cash Flow / Sales and Net Margin

3)
IF { EBIT/I < 0
and | EBIT/I | < | Net Margin | }

OR { EBIT/I > 0
and Net Margin > 0
and | EBIT/I | < 2 * | Net Margin | }
OR { EBIT/I > 0
and Net Margin < 0
and EBIT/I > 2
THEN give a warning signal due to consistency of the relationship between Cash Flow / Sales and EBIT/I

4)
IF { Debt/Equity < 0
and Debt is NO
and Further Analysis is NO }
THEN check again analysis of Debt

5)
IF { CCC < 7
or CCC > 22
or Sales / WC < 7
or Sales / WC > 45 }
AND Liquidity is NO
THEN check the analysis over of Liquidity

6)
IF { EBIT/I > 0
and Net Margin < 0
and Further Analysis is NO
and Debt is NO }
THEN check again analysis of Debt

7)
IF { Cash Flow / Sales > 0
and EBIT/I < 0
and Net Margin < 0
and | Net Margin | < 1
and Cash Flow / Sales > 6 * | Net Margin | }
OR { Cash Flow / Sales > 0
and EBIT/I < 0
and Net Margin < 0
and | Net Margin | > 1
and Cash Flow / Sales > 2 * | Net Margin | }
THEN check the relationship between Cash Flow / Sales, EBIT/I, Net Margin

8)
IF { Sales / WC > 45 *(1 + 10%)
and T / | WI < 1 }
THEN check the consistency between Activity and Liquidity Performance

9)
IF { Sales / WC < 7
and CCC < 7 * (1 + 20%)}
and { Cash Flow / Sales > 2T / | WI < 1
or T / | WI | > 1}
OR {{ Sales / WC < 0
and T / | WI | < 0}
or { CCC < 7 * (1 - 20%)
and T / | WI | < 0 } }
THEN check the consistency between Activity and Liquidity Performance

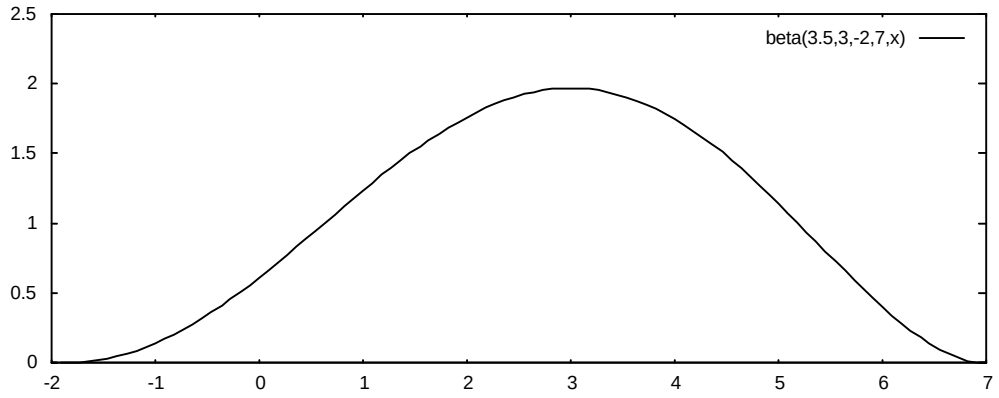
The simulated and after-checking distributions of the different financial ratios are shown from Figure 19 to Figure 25[18].

[18] The only exception for this process is the T / |WI| *trend,* which possible values are 1, 0, -1.

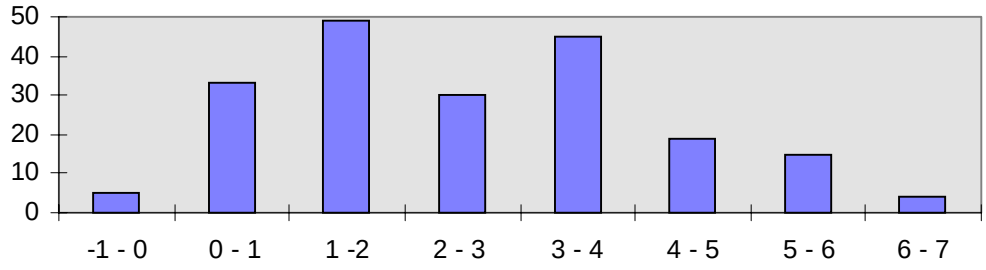
Figure 19: <u>Operational Cash Flow/ Sales:</u> *Beta* distribution simulation & Training and Testing Samples after the *checking* Process

Cash Flow = EBIT + Depreciation + Depletion + Amortization (Bucksmaster's U shaped)

All		**1 - 999.99**		**1 - 24.99**		**25 - 99.99**		**100 & O**	
5.1	2.8	4.0	-.9	3.4	2.0	5.0	3.1	6.1	4.4



CF/ Sales (tra) 1- 200



CF /S (Test) 201 -305

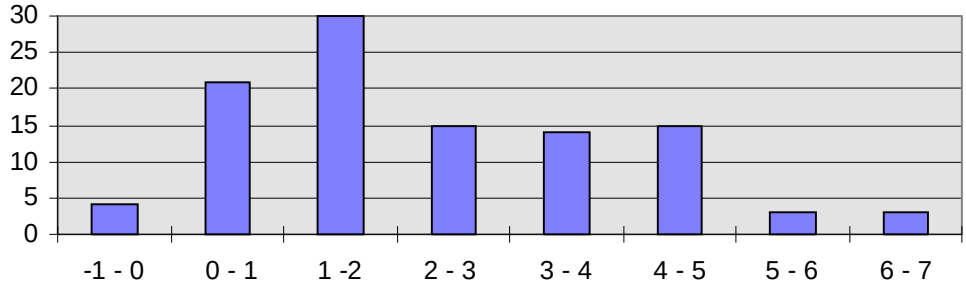
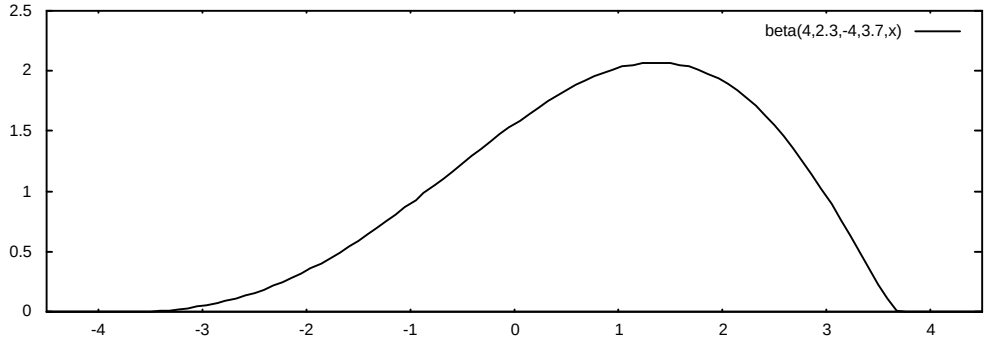
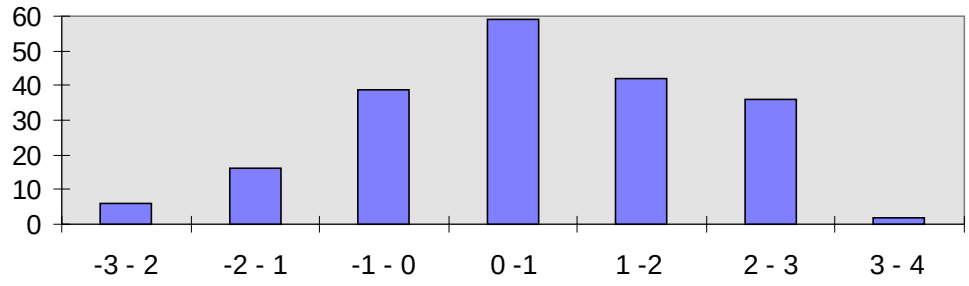


Figure 20: <u>Net Margin:</u> *Beta* distribution simulation & Training and Testing Samples after the *checking* Process

=Net Income / Sales (Bucksmaster's U shaped)									
All		1 - 999.99		1 - 24.99		25 - 99.99		100 & O	
1.9	-1.7	2.2	-2.6	1.5	-0.3	2.6	0.6	2	-1.3



Net_M(tra) 1- 200



Net Margin (test) 201 - 305

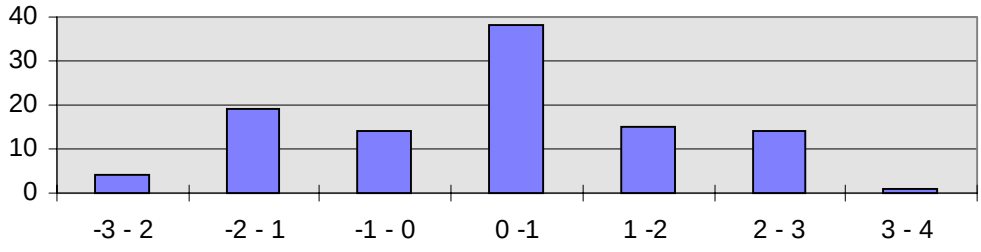
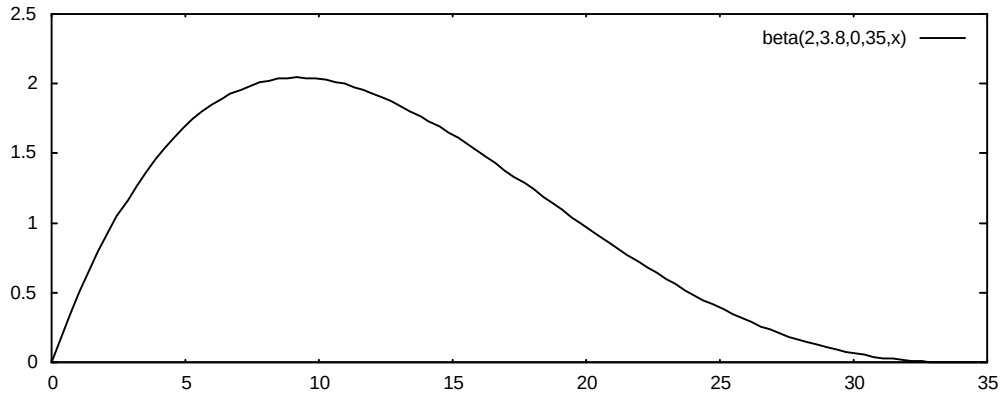
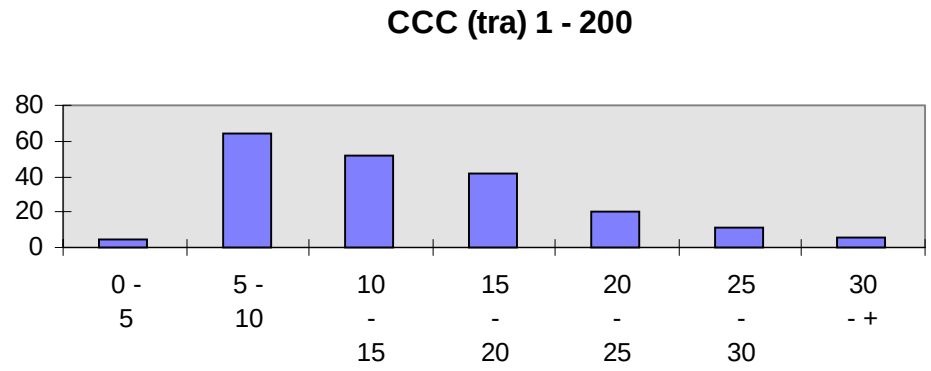


Figure 21: <u>Operational Cash Flow/ Sales:</u> *Beta* distribution simulation & Training and Testing Samples after the *checking* Process

CCC= Days Receivable + Days Inventory - Days Payable (Buckmaster's Reverse J)

