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Bankruptcy prediction : literature survey of the last ten years

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Abstract

Bankruptcy is an important topic for a number of people (shareholders, banks, investors, suppliers,...). For this reason a lot of models were developed in order to predict it. Statistical procedures (multiple discriminant analysis, logit or probit) were among the most used methods in this kind of problem. However, parametric statistical methods require the data to have a specific distribution. In addition to the restriction on the distribution involved, multi-collinearity and autocorrelation could lead to problems with the estimated model when statistical methods are used. Because of these drawbacks, others methods have been investigated : multicriteria methods (UTA, Electre tri,...) or machine learning methods (i.e. neural networks, genetic algorithms, decision trees, rough sets,...). Our main target is to provide a survey of the literature of the last ten years but also to have a larger view than usually by evoking causes, symptoms and remedies of bankruptcy.

Keywords : bankruptcy, survey.

1 Introduction

Since Beaver's seminal work (Beaver [1966]) until nowadays, the business failure prediction problem received a lot of interest from both researchers and academicians. This interest is reflected by the large number of papers published since 1966. This problem is of great importance for two principals reasons. Firstly, the number of bankruptcies increased dramatically all over the world. For example, Table 1 shows the drastic rise in bankruptcies in Belgium. Coleman et al. [1991] reveal the same problem for United-States (from 200,000 bankruptcy filings in the early 80's to 725,000 in 1990). For the banking industry, Tam and Kiang [1992] mention that the number of bankruptcy cases filed under the Federal Deposit Insurance Corporation (FDIC) has increased from less than 50 in 1984 to an estimate of over 400 in 1991. Secondly, people involved in a business failure are large and various: owners or shareholders, managers, workers, lenders, suppliers, clients, the community, the government,.... As the number of people involved in bankruptcy are numerous, the cost of failure is important. For example in Belgium, the 623 business failures occurred during September 2000 led to the loss of 1.124 jobs ! And jobs losses are only a little part of the cost of failure.

Table 1: Number of bankruptcies in Belgium

Year	1990	1992	1994	1998	1999	2000	2001
Number	3907	5273	6446	6925	7150	6791	7062

Source: National Institute of Statistics

The aim of this paper is to provide an up-to-date review of the literature of this important topic. Our review is useful and original for two main reasons. Firstly, we adopt a chronological point of view, from the important work of Beaver (Beaver [1966]) to nowadays. However, our survey focus mainly on last developments occurred during the last 10 years (1991-2001). Secondly, our view is larger than usual. Indeed, we are deeply interested not only in the financial ratios (symptoms of failure) used in studies but also in causes, processes and remedies of failure.

The remainder of the paper will be organized as follows. In section 2, we spend some time to briefly define different notions like failure and bankruptcy. Causes, processes and remedies of bankruptcy will be presented in section 3. Following that we introduce in section 4 symptoms used to reveal the failure. Before the final section containing concluding remarks and further researches, a literature survey of bankruptcy prediction applications is presented.

2 Bankruptcy, failure, financial distress,...What are we talking about exactly?

According to Zopounidis and Doumpos [1999a] the basic goal in business failure prediction is to achieve discrimination between failed (bankrupt) and non-failed (healthy) firms. Thus, we can say that the business failure prediction is a classification problem. Consequently, given data (instances) from previous periods, we are interested in developing models to be able to predict future outcomes using just the input feature values (Piramuthu et al. [1998]). However, in our survey it seems that the outcome may largely differ from bankrupt and healthy firm. In fact, researchers can chose as outcome different level of seriousness (of illness). Indeed, problems a firm can encounter can be placed on a continuum beginning from slight difficulties to more serious problems and perhaps finally bankruptcy which is the final stage of financial distress. It is in this direction that we have to understand the different notions (financial distress, failure, bankruptcy,...) used in the literature. One of the early stage

on the continuum could be the audit qualification given by auditors reports or independent professional accountants. This kind of outcome has been chosen by Coats and Fant [1993], Lacher et al. [1995] or Lenard et al. [1995]. A more serious problem is failure often defined as the inability of the firm to pay its financial obligation when they come due (Beaver [1966], Sharma and Mahajan [1980] or Luoma and Laitinen [1991]). In the same order of idea, Abdel-Khalik and El-Sheshai [1980] and Chalos [1985] choose loan default rather than bankruptcy as an earlier and more representative signal of financial distress.