All		**1 - 999.99**		**1 - 24.99**		**25 - 99.99**		**100 & O**	
15.8	2.8	14.8	4.7	6.0	4.2	3.5	3.6	20.9	2.8





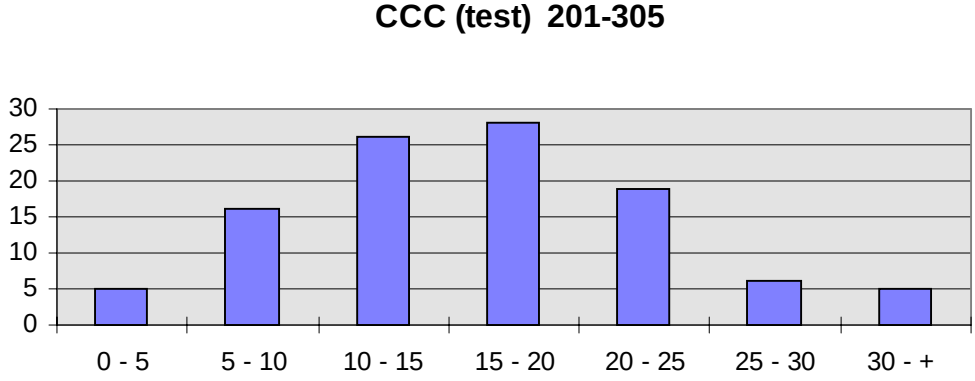
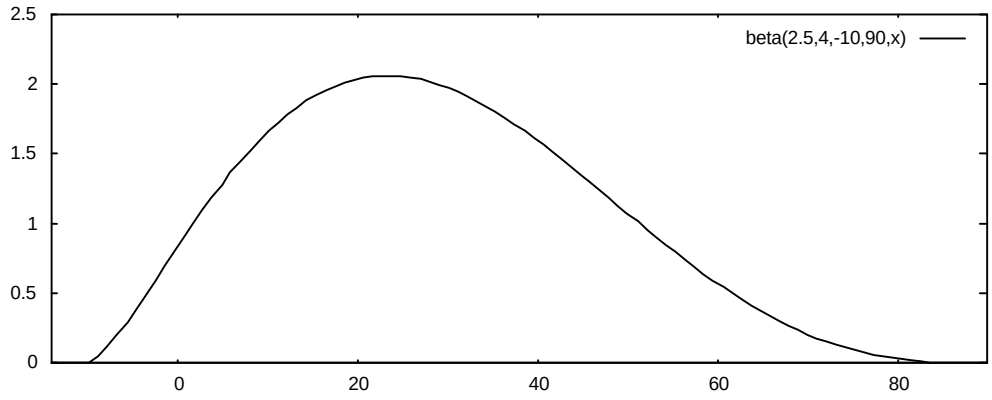
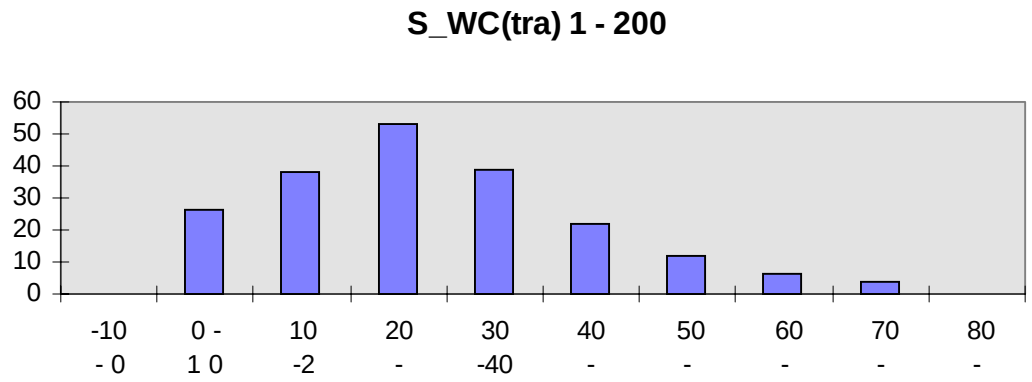


Figure 22: <u>Sales / WC:</u> *Beta* distribution simulation & Training and Testing Samples after the *checking* Process

Buckmaster's J shaped

All		1 - 999.99		1 - 24.99		25 - 99.99		100 & O	
24.6	-122	15.1	54.5	31.1	71.7	41.6	62.1	23.1	-54.6





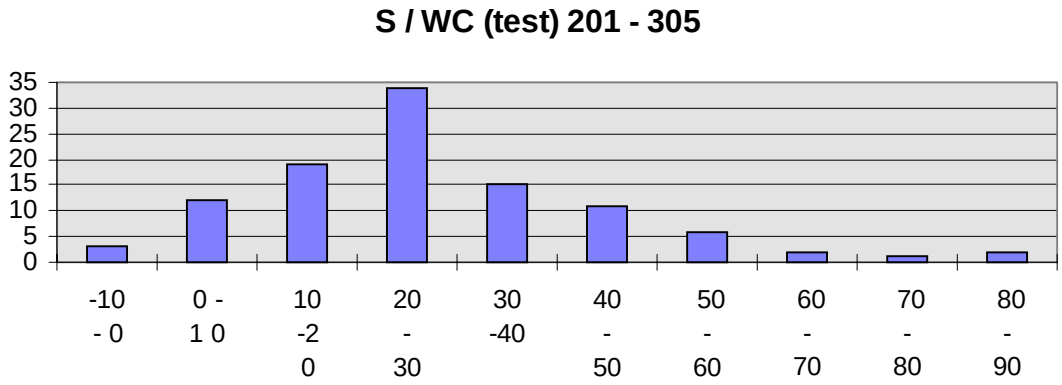
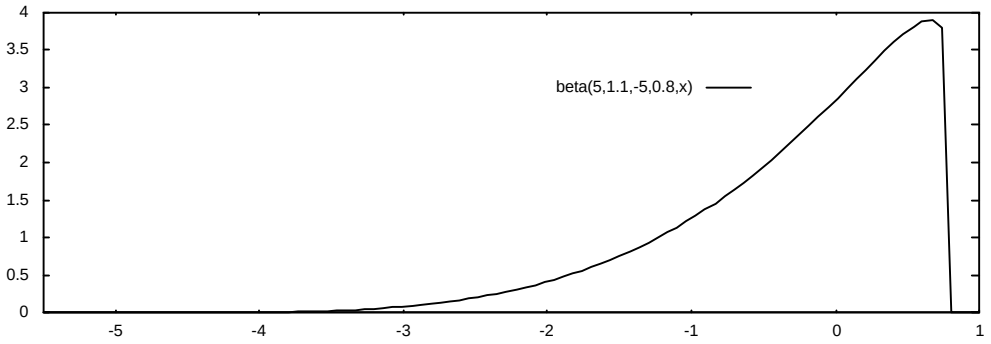


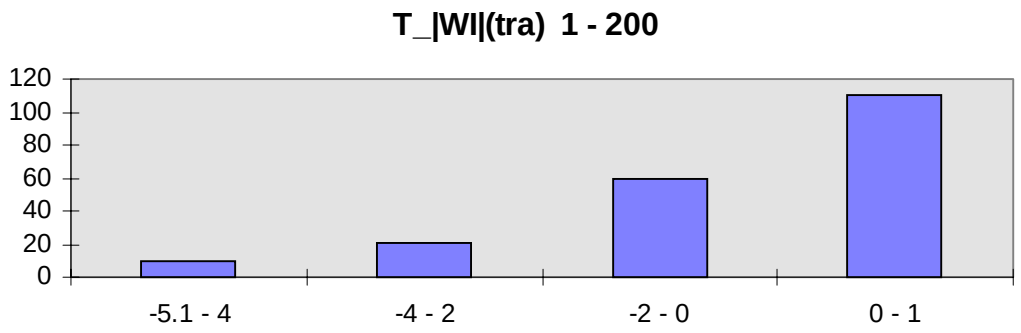
Figure 23:T/|WI|: *Beta* distribution simulation & Training and Testing Samples after the *checking* Process

(Cash + Ms - Short Term Debt) / | Working Investment | = {Cash Turnover - (STD / CA) * (CA/Sales) } / {CA/Sales - Cash/Sales - (1/CR - STD / CA) * CA/Sales}

Ms: Marketable Securities; CR: Current Ratio; CA / Sales: (1/Total Asset Turnover - 1/Fixed Asset Turnover)}

All		1 - 999.99		1 - 24.99		25 - 99.99		100 & O	
-0.15	-3.13	0.35	0.16	0.39	-0.18	.25	-0.24	-0.26	-2.19





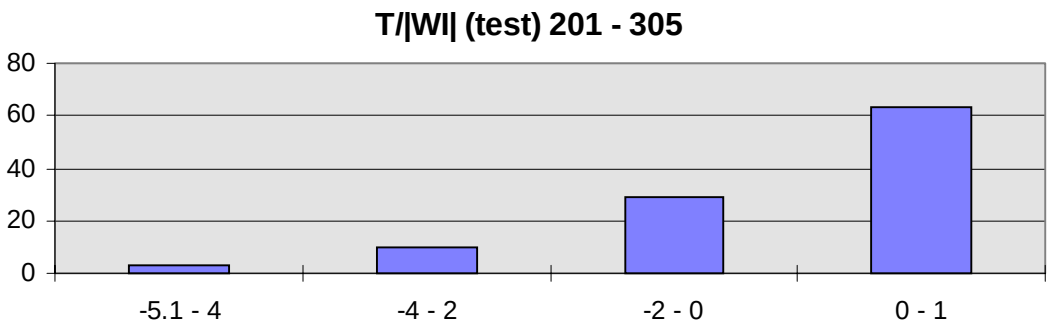
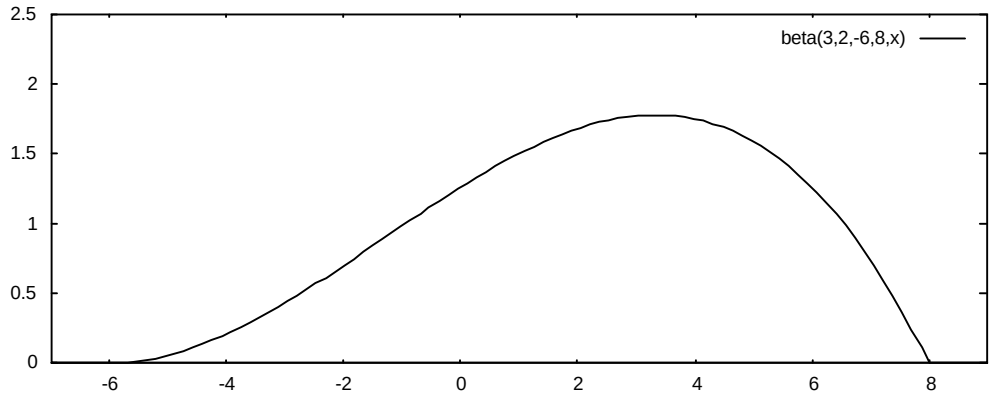
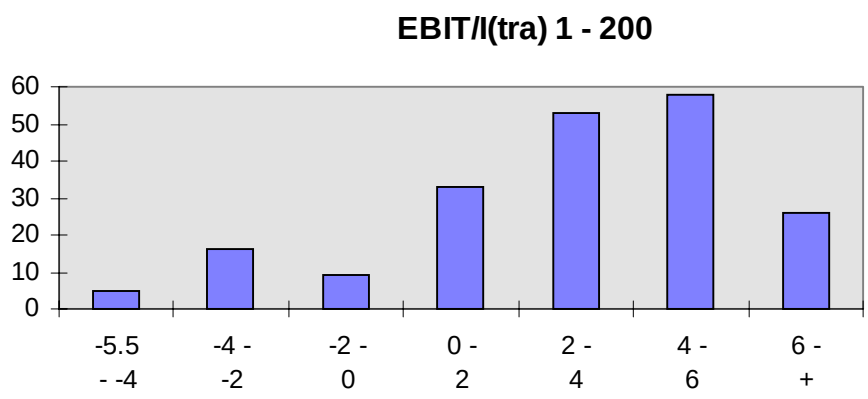


Figure 24: <u>EBIT/ Interest Charges:</u> *Beta* distribution simulation & Training and Testing Samples after the *checking* Process

Buckmaster's J shaped

All		1 - 999.99		1 - 24.99		25 - 99.99		100 & O	
3.1	0.4	6.5	-3.1	5.2	.7	9.0	2.0	2.6	0.7





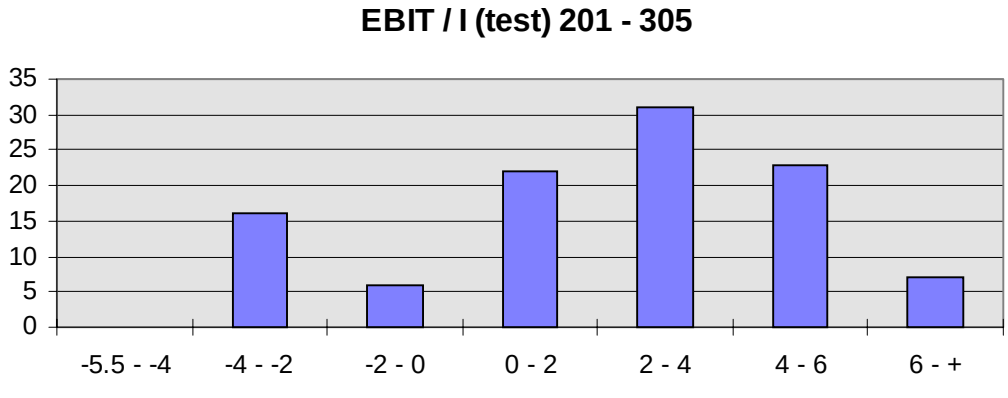
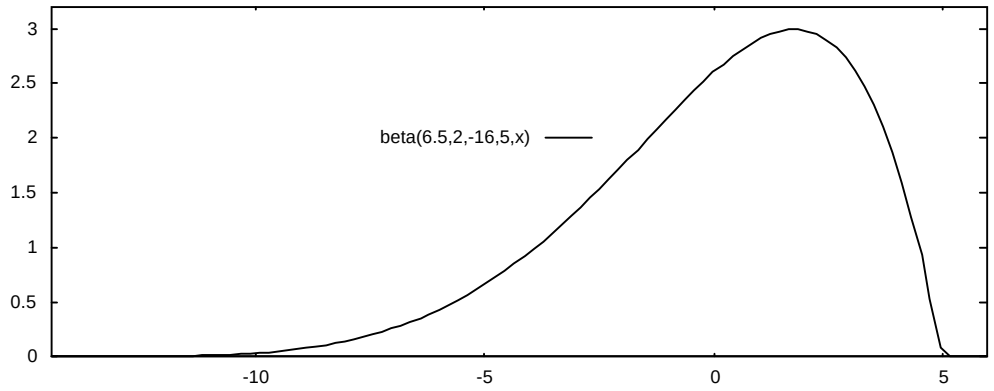
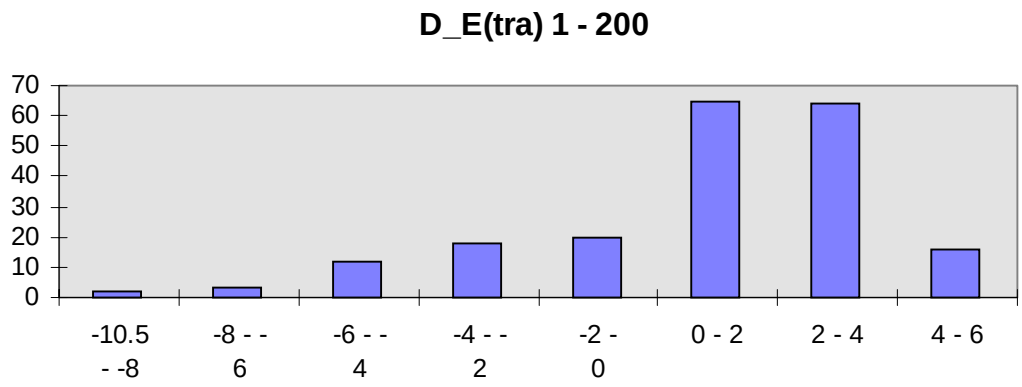


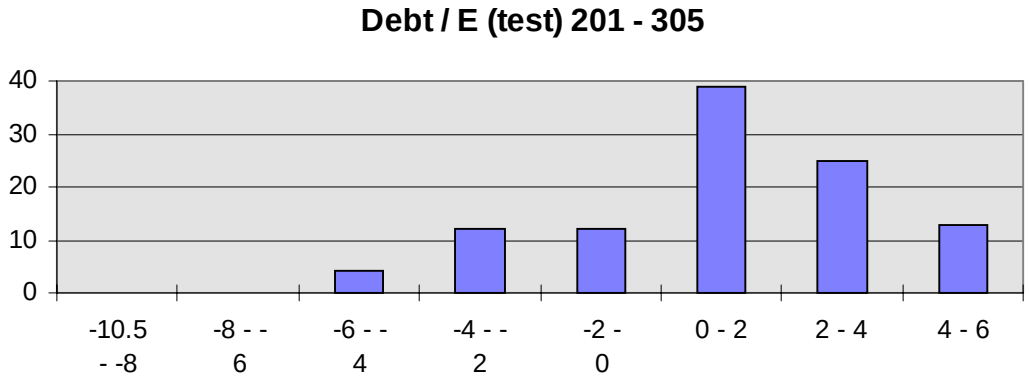
Figure 25: <u>Debt/Equity :</u> *Beta* distribution simulation & Training and Testing Samples after the *checking* Process

Buckmaster's J shaped (indicator of financial leverage)

All		**1 - 999.99**		**1 - 24.99**		**25 - 99.99**		**100 & O**	
1.8	-6.2	1.2	-11.5	1.5	3.9	1.0	2.4	1.9	-5.2







5.5 Expert System Operation

5.5.1 Basic Types of the Financial Variables

The financial variables used by the ES can be classified into three categories, as it is shown on Table 12.

Table 12: ES variables

State variables	deterministic variables that define particular state: their main use is to describe the macroeconomics environment
Fuzzy variables	used to model the imprecision of the linguistic variables
Restricted Variables	numeric variables that affect the process of decision making by analyzing whether or not their value is *in* or *out* of a region

An example of the variable of state is *seasonally.* This type of variable switches the expert's focus of decision, specially in the liquidity analysis, in which case the horizon period is shorter than the other categories. A specific numeric value of the current assets turnover may be considered low or high depending on the business cycle. If the ES wouldn't recognize such particularities, the overall output of the hybrid intelligent system would be questionable frequently. Another example of variable of state are the trends variables.

The paradigm that is modeled by the fuzzy variables is the one that corresponds to approximate reasoning. What is actually modeled in terms of fuzzy variables is the imprecision due to the linguistic variables used by the expert. The ES, from now on Fuzzy Expert System (FES) consider all the premises, rules and conclusions with necessity one.

The financial ratios are typical examples of restricted variables; for this type of variable it is always implicit the comparison of it numeric value with some other reference value.

5.5.2 Fuzzy Characterization of the Rules

The necessity to use fuzzy set theory to model several of the ES variables is due to the fact that many financial rules formulated by the expert are linguistic by nature. As an example, one may consider the following rule:

IF *(1)* LIQUIDITY
and *(2)* Seasonal *is no*
and *(3) Inventory is LOW*
and *(4) Average Purchases trend is* stable

and *(5) CCC is HIGH*
and *(6) Sales forecast trend is* stable or decreasing

THEN *(1) Reduce Inventories is LOW*

In this example there exists three fuzzy variables: inventory, cash conversion cycle and inventory reduction. The terms 'LOW", "MEDIUM", and "HIGH" represent the linguistic terms used by the expert on his/her reasoning. A sample of the fuzzy sets used by the Fuzzy Expert System is shown in Figure 26.

The fuzzy inference method used is max-min and the correspondent *defuzzification* method is the centroid. Both methodologies were chosen because they represented good results in tests performed. After a trial and error process followed by a simulation test, the final shape of the fuzzy *consequent* sets is obtained [19].

[19] *See* [PAC96] for more details.