As stated before, the final stage is the death of the firm represented by bankruptcy. Bankruptcy occurs when a company file a formal legal document in court for the purpose of either liquidation or reorganization. This "legal" definition may differ across countries but is often chosen by authors (Collongues [1977], Taffler [1982], Gilbert et al. [1990], Mar Molinero and Ezzamel [1991] or Bryant [1997]) since it is of practical use. Of course, in order to have a larger sample, authors can be tempted to chose a very large definition of financial distress. For example, Lee et al. [1996] define the state of bankruptcy as follows: the firms which applied for, have started, or are under the process of corporate clearance, the firms which quit or closed business, the firms which have had losses for the consecutive three years and are currently under legal control and the firms which reported the withdrawal of listing or terminated to be listed by the Stock Exchange.

3 Causes, process and remedies

" *The failure process of a firm can be compared with the evolution of a disease in a human being. In the same way, failure itself is comparable to death. The causes of failure are often associated with management adequacy. These cause lead to occurrence of symptoms which are observable from the deterioration of financial ratios. This deterioration factually forms the failure process*". From this statement given by Luoma and Laitinen [1991] (and confirmed by other authors), we can infer that (a) failure is not a sudden event, it takes some time ("*evolution of the disease*") for a company to become bankrupt (b) financial ratios are only symptoms of failure and (c) failure process is triggered off by something (causes). We could also add to this statement that as in human being if disease is revealed early enough, some remedies can be taken. Unfortunately, very few authors are interested in causes, process or remedies. They only work with symptoms of failure, often represented by financial ratios (Section 4 will be exclusively devoted to the variables used as symptoms of failure). However, it seems of prime necessity to look into these three aspects of the failure.

As mentioned earlier, very few authors (Meyer and Pifer [1970], Altman [1971], Vernimmen [1978], Dambolena and Khoury [1980], Sharma and Mahajan [1980], Barbe [1982], Koenig [1985], Makridakis [1991] or Honjo [2000]) are really interested in origins of bankruptcy. Even if the list of causes may be different across studies, we can distinguish two main causes of failure: endogenous and exogenous factors. The main cause within organisation is managerial incompetence. Barbe [1982] mentions that more than fifty percent of firms had to file petition in bankruptcy due to problems of management or inexperience. This is the case in France, Belgium but also in US where 90% of bankruptcies can be impute to this factor (Sharma and Mahajan [1980]). Dambolena and Khoury [1980] add that bad management appears through lack of responsiveness to change in technology, insufficient consideration for cost factors, poor knowledge of financial matters,.... Koenig [1985]

completes this analysis by affirming that direction's incapacity to collect and process relevant data is also a cause of failure. This incapacity prevents the company from taking adequate measures. Meyer and Pifer [1970] and Makridakis [1991] corroborate the others but add also the integrity of employees, the organizational arteriosclerosis, the undervaluation of the competition or the believe in barriers to entry as factors explaining failures.

What exogenous factors concern, Altman [1971] mentions that the change in the nation's failure rate is negatively associated with changes in overall economic activity, stock market performance, and money supply conditions. Dambolena and Khoury [1980] point out also that government regulations impede the functioning of the market system, distorting its signals to the corporate decision makers. Moreover Vernimmen [1978] signals that the failure of a customer was the main cause of bankruptcy in France. This last statement reinforces what we said in the introduction: bankruptcy prediction is a very important topic because failure of a particular company could have unfortunate impact on other entities. Age, size, gross entry rate or geographical concentration are also mentioned as determinants of business failure and included in models (Honjo [2000]).

In our opinion, having a better knowledge of causes of failure is of prime importance in order to do a choice of variables with full knowledge of the fact.

As emphasised by Luoma and Laitinen [1991], failure is not a sudden event, it follows a kind of "path". Some authors (Ooghe and VanWymeersch [1986], Luoma and Laitinen [1991] and Laitinen [1992]) looked into the "failure path". Even if the process can be very different across distressed companies, it seems that we can identify some constants. The earliest symptoms of failure and the starting point of the process is an insufficiency of revenue and a poor profitability. When the availability of share capital is limited, firms are forced to get more indebted (first with long terms and next with short terms). This is the beginning of a vicious circle that ends in bankruptcy. This increasing indebtedness leads to a poor solvency, creditors becomes suspicious and liquidity problems arises. Thus final symptoms come to light through an increase in short-term debt which leads to poor liquidity and long average payment period for accounts payable. According to Luoma and Laitinen [1991], in the same time the firm may use "creative accounting" to show better financial figures.

As we can see, the failure process is dynamic, ratios useful to detect financial distress in the beginning of these problems are not the same as these at the end of the process. Through multidimensional scaling, Mar Molinero and Ezzamel [1991] has also point out this dynamic nature of the problem.

The majority of the papers considered here are interested in the diagnosis (failure or bankruptcy prediction) but not in avoidance of serious problems. Nevertheless, it would be much more fruitful for companies in difficulties to know how to avoid (or limit) the failure (or losses). Even if Laitinen [1992] gives some very general preventive advices (for example ensuring a positive profitability and cash flows in the very first years or ensuring that there is enough stockholders capital to form a safe buffer for future losses[1]) to entrepreneurs and managers of newly founded companies, these advices are general and unrelated with a particular diagnosis. Nevertheless, Barbe [1982] underlined that a help system to distressed firm must be articulated in 3 stages: a diagnosis, a recovery plan and the following up of the plan fulfilment.

[1] We can noticed that these advices are stricly in line with the process described earlier.

On the other hand, the expert system of Coleman et al. [1991] can recommend remedial action to improve the financial condition of the company. This is a vital capability, as the system is not only able to pinpoint potential problems but also can suggest ways to avoid problems. Moreover, this system is able to play "what-if" games to determine the efficiency of remedial action. Lincoln [1984] not only develops models to measure the levels of insolvency risk for firms in different industries but he can also suggest some remedies (for example, in his paper he studies a company to which he made this kind of advices following his diagnosis: improve cash-flow coverage of current liabilities, reduce investment in stock and increase its equity base) and calculate the impact of alternative courses of action on its insolvency risk.

4 The financial ratios and others variables

In Section 3 we have already point out that authors rely on symptoms of the disease in order to predict bankruptcy. A large number of ratios has been proposed in the literature. We have counted all the ratios used in the 53 papers contained in Table 2. In 6 papers, the ratios are not given (Altman et al. [1994], Jo and Han [1996], Bardos and Zhu [1997], Jeng et al. [1997], Bardos [1998] and Varetto [1998]) and for 3 papers it was either impossible (Vermeulen et al. [1998]) or very difficult (Cormier et al. [1994] and Honjo [2000]) to give the ratios used. On the 44 remaining papers, about 200 different (even slightly) ratios were used. As you can imagine it's strictly impossible to give here all these ratios. That's why we will give only the ratios at least used in fifteen applications. This is the list of ratios (between brackets is the number of applications in which we find the ratio): Current ratio (23), $\frac{\text{Working capital}}{\text{Total assets}}$ (22), $\frac{\text{EBIT}}{\text{Total assets}}$ (22), $\frac{\text{Net income}}{\text{Total assets}}$ (18), Quick ratio (17) and $\frac{\text{Retained earnings}}{\text{Total assets}}$ (15) . It is remarkable to note that 3 of these 6 ratios are included in the Altman [1968]'s model!