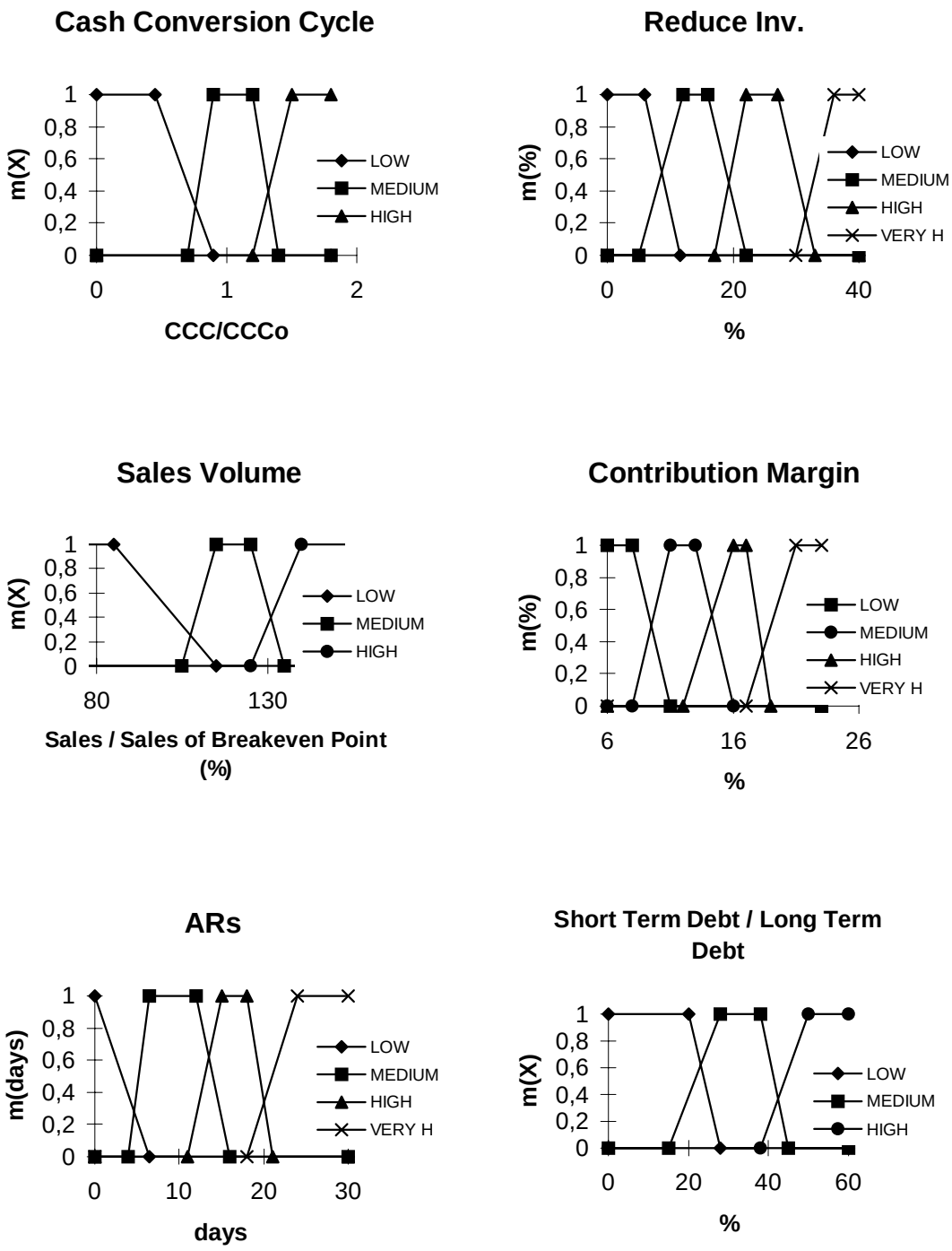


Figure 26: An Example of the Fuzzy Sets Used by the System

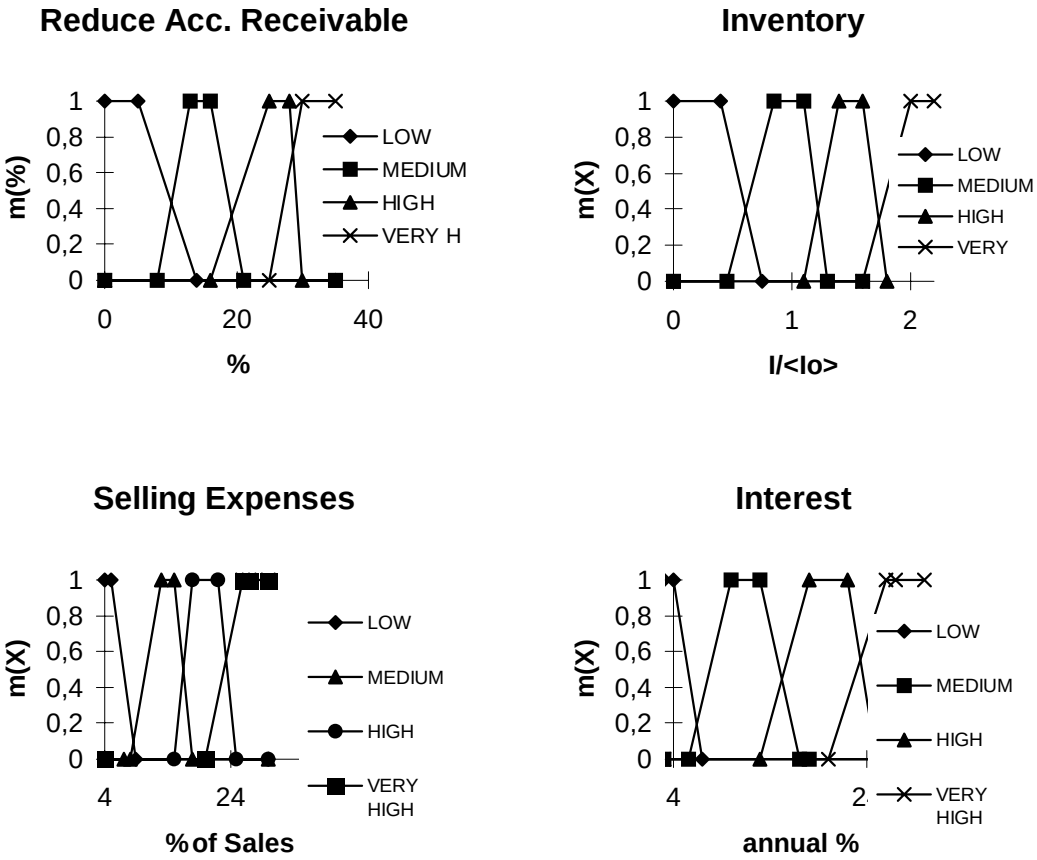


Figure 26 (cont.)

A basic antecedent for the majority of the ES rules is the categorization pre-diagnostic done by the ANN. The knowledge base of the ES contains firm's *internal* and *external* information . The firm's internal information is composed by numeric variables and perceptions about the trend (e.g., average purchases and sales forecasting trends). The *external* information is related to market trends and economic sector that the firm belongs to.

Once the pre-diagnosis is concluded by the ANN, the ES has specific financial problems to concentrate in and is capable to fire *qualitative rules*. This later concept is worthy to be explained by the following example:

IF *DEBT*
and *PROFITABILITY is no*
and ***Sales Volume*** *is HIGH*
and ***ST I Expense / LT I Expense*** *is MEDIUM or HIGH*
and Interest mid-term forecast trend *is increasing*

THEN Increase Debt Payment[20]

The quality of a rule refers to the necessity to know a pre - diagnostic of a firm's financial problem. To fire the rule above, it is required a knowledge about a pre-diagnostic phase (Debt and *no* Profitability). If it were both Debt and Profitability positive in the premises, then the consequence is no longer "Increase Debt Payment". A case of a rule with a fuzzy consequence behaves in a similar way; in such a case, the consequent, depending of the pre - diagnostic of the firm's problem, could be represented by either a different alternative or by another fuzzy set corresponding to a different degree of the *semantic alternative.*

[20] *Crisp* consequent.

5.5.3 Different Types of Variables

The following is a list of the main variables of the financial representation proposed.

Table 13: Crispy Variables of the Fuzzy Expert System	
DEBT	ANN output
LIQUIDITY	ANN output
PROFITABILITY	ANN output
FURTHER ANALYSIS	ANN output
APs trend	Average Purchases in days of Sales trend
business phase	growth
Check pricing in relation to product turnover	*statement*
Credit Line	available or nor available
elasticity	yes, no or yes!
Increase Debt payment	*statement*
Increase Leverage by LTDebt	*statement*
Increase LTDebt position	*statement*
Increase On Sale offers	*statement*
Inject Equity	*statement*
Interest mid-term forecast trend	increasing, decreasing, stable
mid-term Sales forecast trend	increasing, decreasing, stable
Negotiate debt terms	*statement*
Negotiate Lease terms	*statement*
Negotiate Payable	*statement*
Redefine On Sale mix	*statement*
Reduce Investments in Fixed Assets	*statement*
Restructure terms between LT and ST Debt	*statement*
Sales forecast trend	stable, increasing, decreasing
Seasonal	yes, no
Slow down business growth	*statement*
Stop borrowing	*statement*
T / | WI | trend	increasing, decreasing, stable

Table 14: Fuzzy Variables (LOW, MEDIUM, HIGH, VERY)	
Accounts Receivable in Days of Sales	Investment in Receivables
Administrative Expenses	Profitability aspect
Average Cost of Purchases	Profitability aspect
CCC	Liquidity perception (days)
Contribution Margin	Profitability aspect
Fixed Assets Turnover	Debt aspect
Fixed Charge Coverage	Debt aspect
Increase Margin	Fuzzy Consequence
Interest	Influence on all the financial categories
Inventory	Liquidity variable
Leverage	Debt & Risk evaluation
Operational Cash Flow	Cash Flow generating capacity
Operational Income	Profitability variable
Reduce Accounts Receivable	Fuzzy consequent of LIQUIDITY
Reduce Administrative Expenses	Profitability; looks for a reduction on Fixed Costs
Reduce Cost of Purchases	Profitability; looks for an efficiency
Reduce Fixed Costs	Debt related variable
Reduce Inventories	ST Liquidity variable
Reduce Margin	Profitability variable
Reduce Selling Expenses	Looks for fixed costs reduction
Sales Volume	Looks for possible alternatives
Selling Expenses	Profitability; looks for a reduction on Fixed Costs
ST I Expense / LT I Expense	Analyses debt matching
STDebt	Analyses the incidence of STDebt on the ST liquidity

5.5.4 Fuzzy Expert System's Rules

The following is the list of the rules implemented. The *explosion of the* different combinations between different values of the premises was partially developed, in order to focus on the *normative* and *practical* fundamentals of each rule, and the Expert Systems response.

1) IF *LIQUIDITY* — Current Assets Turnover Efficiency / ST Liquidity Position Correction
and Seasonal *is no*
and ***Inventory*** *is HIGH*
and <Purchases> in days of Sales trend *is increasing or stable*
and ***CCC*** *is HIGH*
and Sales forecast trend *is stable or decreasing*

THEN ***Reduce Inventories*** *is HIGH*

2) IF *LIQUIDITY* — Current Assets Turnover Efficiency / ST Liquidity Position Correction
and Seasonal *is no*
and ***Inventory*** *is HIGH*
and <Purchases> in days of Sales trend *is unstable*
and ***CCC*** *is HIGH*
and Sales forecasts trend *is stable or decreasing*

THEN ***Reduce Inventories*** *is MEDIUM*

3) IF *LIQUIDITY* — Current Assets Turnover Efficiency / ST Liquidity Position Correction
and Seasonal *is no*
and ***Inventory*** *is MEDIUM*
and <Purchases> in days of Sales trend *is* increasing *or stable*
and ***CCC*** *is HIGH*
and Sales forecast trend *is stable or decreasing*

THEN ***Reduce Inventories*** *is MEDIUM*

4) IF *LIQUIDITY* — Current Assets Turnover Efficiency / ST Liquidity Position Correction
and Seasonal *is no*
and ***Inventory*** *is LOW*
and <Purchases> in days of Sales trend *is stable*
and ***CCC*** *is HIGH*
and Sales forecast trend *is stable or decreasing*

THEN ***Reduce Inventories*** *is LOW*

5) IF *LIQUIDITY* — Current Assets Turnover Efficiency / ST Liquidity Position Correction
and Seasonal *is no*
and ***Inventory*** *is LOW*
and <Purchases> in days of Sales trend *is stable*
and ***CCC*** *is HIGH*

and Sales forecast trend *is stable or decreasing*

THEN ***Reduce Inventories*** *is LOW*

6) IF	*LIQUIDITY*	Current Assets Turnover Efficiency / ST Liquidity Position Correction; analysis of Receivables *and* Inventory.
and	Seasonal *is no*	
and	***Interest*** *is HIGH*	
and	***Accounts Receivable in Days of Sales*** *is HIGH*	
and	***Inventory*** *is HIGH*	
THEN	***Reduce Inventories*** *is HIGH*	
and	***Reduce Accounts Receivable*** *is HIGH*	
7) IF	*LIQUIDITY*	Current Assets Turnover Efficiency / ST Liquidity Position Correction; analysis of Receivables *and* Inventory
and	Seasonal *is no*	
and	***Interest*** *is HIGH*	
and	***Accounts Receivable in Days of Sales*** *is MEDIUM*	
and	***Inventory*** *is MEDIUM*	
and	Sales forecast trend *is stable or decreasing*	
THEN	***Reduce Inventories*** *is MEDIUM*	
and	***Reduce Accounts Receivable*** *is MEDIUM*	
8) IF	*LIQUIDITY*	Current Assets Turnover Efficiency / ST Liquidity Position Correction; analysis of Receivables *and* Inventory
and	Seasonal *is no*	
and	***Interest*** *is MEDIUM*	
and	***Accounts Receivable in Days of Sales*** *is HIGH*	
and	***Inventory*** *is HIGH*	
and	Sales forecast trend *is stable or decreasing*	
THEN	***Reduce Inventories*** *is HIGH*	
and	***Reduce Accounts Receivable*** *is MEDIUM*	
9) IF	*LIQUIDITY*	Current Assets Turnover Efficiency / ST Liquidity Position Correction; analysis of Receivables *and* Inventory
and	Seasonal *is no*	
and	***Interest*** *is MEDIUM*	
and	***Accounts Receivable in Days of Sales*** *is HIGH*	
and	***Inventory*** *is HIGH*	
and	Sales forecast trend *is unstable*	
THEN	***Reduce Inventories*** *is MEDIUM*	
and	***Reduce Accounts Receivable*** *is MEDIUM*	
10)IF	*LIQUIDITY*	Current Assets Turnover Efficiency / ST Liquidity Position Correction; analysis of Receivables *and* Inventory
and	Seasonal *is no*	
and	***Interest*** *is MEDIUM*	
and	***Accounts Receivable in Days of***	

Sales *is MEDIUM*
and ***Inventory*** *is MEDIUM*
and Sales forecast trend *is decreasing*

THEN ***Reduce Inventories*** *is MEDIUM*
and ***Reduce Accounts Receivable*** *is LOW*

11)IF *LIQUIDITY* — Current Assets Turnover Efficiency / ST Liquidity Position Correction; analysis of Receivables *and* Inventory
and Seasonal *is no*
and ***Interest*** *is LOW*
and ***Accounts Receivable in Days of Sales*** *is HIGH*
and ***Inventory*** *is HIGH or MEDIUM*
and Sales forecast trend *is stable or decreasing*

THEN ***Reduce Inventories*** *is MEDIUM*
and ***Reduce Accounts Receivable*** *is MEDIUM*

12)IF *LIQUIDITY* — Current Assets Turnover Efficiency / ST Liquidity Position Correction; analysis of Receivables *and* Inventory
and Seasonal *is no*
and ***Interest*** *is LOW*
and ***Accounts Receivable in Days of Sales*** *is MEDIUM*
and ***Inventory*** *is HIGH*
and Sales forecast trend *is unstable*

THEN ***Reduce Inventories*** *is LOW*
and ***Reduce Accounts Receivable*** *is LOW*

13)IF *LIQUIDITY* — Current Assets Turnover Efficiency / ST Liquidity Position Correction; analysis of Receivables *and* Inventory
and Seasonal *is yes*
and ***Inventory*** *is VERY HIGH*
and Sales forecast trend *is decreasing*

THEN ***Reduce Inventories*** *is MEDIUM*

14)IF *LIQUIDITY* — Inventory analyzed as a determinant ST Liquidity factor
and Seasonal *is yes*
and ***Inventory*** *is VERY HIGH*
and Sales forecast trend *is unstable*

THEN ***Reduce Inventories*** *is LOW*

15)IF *LIQUIDITY* — Inventory analyzed as a determinant ST Liquidity factor
and Seasonal *is yes*
and ***Inventory*** *is HIGH*
and Sales forecast trend *is decreasing*

THEN ***Reduce Inventories*** *is LOW*

16)IF *LIQUIDITY* — ST Liquidity analysis under Seasonal factors
and Seasonal *is yes*
and ***Interest*** *is HIGH*
and ***Accounts Receivable in Days of Sales*** *is VERY HIGH*
and ***Inventory*** *is VERY HIGH*

THEN ***Reduce Inventories*** *is MEDIUM*
and ***Reduce Accounts Receivable*** *is MEDIUM*

17)IF *LIQUIDITY* — ST Liquidity analysis under Seasonal factors
and Seasonal *is yes*
and ***Interest*** *is HIGH*
and ***Accounts Receivable in Days of Sales*** *is VERY HIGH*
and ***Inventory*** *is HIGH*

THEN ***Reduce Inventories*** *is LOW*
and ***Reduce Accounts Receivable*** *is LOW*

18)IF *LIQUIDITY* — ST Liquidity analysis under Seasonal factors
and Seasonal *is yes*
and ***Interest*** *is MEDIUM*
and ***Accounts Receivable in Days of Sales*** *is VERY HIGH*
and ***Inventory*** *is HIGH or VERY HIGH*

THEN ***Reduce Inventories*** *is LOW*
and ***Reduce Accounts Receivable*** *is LOW*

19)IF *LIQUIDITY* — ST Liquidity analysis under Seasonal factors
and Seasonal *is yes*
and ***Interest*** *is MEDIUM*
and ***Accounts Receivable in Days of Sales*** *is HIGH*
and ***Inventory*** *is HIGH*
and Sales forecast trend *is decreasing*

THEN ***Reduce Inventories*** *is MEDIUM*
and ***Reduce Accounts Receivable*** *is LOW*

20)IF *LIQUIDITY* — ST Liquidity analysis under Seasonal factors
and Seasonal *is yes*
and ***Interest*** *is MEDIUM*
and ***Accounts Receivable in Days of Sales*** *is HIGH*
and ***Inventory*** *is HIGH*
and Sales forecast trend *is unstable*

THEN ***Reduce Inventories*** *is LOW*
and ***Reduce Accounts Receivable*** *is LOW*

21)IF *LIQUIDITY* — ST Liquidity analysis under Seasonal factors
and Seasonal *is yes*
and ***Interest*** *is LOW*
and ***Accounts Receivable in Days of Sales*** *is HIGH*
and ***Inventory*** *is HIGH or MEDIUM*
and Sales forecast trend *is stable or decreasing*

THEN ***Reduce Inventories*** *is LOW*
and ***Reduce Accounts Receivable*** *is LOW*

22)IF *LIQUIDITY* — Explicit ST Liquidity analysis of trade

and ***Accounts Payable in Days of Sales*** *is* credit *LOW*

THEN Negotiate Payable terms

23)IF *LIQUIDITY* Business growth influence on Liquidity
and Seasonal *is no*
and ***STDebt*** *is HIGH*
and ***Interest*** *is HIGH*
and *T / | WI | trend is negative*
and ***Sales Volume*** *is HIGH*
and business phase *is growth*

THEN Slow down business growth

24)IF *LIQUIDITY* ST Liquidity *tight* situation
and Seasonal *is no*
and ***STDebt*** *is HIGH*
and ***Leverage*** *is HIGH*
and ***Operational Income*** *is HIGH*

THEN Inject Equity

25)IF *LIQUIDITY* Switching of debt terms
and DEBT is no
and Seasonal *is no*
and mid-term Sales forecast trend *is stable or increasing*
and ***STDebt*** *is HIGH or MEDIUM*
and ***Leverage*** *is LOW*
and ***Operational Income*** *is HIGH*

THEN Increase LTDebt position

26)IF *PROFITABILITY* Profitability correction by a reduction on expenses
and ***Sales Volume*** *is LOW*
and ***Contribution Margin*** *is HIGH*
and ***Selling Expenses*** *is HIGH*

THEN ***Reduce Selling Expenses*** *is HIGH*

27)IF *PROFITABILITY* Influence of the purchases policy efficiency on profitability
and ***Sales Volume*** *is LOW*
and ***Contribution Margin*** *is HIGH*
and ***Average Cost of Purchases*** *is HIGH*

THEN ***Reduce Cost of Purchases*** *is HIGH*

28)IF *PROFITABILITY* Influence of the purchases policy efficiency on profitability
and ***Sales Volume*** *is LOW*
and ***Contribution Margin*** *is HIGH*
and ***Average Cost of Purchases*** *is AVERAGE*
and ***Selling Expenses*** *is HIGH*

THEN ***Reduce Cost of Purchases*** *is LOW*

29)IF *PROFITABILITY* Influence of the purchases policy

and ***Sales Volume*** *is LOW* efficiency on profitability
and ***Contribution Margin*** *is HIGH*
and ***Average Cost of Purchases*** *is AVERAGE*
and ***Selling Expenses*** *is AVERAGE*

THEN ***Reduce Cost of Purchases*** *is MEDIUM*

30)IF *PROFITABILITY* *Demand-side* considerations
and ***Sales Volume*** *is LOW*
and ***Contribution Margin*** *is HIGH*
and elasticity *is yes*
and ***Average Cost of Purchases*** *is LOW*
and ***Selling Expenses*** *is LOW*

THEN ***Reduce Margin*** *is MEDIUM*

31)IF *PROFITABILITY* *Demand-side* considerations
and ***Sales Volume*** *is LOW*
and ***Contribution Margin*** *is HIGH*
and elasticity *is no*
and ***Average Cost of Purchases*** *is LOW*
and ***Selling Expenses*** *is LOW*

THEN ***Reduce Margin*** *is LOW*

32)IF *PROFITABILITY* *Demand-side* considerations
and ***Sales Volume*** *is LOW*
and ***Contribution Margin*** *is HIGH*
and elasticity *is yes!*
and ***Average Cost of Purchases*** *is LOW*
and ***Selling Expenses*** *is LOW*

THEN ***Reduce Margin*** *is HIGH*

33)IF *PROFITABILITY* *Demand-side* considerations
and ***Sales Volume*** *is HIGH*
and ***Contribution Margin*** *is LOW*
and elasticity *is yes!*

THEN ***Increase Margin*** *is MEDIUM*

34)IF *PROFITABILITY* *Demand-side* considerations
and ***Sales Volume*** *is MEDIUM*
and ***Contribution Margin*** *is LOW*
and elasticity *is yes!*

THEN ***Increase Margin*** *is LOW*

35)IF *PROFITABILITY* Profitability correction by
and ***Administrative Expenses*** *is HIGH* administrative. expenses cutting

THEN ***Reduce Administrative Expenses*** *is HIGH*

36)IF *PROFITABILITY* Profitability correction by
and ***Administrative Expenses*** *is MEDIUM* administrative. expenses cutting

THEN ***Reduce Administrative Expenses*** *is LOW*

37)IF *PROFITABILITY* Considerations on *pricing*
and ***Contribution Margin*** *is HIGH*

THEN Check pricing in relation to product turnover

38)IF *PROFITABILITY* Current assets turnover-Interest compound effect on Profitability
and Seasonal *is yes*
and ***Interest*** *is HIGH*
and ***Inventory*** *is VERY HIGH OR HIGH*

THEN ***Reduce Inventories*** *is MEDIUM*

39)IF *PROFITABILITY* Current assets turnover-Interest compound effect on Profitability
and Seasonal *is yes*
and ***Interest*** *is HIGH*
and ***Inventory*** *is MEDIUM*

THEN ***Reduce Inventories*** *is LOW*

40)IF *PROFITABILITY* Current assets turnover-Interest compound effect on Profitability
and Seasonal *is no*
and ***Interest*** *is HIGH*
and ***Inventory*** *is VERY HIGH OR HIGH*

THEN ***Reduce Inventories*** *is MEDIUM*

41)IF *PROFITABILITY* Current assets turnover-Interest compound effect on Profitability
and Seasonal *is no*
and ***Interest*** *is (HIGH or MEDIUM)*
and ***Inventory*** *is VERY HIGH OR HIGH*

THEN ***Reduce Inventories*** *is HIGH*

42)IF *PROFITABILITY* Current assets turnover-Interest compound effect on Profitability
and Seasonal *is no*
and ***Interest*** *is (VERY HIGH OR HIGH or MEDIUM)*
and ***Inventory*** *is MEDIUM*

THEN ***Reduce Inventories*** *is MEDIUM*

43)IF *PROFITABILITY* Current assets turnover-Interest compound effect on Profitability
and ***Interest*** *is LOW*
and ***Inventory*** *is HIGH or VERY HIGH or MEDIUM*

THEN ***Reduce Inventories*** *is MEDIUM*

44)IF *PROFITABILITY* Current assets turnover-Interest compound effect on Profitability
and ***Interest*** *is HIGH*
and ***Accounts Receivable in Days of Sales*** *is VERY HIGH*

THEN ***Reduce Accounts Receivable*** *is HIGH*

45)IF *PROFITABILITY* Current assets turnover-Interest compound effect on Profitability
and Seasonal *is yes*
and ***Interest*** *is HIGH*
and ***Accounts Receivable in Days of***

Sales *is HIGH*

THEN ***Reduce Accounts Receivable*** *is MEDIUM*

46)IF *PROFITABILITY* — Current assets turnover-Interest compound effect on Profitability
and ***Interest*** *is MEDIUM*
and ***Accounts Receivable in Days of Sales*** *is VERY HIGH*

THEN ***Reduce Accounts Receivable*** *is MEDIUM*

47)IF *PROFITABILITY* — Current assets turnover-Interest compound effect on Profitability
and Seasonal *is no*
and ***Interest*** *is MEDIUM*
and ***Accounts Receivable in Days of Sales*** *is HIGH*

THEN ***Reduce Accounts Receivable*** *is MEDIUM*

48)IF *PROFITABILITY* — Leverage effect on Profitability (low financial risk)
and *LIQUIDITY is no*
and mid-term Sales forecast trend *is stable or increasing*
and ***Leverage*** *is LOW*
and Interest mid-term forecast trend *is stable or decreasing*
and ***Operational Income*** *is HIGH*