Rapidly after his initial work (Altman [1968]), Altman was aware that it was necessary to include non-financial and more qualitative information in the model (Altman and Loris [1976]). Others authors are agree with him (for example Collongues [1977] and Vernimmen [1978] or Doumpos et al. [2000] who stated that "*in financial risk assessment the analysis of the available qualitative information is essential*"). However, only 5 papers (Cormier et al. [1994], Dimitras et al. [1995], Slowinski and Zopounidis [1995], Greco et al. [1998] and Zopounidis and Doumpos [1999b]) really include qualitative information in bankruptcy prediction model. The last four papers include as qualitative information: managers'work experience, firm's market niche-position, technical structure-facilities, organization-personnel, special competitive advantage of firms and market flexibility. Cormier et al. [1994] include (through dummies variables) other qualitative indicators like investment in a new sector, change in the depreciation method or change in the ownership.

In Section 3 we refer to the influence of exogenous factors on the health of a company. That's why some authors (Altman [1971], Mensah [1984] or Honjo [2000]) include in their models macroeconomic factors. With the same idea in mind, Shah and Murtuza [2000] gave consideration "*to ratios that are sensitive to issues such as inflation, interest rate changes and credit availability, and economic business cycles*". The influence of macroeconomic factors on bankruptcy seems particularly important because according to Graydon[2], the number of bankruptcies in 2000 is decreasing in Belgium thanks to the relatively good and stable economic situation in our country.

A lot of authors (Blum [1974], Abdel-Khalik and El-Sheshai [1980], Casey [1983], Appetiti [1984] or Chalos [1985]) use trend data in the form of the average change over several years in different ratios. It seems that trend variables has a greater ability to draw out information from balance sheet data. Dambolena and Khoury [1980] and Meyer and Pifer [1970] were a bit more advanced. They computed for each company, for different ratios and for several years prior to failure, four different measures of ratio stability: the standard deviation of the ratio over the three-year periods, its standard deviation over four-year periods, its standard error of estimate around a 4-year linear trend and its coefficient of variation over four-year periods. As stated by Luoma and Laitinen [1991], in his last stage before bankruptcy, the firm is tempted to use "creative accounting" to show better financial figures and trend data are often selected to depict creative accounting.

Others important variables were also put forward by researchers. For example, industry type seems to be of critical importance in failure prediction and therefore was included in some models. Some authors also advise to develop a separate model for each industry (Mader [1975], Taffler [1984], Mensah [1984], Izan [1984], Chalos [1985]). The size seems also have an impact on the financial distress of a firm. Consequently, authors incorporate the size represented by, for example, the total assets, sales (Jo and Han [1997]), the total number of employees (Lennox [1999]), the ratio $\frac{\text{Total assets}}{\text{GNP price level}}$ (Bryant [1997], Boritz et al. [1995] or Boritz and Kennedy [1995]) or ln(net sales) (Laitinen [1992]).

The link between causes and symptoms is not always clearly established. However, Lincoln [1984] states for example that poor management will be reflected in the profit and loss statement and the economic downturns will be shown in the company's declining cash-flow.

5 Survey of methods

After an extensive but not necessarily exhaustive review of journal articles written in English or French, we identified a list of 155 references on business failure prediction. These papers were published in the period 1966-2002 in various journals specialized in accounting, finance, operations research and decision science. Readers should be cautious in interpreting the results of this survey, since the findings are based on data collected only from journal articles. Conferences proceedings, working papers and doctoral dissertation were excluded except if they were directly and easily at our disposal.

[2] GRAYDON is one of the leading service providers in the field of Credit Management and database business information (http://www.graydon.be/).

Our approach of the methods will be twofold. First of all, we will have a chronological point of view. This kind of approach allow us to glance at the history of business failure prediction methods. Secondly, we will focus on the papers published during the last ten years (1991-2001) with a classical framework, namely Authors, Year of publication, Country, Industry type and Methods.