THEN Increase Leverage by LTDebt

49)IF *DEBT* — Effect of Fixed Assets Turnover on Debt
and mid-term Sales forecast trend *is stable or decreasing*
and ***Fixed Assets Turnover*** *is LOW*

THEN Reduce Investments in Fixed Assets

50)IF *DEBT* — Reduction of the *financial risk.*
and *PROFITABILITY is no*
and mid-term Sales forecast trend *is stable or decreasing*
and ***Interest*** *is (HIGH and* Interest mid-term forecast trend *is stable or decreasing)*
and *Leverage is HIGH*

THEN Negotiate debt terms *and* inject Equity

51)IF *DEBT* — Leverage effect on Profitability (low financial risk)
and mid-term Sales forecast trend *is stable or decreasing*
and ***Interest*** *is HIGH and* Interest mid-term forecast trend *is increasing*
and ***Leverage*** *is HIGH*

*THEN (*Negotiate debt terms *or* inject Equity*) and* Stop borrowing

52)IF *DEBT* — Leverage effect on Profitability (low financial risk)
and mid-term Sales forecast trend *is stable*

or decreasing
and ***Interest*** *is HIGH and* Interest mid-term forecast trend *is stable or decreasing*
and *Leverage is MEDIUM*

THEN Negotiate debt terms

53)IF *DEBT* — Debt matching restructure
and ***Sales Volume*** *is (LOW or MEDIUM)*
and ***ST I Expense / LT I Expense*** *is MEDIUM or HIGH*
and ***Interest*** *is HIGH or MEDIUM and* Interest mid-term forecast trend *is stable or decreasing*

THEN Restructure terms between LT and ST Debt

54)IF *DEBT* — Debt matching restructure
and *PROFITABILITY is no*
and ***Sales Volume*** *is HIGH*
and ***ST I Expense / LT I Expense*** *is MEDIUM or HIGH*
and Interest mid-term forecast trend *is increasing*

THEN Increase Debt payment

55)IF *DEBT* — Effect of the cash flow generation capacity on the debt position
and ***Operational Cash Flow*** *is HIGH*

THEN ***Reduce Fixed Costs*** *is MEDIUM*

56)IF *DEBT* — Effect of the cash flow generation capacity on the debt position
and ***Operational Cash Flow*** *is MEDIUM*

THEN ***Reduce Fixed Costs*** *is MEDIUM*

57)IF *DEBT* — Fixed costs reduction when a financial external assistance is restricted
and ***Leverage*** *is HIGH or MEDIUM*
and ***Interest*** *is HIGH or VERY HIGH*
and Credit Line *is restricted*

THEN ***Reduce Fixed Costs*** *is HIGH*

58)IF *DEBT* — Fixed costs reduction when the financial external assistance is available
and ***Leverage*** *is MEDIUM*
and ***Interest*** *is MEDIUM*
and Credit Line *is available*

THEN ***Reduce Fixed Costs*** *is MEDIUM*

59)IF *DEBT* — Combine effect of leverage and interest rate when DEBT
and ***Leverage*** *is HIGH or MEDIUM*
and ***Interest*** *is HIGH or VERY HIGH*

THEN ***Reduce Inventories*** *is HIGH*
and ***Reduce Accounts Receivable*** *is MEDIUM*

60)IF *DEBT* — Combine effect of leverage and

and ***Leverage*** *is HIGH* interest rate when DEBT
and ***Interest*** *is LOW*

THEN ***Reduce Inventories*** *is MEDIUM*
and ***Reduce Accounts Receivable*** *is LOW*

61)IF *DEBT* Leasing effect on Long Term Debt
and ***Interest*** *is HIGH*
and ***Fixed Charge Coverage*** *is LOW*
and Sales forecast trend *is decreasing*

THEN Negotiate Lease terms

62)IF *DEBT* Debt maturity matching
and *PROFITABILITY is no*
and ***ST I Expense / LT I Expense*** *is MEDIUM or HIGH*
and mid-term Sales forecast trend *is stable or decreasing*

THEN Restructure terms between LT and ST Debt (Extend Debt terms)

63)IF *DEBT* Influence on *pricing* in order to generate cash
and *LIQUIDITY*
and *PROFITABILITY is no*
and ***Interest*** *is HIGH or MEDIUM*
and ***Contribution Margin*** *is AVERAGE or HIGH*

and ***Sales Volume*** *is HIGH*

THEN Increase On Sale offers

64)IF *DEBT* Influence on *pricing* in order to generate cash
and *LIQUIDITY*
and *PROFITABILITY is no*
and ***Interest*** *is HIGH or MEDIUM*
and ***Contribution Margin*** *is LOW*

THEN Redefine On Sale mix

5.6 System Validity from a Financial Point of View

The goal of this stage is to test the system in relation to different situations (including an analysis of the ANN knowledge acquired). A description of the different aspects over study at this stage is shown on Table 15.

In order to have flexibility in relation to changes of the economic *rules,* one may consider the following points in the system,:

- it is necessary to model the variables in *relative* terms; that is, the system flexibility decreases with the number of variables modeled in absolute terms.
- use as many fuzzy variables as possible on the premises and conclusions.
- establish a balance between the degree of specificity of the FES output and the number of factors necessary to describe the firm's internal environment; this consideration is due to the fact that the primary purpose of the system proposed is to use it among specific sectors but not among specific firms.

Table 15: Main Aspects Considered at the Validation Stage

Flexibility to the modification of rules
Knowledge base capability to be updated
Knowledge acquisition by the ANN
Cross sectional adaptation

The system capability of maintenance refers to the necessity to update the different values of both relative and absolute variables; this values may be revisited periodically. The guidance here is to follow the principle of minimum energy: if possible, anything should be update. The later point translates in practical terms on the effort to describe the fuzzy sets in relative terms.

The adaptation of the system to different economic activities will be a consequence of the success or not of the directions stated above and the degree of dependence of the different sectors.

The translation of the knowledge acquired by the ANN in terms of IF - THEN rules is a topic that is being widely developed [CAR95], [CRA94], FU94], [THR95]. The analysis of the ANN mapping will have two basic purposes: the overall validation of the ANN knowledge and the measure of the structure degree of such knowledge. A further aim of that analysis is to incorporate the ANN in the FES (after subsequent periods);

by this way, the training and testing stage of the ANN will be avoided, turning the implementation more practical.

6. CONCLUSIONS AND FUTURE WORK

It was presented in this thesis the knowledge representation required to formulate a computational system capable of perform a financial diagnosis and propose alternatives of action. The knowledge representation proposed considered explicitly both connectionist and deductive reasoning.

The source of data used was financial statements, averages, reference values from the sector, and firm's internal and external information about trends. In order to model a system with that type of data sources, it was necessary to determine an specific sector of activity and a threshold on the size of the firm. In such *homogeneity* conditions, the information derived from the financial statements is able to signal financial *warnings* and deviations.

The categorization of the pre-diagnosis phase in *Profitability, Short Term Liquidity* and *Debt* financial problems made possible to improve the *quality* of the diagnostic rules; similar premises could lead to different semantic consequences depending on the financial pre-diagnostic.

Fuzzy **S**et **T**heory was used in order to represent the different *semantic* variables that derive from practical experience and the normative theory of finance; that is, FST was used in the approximate reasoning paradigm. The advantage of such approach is that many semantic variables could be modeled in a flexible way, giving as a response a *buffer* number that specifies the *magnitude* of the alternative proposed[21].

In order to generalize the knowledge representation as much as possible[22], the different variables were expressed in relative instead of absolute terms.

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[21] These are the cases when FST is used to model the consequent(s) of a rule.

[22] In relation to the financial restrictions to generalization of economic sector and size of a firm.

This work suggests several areas in which further work is needed.

First, in order to generalize the validation of the knowledge representation proposed, it would be helpful to develop the proposed application in different economic sectors. In particular, it is important to adapt the present work to the industrial sector, in which case many variables and rules related to production costs would appear.

Another further development consists in incorporate with more emphasis the influence of the different business phases which could characterize other sets of financial rules.

Finally, in order to introduce financial rules that are possible but not certain, the introduction of the possibilistic paradigm would be necessary.

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UNIVERSIDADE FEDERAL DE SANTA CATARINA

PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA DE PRODUÇÃO E SISTEMAS

Modeling Financial Statement Analysis for Indicating Corrective Actions to Financial Problems

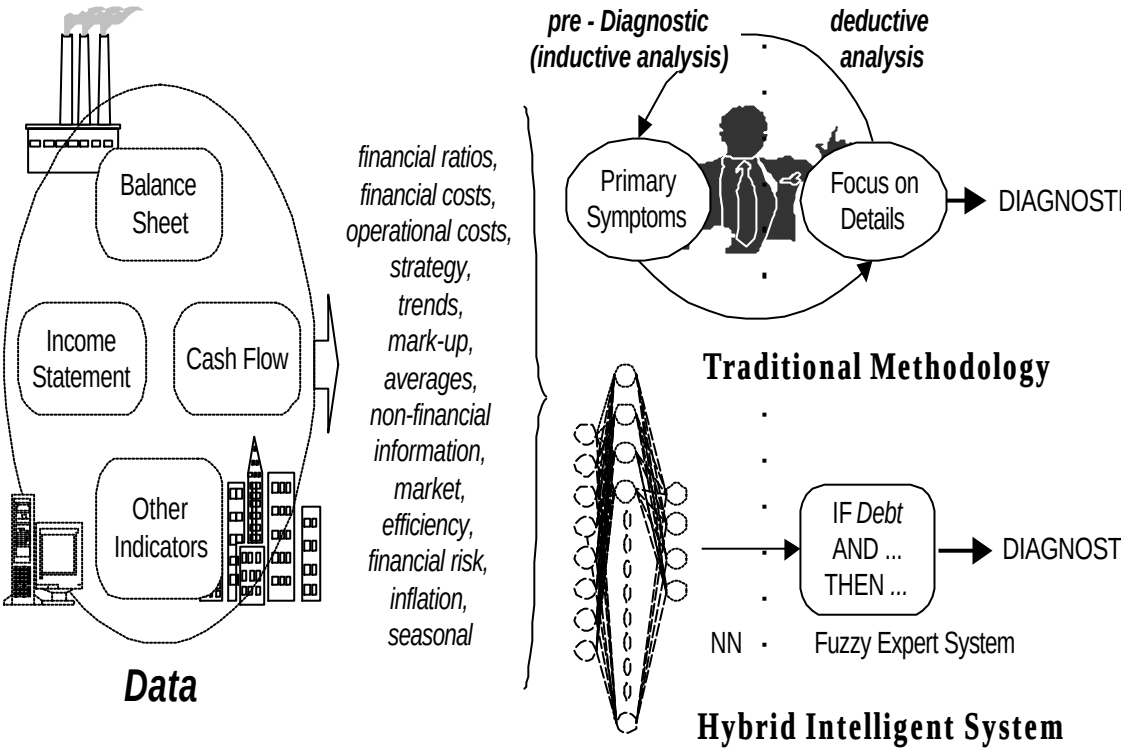
Alejandro Martins Rodriguez

ADVISOR: PROF. R. M. BARCIA, Ph.D.