If we start from the second War World, the first researcher to work on business failure prediction was Beaver [1966]. Undoubtedly, he made the most contributive **Univariate** analysis of business failure. He was rapidly followed by the most famous researcher on this topic i.e. Altman [1968]. Altman performed a **Multivariate analysis** of failure by means of multiple discriminant analysis. The discriminant analysis was rapidly extended to different sectors (bank failure prediction by Meyer and Pifer [1970] or railroad bankruptcy by Altman [1971]). In spite of discriminant analysis' drawbacks, it takes about 10 years before seeing appearance of **Logit** model (Martin [1977]). Meanwhile, discriminant analysis was occasionally modified, for example the Quadratic Discriminant Analysis (Altman and Loris [1976]). Between 1968 and 1984 all applications utilised either the discriminant analysis (sometimes ameliorated) or the Logit model. Though, the beginning of '80 were marked by numerous works using **Human expert** in order to detect failure (Zimmer [1980], Casey [1980], Abdel-Khalik and El-Sheshai [1980], Casey [1983] or Houghton and Sengupta [1984]). In 1984 we see the first **Probit** models applied to corporate distress (Izan [1984] and Zmijewski [1984]). During the same year, Takahashi et al. [1984] used **Principal Component Analysis** to bankruptcy prediction.

The second part of the eighties was a true turning in bankruptcy prediction. Indeed, between 1985 and 1988 researchers leave the statistical sphere in order to enter in the **Multicriteria** era (Zopounidis [1985]) or in the **Machine Learning** world (Frydman et al. [1985]). In 1988, Elmer and Borowski [1988] used the first **Expert System** for the financial analysis of Savings & Loans bankruptcy. The first application on insurance institution was the Ambrose and Seward [1988]'s paper. 1990 was also the beginning of a new and prosperous epoch in business prediction model: the first **Neural Network** approach was born (Tam and Kiang [1990]). It was the beginning of a very long serie. Tam and Kiang [1990] were also the first to apply **K Nearest Neighbour** to failure prediction. Contrary to Neural Networks, Survival Analysis didn't know a lot of success. The only application indexed was Luoma and Laitinen [1991]. Neural Networks were not only often used in the classical way i.e. as a supervised learning algorithm but they were also used as a clustering method i.e. as an unsupervised algorithm, the **Self-Organizing Map** (SOM) (Martin-del-Brío and Serrano-Cinca [1993]). As Survival Analysis, non parametric methods like **Data Envelopment Analysis** were not often used for this kind of problem. The first one was Fernandez-Castro and Smith [1994], later followed by Pille and Paradi [2002].

Given the great number of different methods used for bankruptcy prediction, it was obvious that some researchers decide to combine different methods in order to obtain better results. The first **Hybrid** method was created by Markham and Ragsdale [1995] who mixed Discriminant Analysis and Neural Networks to solve the bankruptcy prediction problem. They were followed by Jeng et al. [1997], Gorzalczany and Piasta [1999] or Ahn et al. [2000]. The two first applications were the first ones to exploit the fuzzy set theory on the business failure prediction problem. From 1995 until nowadays, a lot of new methods were used: **Rough Sets** (Slowinski and Zopounidis [1995]), **Genetic Algorithm** (Back et al. [1996]), the **Case Based Forecasting** (Jo and Han [1996]), the **Multi-Factor Analysis** (Vermeulen et al.

[1998]), the **Fuzzy clustering** (Alam et al. [2000]), **Multiplicative hazards model** (Honjo [2000]) or **Genetic programming** (McKee and Lensberg [2002]). **New Multicriteria methods** were also finalised recently (Zopounidis and Doumpos [1998], Zopounidis and Doumpos [1999b], Doumpos et al. [2000] or Zopounidis and Doumpos [2002]) .

As we can see through this rapid and chronological overview, a lot of different methods were used starting from statistical methods (discriminant analysis, logit or probit) at the beginning to the extended use of machine learning methods (neural networks, genetic algorithms, trees,...) in the nineties.

Our chronological survey of business failure prediction methods was a good starting point but it seems obvious that emphasis should be put on more recent applications. That's why Table 2 contains a list of recent publications. In order to keep this review manageable, our analysis contain only : (a) papers published between 1991 and 2001 (included), (b) journal articles presenting an application of a method and (c) these applications should not concern too typical sectors. The second condition eliminates all the others reviews (Keasy and Watson [1991], Zopounidis and Dimitras [1993], Dimitras et al. [1996], Paquet [1997] or Guilhot [2000]) but also all papers which focus on bankruptcy prediction but without doing a true application of a particular method (Mar Molinero and Ezzamel [1991]). The third condition excluded from the analysis a lot of banking applications (Coleman et al. [1991], Tam [1991], Salchenberger et al. [1992], Tam and Kiang [1992], Martin-del-Brío and Serrano-Cinca [1993], Barr et al. [1994], Zanakis and Walter [1994], Markham and Ragsdale [1995] Tan [1996], Olmeda and Fernandez [1997], Bell [1997], Alam et al. [2000] and Etheridge et al. [2000]), few insurance applications (Barniv and McDonald [1992] and Brockett et al. [1994]) and an application about hospitals (Wertheim and Lynn [1992]). Table 2 contains 53 applications described by Author(s) and year of publication, Country, Industry type and Methods used (Appendix provides a list of abbreviations). People interested in the same kind of analysis for older applications, see Zopounidis and Dimitras [1993].

Table 2: Characteristics of bankruptcy studies

Author (year pub)	Country	Industry type	Method
Raghupathi et al. [1991]	US	Several	NN
Luoma and Laitinen [1991]	Finland	Manufacturing/ Retailing	SA, DA & LA
Laitinen [1992]	Finland	Manufacturing	Univariate & DA
Theodossiou [1993]	US	Manufacturing/ Retailing	DA & CUSUM
Coats and Fant [1993]	US	Manufacturing/ Services	NN & MDA
Fletcher and Goss [1993]	US	Industrial	NN & LA
Altman et al. [1994]	Italy	Several	NN, LDA & LA
Fanning and Cogger [1994]	US	Several	NN, LA & model-based methods
Fernandez-Castro and Smith [1994]	UK	Several	DEA
Tsukuda and Baba [1994]	Japan	Manufacturing	NN
Wilson and Sharda [1994]	US	Several	NN & DA
Cormier et al. [1994]	Canada	/	LDA, MDA, LA & Tree
Lenard et al. [1995]	US	/	NN & LA

Lacher et al. [1995]	US	Several	NN & DA
Dimitras et al. [1995]	Greece	Several industries/ Commercial	Electre tri
Boritz and Kennedy [1995]	US	/	NN, DA, LA & PA
Chen et al. [1995]	US	Several	SOM
Slowinski and Zopounidis [1995]	Greece	/	RS
Boritz et al. [1995]	US	Several	NN, LDA, QDA, NPDA, LA & PA
Ignizio and Soltys [1996]	US	/	NN & DA
Back et al. [1996]	Finland	Several	Hybrid (DA or LA or GA + NN)
Jo and Han [1996]	Korea	Several	DA, NN & CBF
Lee et al. [1996]	Korea	/	Hybrid (MDA or Tree or SOFM +NN)
Leshno and Spector [1996]	US	/	NN
Serrano-Cinca [1996]	US	/	SOFM
Rahimian et al. [1996]	US	/	NN
Bardos and Zhu [1997]	France	SME	NN, DA & LA
Bryant [1997]	US	Manufacturing/ Retailing	CBR & LA
Jeng et al. [1997]	/	/	Hybrid (Tree+Fuzzy), Tree & DA
Jo and Han [1997]	Korea	Several	NN, CBR & DA
Bardos [1998]	France	Manufacturing	DA
Bhargava et al. [1998]	CA & US	Retailing	LA
Greco et al. [1998]	Greece	Industrial/ commercial	RS
Kiviluoto [1998]	Finland	Industrial	SOM
Laitinen and Latinen [1998]	Finland	Manufacturing SME	Human Expert
McGurr and DeVaney [1998]	US	Retailing	MDA
Piramuthu et al. [1998]	Belgian	Several	Hybrid (Tree + NN)
Varetto [1998]	Italy	Several	GA & DA
Vermeulen et al. [1998]	NA[3]	NA	Multi-Factor
Zopounidis et al. [1998]	Greece	Several	DA & Electre tri
Zopounidis and Doumpos [1998]	Greece	Several	FINCLAS
Gorzalczany and Piasta [1999]	US	Manufacturing	Hybrid (NN+fuzzy), RS, Tree
Kim and McLeod [1999]	US	Several	Human expert, DA, LA, Tree, NN
Lennox [1999]	UK	Several	DA, LA & PA
Dimitras et al. [1999]	Greece	Several	RS, DA & LA
Zhang et al. [1999]	US	Manufacturing	NN & LA
Zopounidis and Doumpos [1999a]	Greece	Several	UTADIS, DA, PA & LA