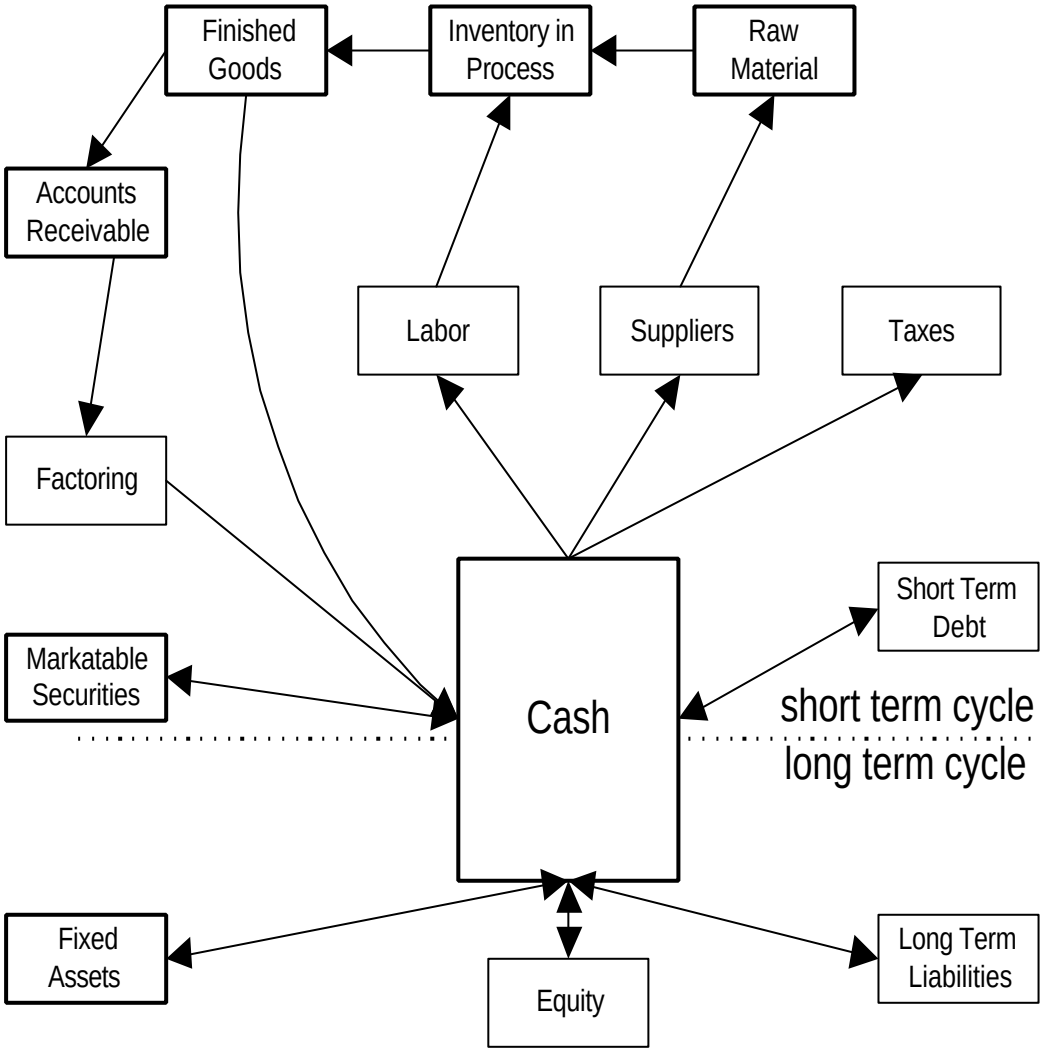
FLORIANÓPOLIS

SANTA CATARINA - BRASIL

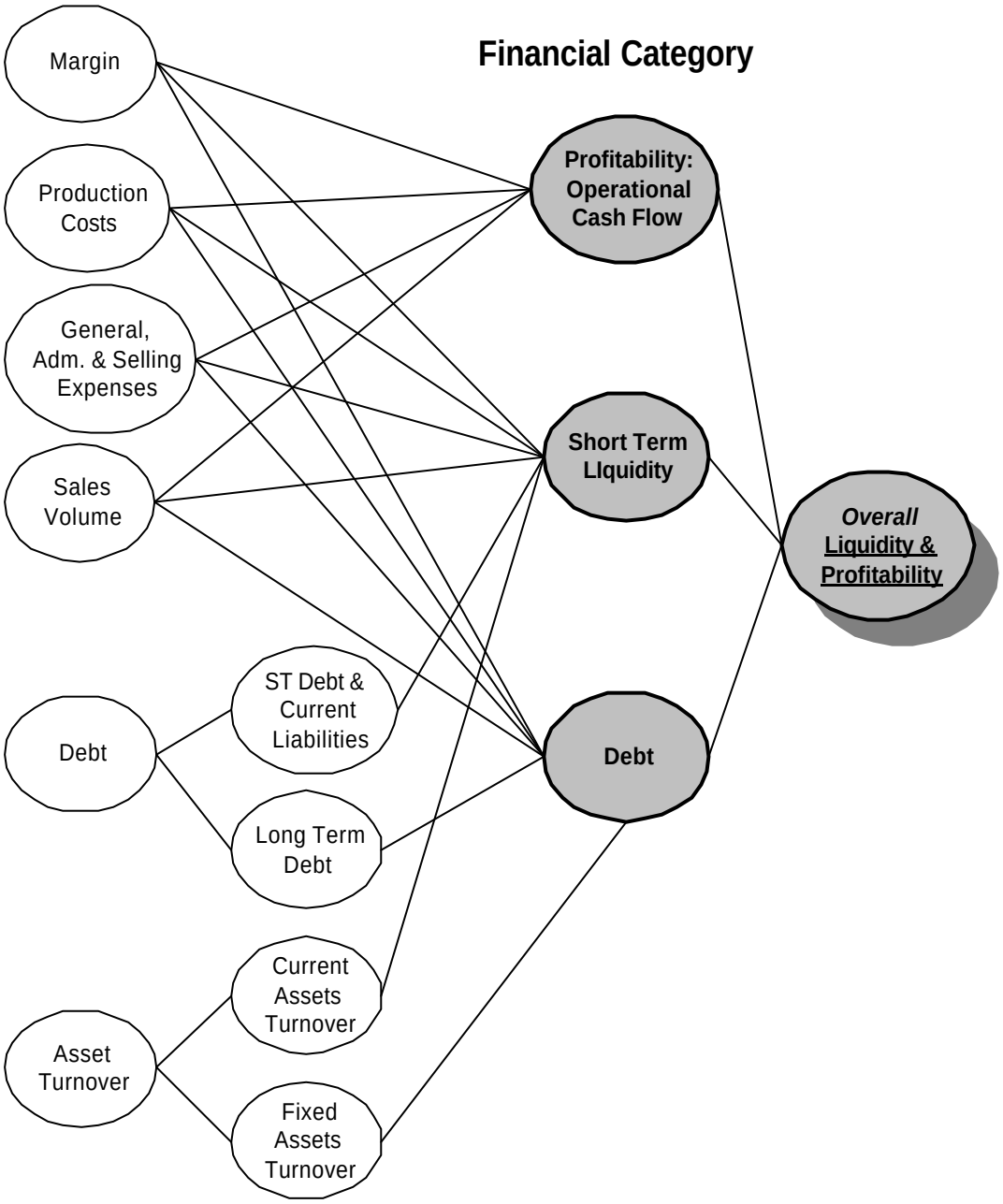
MARÇO DE 1996



Analyzing Financial Health: Traditional Methodology vs. the Hybrid System Technology