[3] The use of the conditional failure prediction model in Vermeulen et al. [1998] is demonstrated with a constructed example.

Zopounidis and Doumpos [1999b]	Greece	/	UTADIS & DA
Ahn et al. [2000]	Korea	Several	Hybrid (RS+NN), NN & DA
Doumpos et al. [2000]	Greece	Several	M.H.DIS
Honjo [2000]	Japan	Manufacturing	Hazards model
Shah and Murtuza [2000]	US	Computers	SOM
Beynon and Peel [2001]	UK	Manufacturing	RS, Trees, MDA & LA

To conclude this last but one section, we have to notice that 69 applications (53 in Table 2, 13 applications on bank failure, 2 on insurance institutions and 1 on hospitals) were published between 1991 and 2001. Therefore, we can say that bankruptcy prediction was really a big problem of the last ten years. As we can also see from Table 2, failure is an international problem. 10 different countries are represented in this table. If we take into account applications published before 1991, we could also add Australia (Izan [1984]) or Israel (Tamari [1984]). If we have to dwell on a particular industry we can say that manufacturing and, of lesser importance, retailing have been a privileged field of research. As far as the methods are concerned, it is clear that Neural Networks dominate the majority of applications. At least 23 studies indexed in Table 2 utilised Neural Network. Discriminant Analysis is also often used, regularly as a benchmark for others methods.

6 Concluding remarks and further research

The goal of this paper was to provide an up-to-date review of the literature. We have also decided to spend time on the causes, the process and the remedies of failure. For us, it's of prime interest to waste some time on these topics. Indeed, we believe that a better comprehension of the causes and the process of failure can lead to a better choice of the variables used to detect the problems. We insist on the necessity to distinguish the causes (causes are often more qualitative factors) and the symptoms (which are more quantitative factors) of failure because we believe that combining a method analysing causes of failure with a method considering symptoms of failures could be an interesting topic for further research. Moreover, given that the dynamic nature of the failure process has simply been unused in failure prediction, it seems useful to go deeply into these question. As mentioned in section 3, making proposal of remedial action would be of greatest interest for firms in financial distress. Business failure prediction is one step, failure avoiding is one step further.

In Section 5, we have seen that a lot of methods were extended used for business failure prediction. Their advantages but also their drawbacks are now known. Therefore we have to think a way to take advantage of the benefits of these methods without inheriting the defaults. Some authors have already proposed the integration of different methods with others but it's authors' opinion that going further into integration and/or hybridisation of different methods will be an exciting domain of research.

Moreover, in applications we surveyed, an important aspect was often neglected: the decision maker. It is our opinion that in future development of new methods, the decision maker must be central in the process. The tool must be interactive and help the decision maker, not replace him. That's why we think that a Interactive Multidimensional Decision Support System which will integrate causes and symptoms will be of more interest.

Appendix

CBF	Case Based Forecasting	LDA	Linear Discriminant Analysis
CBR	Case Based Reasoning	MDA	Multiple Discriminant Analysis
CUSUM	Multivariate Cumulative Sum	M.H.DIS	Multi-Group Hierarchical Discrimination
DA	Discriminant Analysis	NN	Neural Networks
DEA	Data Envelopment Analysis	RS	Rough Sets
GA	Genetic Algorithm	PA	Probit Analysis
GP	Genetic Programming	QDA	Quadratic Discriminant Analysis
kNN	K Nearest Neighbour	SA	Survival Analysis
LA	Logit Analysis	SO(F)M	Self Organizing (Feature) Map

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