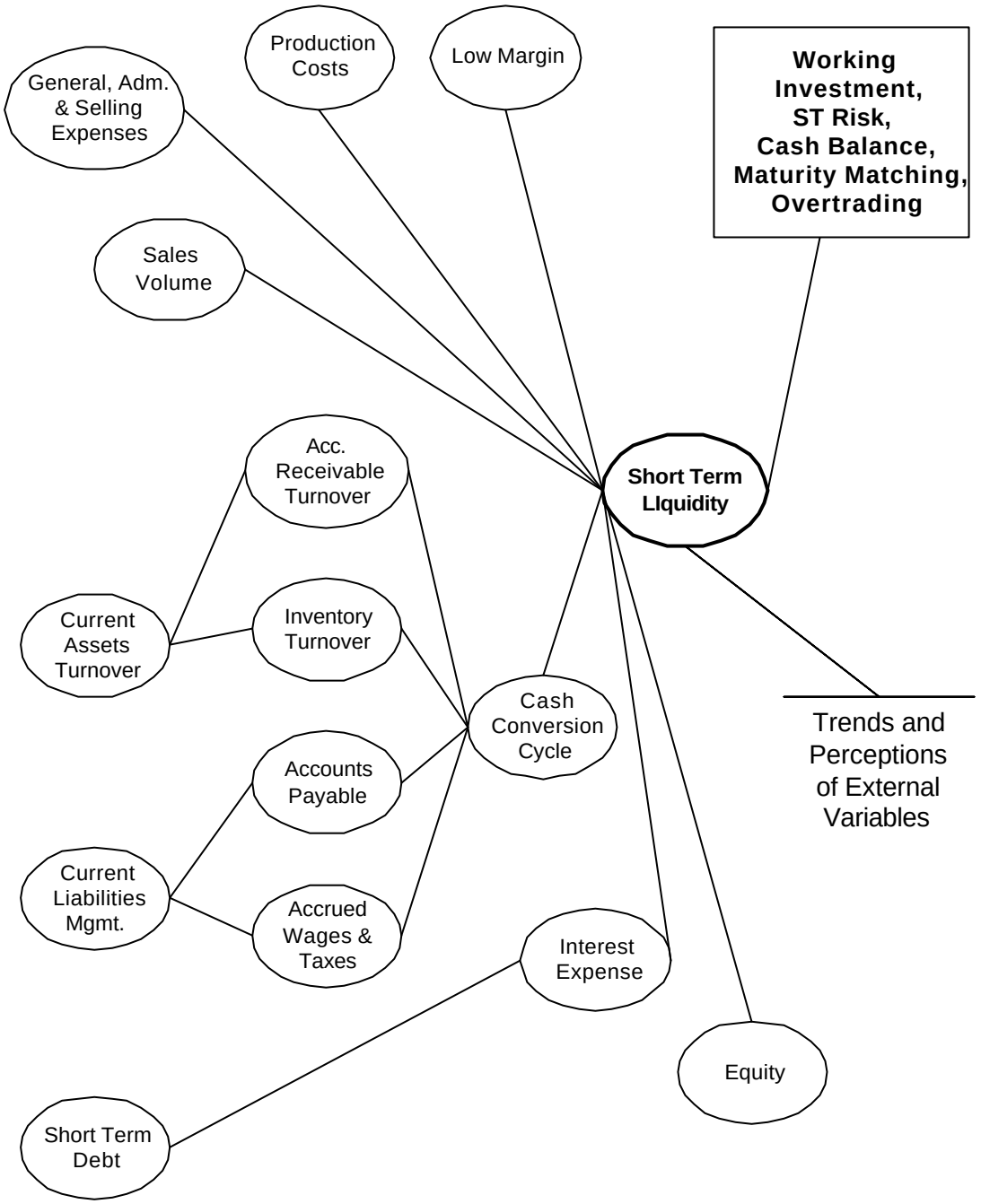
Operational Cycle

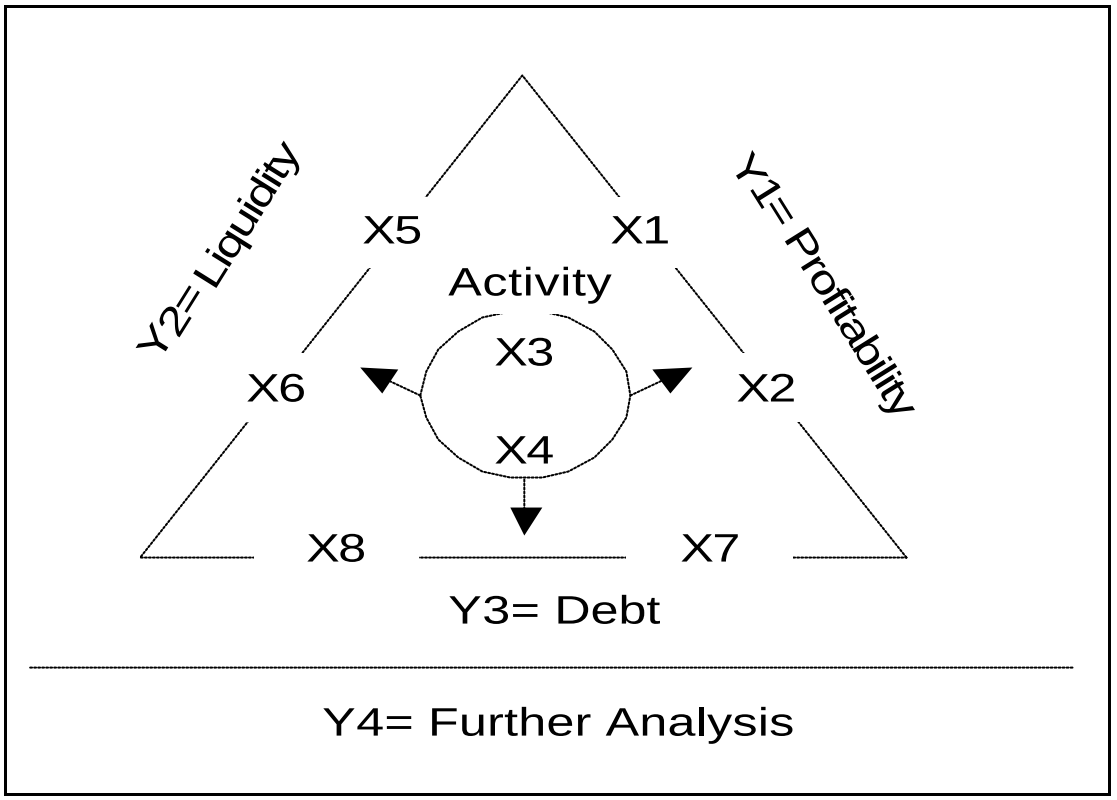


The Conceptualization of the Financial Diagnostic of Small Firms

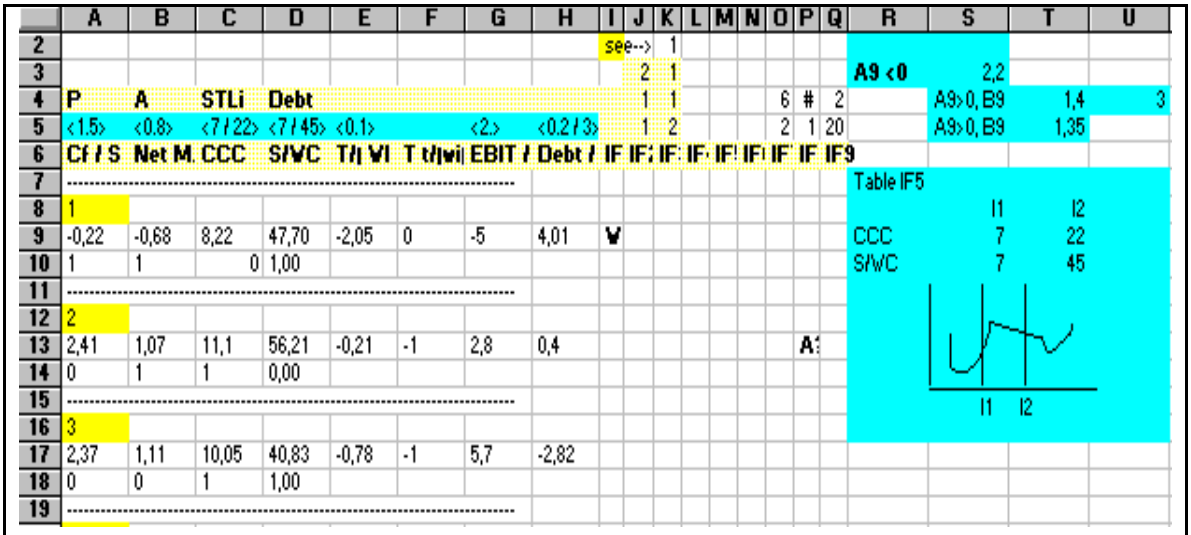
SHORT TERM LIQUIDITY PROBLEMS

Liquidity Problems
Working Investment
Short term debt maturity matching
Cash Balance
Overtrading
Overall Short Term Risk Position


General, Adm. & Selling Expenses
Production Costs
Low Margin
Working Investment, ST Risk, Cash Balance, Maturity Matching, Overtrading
Sales Volume
Acc. Receivable Turnover
Short Term LIquidity
Current Assets Turnover
Inventory Turnover
Cash Conversion Cycle
Trends and Perceptions of External Variables
Accounts Payable
Current Liabilities Mgmt.
Accrued Wages & Taxes
Interest Expense
Equity
Short Term Debt



Ratio	**Comment**
X_1	Powerful indicator of the Cash Flow generation capability; main
X_2	“Bottom edge” indicator of Profitability
X_3	Indicator of financial efficiency
X_4	Accurate indicator of liquidity
X_5	Accurate indicator of liquidity
X_6	Accurate indicator of liquidity trend
X_7	Indicator of Coverage
X_8	Indicator of Capital Structure



1)=IF(OR(A9<0;B9<0;G9<0);"W !"; "")

2)=IF(OR(AND(A9<0;ABS(B9)<$S$3*ABS(A9));AND(A9>0;B9<0;ABS(A9)<$T$4*ABS(B9));AND(A9>0;B9>0;ABS(A9)<$T$5*ABS(B9)));"C!";"")

3)=IF(OR(AND(G9<0;ABS(G9)<$K$3*ABS(B9));AND(G9>0;B9>0;ABS(G9)<$K$5*ABS(B9));AND(G9>0;B9<0;G9>1+$K$2));"I !!";"")

4)=IF(AND(H9<0;C10<1;D10<1);"L?";"")

5)=IF(AND(OR(C9<$S$9;C9>$T$9;D9<$S$10;D9>$T$10);B10<1);"A?";"")

6)=IF(AND(G9>0;B9<0;D10<1;C10<1);"JJ!";"")

7)=IF(OR(AND(A9>0;G9<0;B9<0;ABS(B9)<1;A9>$O$4*ABS(B9));AND(A9>0;G9<0;B9<0;ABS(B9)>1;A9>$O$5*ABS(B9)));"C$!";"")

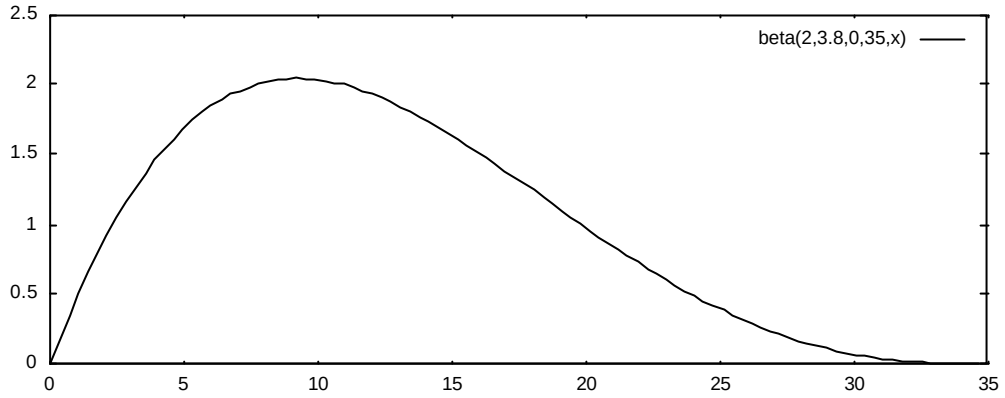
8)=IF(AND(D9>$T$10*(1+$P$4/100);E9<$P$5);"A?L?";"")

9)=IF(OR(AND(D9<$S$10;C9<$S$9*(1+$Q$5/100);OR(A9>$Q$4;E9>$P$5));OR(AND(D9<0;E9<0);AND(C9<$S$9*(1-$Q$5/100);E9<0)));"C? turnover?";"")

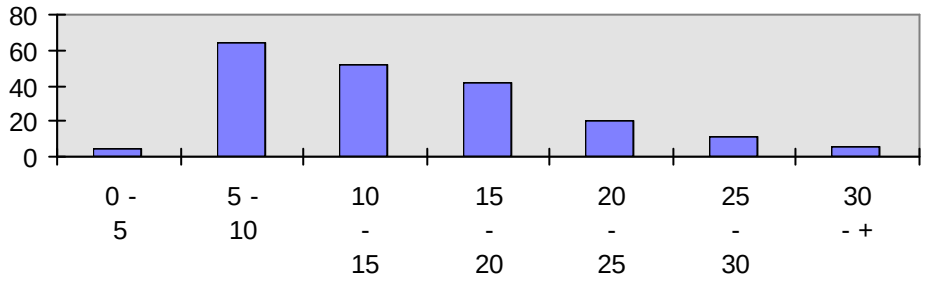
Cash Conversion Cycle:

CCC= Days Receivable + Days Inventory - Days Payable (Buckmaster's Reverse J)

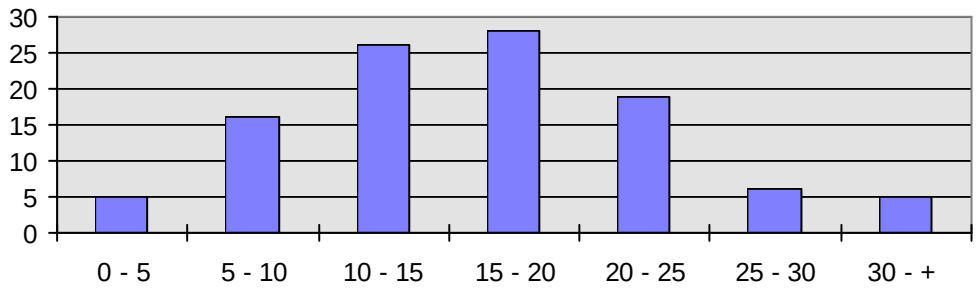
All		25 - 99.99		100 & O			
15.8	4.7	6.0	4.2	3.5	3.6	20.9	2.8



CCC (tra) 1 - 200



CCC (test) 201-305



PROFITABILITY
Reduce Accounts Receivable
Sales Volume
Slow down business growth
Stop borrowing
T / | WI | trend
APs trend
Seasonal

IF *PROFITABILITY*
and Seasonal *is no*
and ***Interest*** *is MEDIUM*
and ***Accounts Receivable in Days of Sales*** *is HIGH*

THEN ***Reduce Accounts Receivable*** *is MEDIUM*

==========

IF *DEBT*
and *PROFITABILITY is no*
and mid-term Sales forecast trend *is stable or decreasing*
and ***Interest*** *is (HIGH and* Interest mid-term forecast trend *is stable or decreasing)*
and *Leverage is HIGH*

THEN Negotiate debt terms *and* inject Equity

Validation

Flexibility
Knowledge base capability to be updated
Knowledge acquisition by the ANN
Cross sectional adaptation

CONCLUSIONS

SPECIFIC SECTOR OF ACTIVITY

THRESHOLD ON THE SIZE OF THE FIRM.

CATEGORIZATION: QUALITY OF THE DIAGNOSTIC RULES

FUZZY **S**ET **T**HEORY:

- SEMANTIC VARIABLES
- *BUFFER* NUMBER THAT SPECIFIES THE *MAGNITUDE* OF THE ALTERNATIVE PROPOSED

RELATIVE INSTEAD OF ABSOLUTE TERMS

FURTHER WORK:

DIFFERENT ECONOMIC SECTORS

BUSINESS PHASES

POSSIBILISTIC PARADIGM

RELATED WORK

ANSWERS

FINANCIAL STATEMENT ANALYZER (FSA)

BANKRUPTCY FORECASTING

CREDIT ANALYSIS