Bayesian Networks for Firm Performance Evaluation

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ABSTRACT: In a competitive environment a proper evaluation of the financial status and performance of a firm is an important issue. Different kind and source of information should be taken into account. Among the possible solutions, we propose to use Bayesian Networks as a quantitative management tool for firm performance evaluation. Via the use of the network we can combine accounting data with qualitative information related to industry environment, ownership, management and board composition. Bayesian Networks allow to describe the relationship between the examined variables in an immediate way, and permit to identify, in a mouse click time scenarios that could lead to financial distress.

KEYWORDS: Bayesian Networks, Financial Distress, Performance Evaluation

1 Introduction

In nowadays competitive and financial turbulent environment, the prediction of financial distress is an important and challenging issue. Financial distress could be a harbinger of firm bankruptcy. Consequently, developing an early warning method is of great importance for entrepreneurs, investors, creditors and auditors. Researchers and practitioners are putting a lot of efforts in developing early warnings models. Several different solutions have been proposed in the Literature, starting from the well known works of Beaver (1966), Altman (1968) and Altman et al. (1977). The methodologies proposed by the previous authors are easy to apply, but they are based only on financial ratios without taking into account other important type of information, i.e. governance and industrial environment.

Since distress prediction involves probabilistic reasoning under uncertainty, we propose to apply Bayesian Networks (BN hereafter). BNs are used to develop a comprehensive model incorporating information deriving from both

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governance attributes (i.e. ownership and management) and financial ratios. For an application of BN to bankruptcy prediction using balance sheet data see e.g. Aghei and Saeedi (2009) and Sun et al. (2007).

A BN, see e.g. Jensen (1996), is a tool for modeling large multivariate probability models and making inferences. It is a probabilistic graphical model that represents a set of random variables and their conditional dependencies via a Directed Acyclic Graph (DAG). The nodes of the DAG, which represent the variables under investigation, are associated with the conditional probability distributions given their parents. The use of a graph, as a pictorial representation of the problem at hand, simplifies model interpretation and facilitates communication and interaction among experts with different backgrounds. By using the DAG representation the joint distribution can be decomposed in a straightforward way in terms of the product of the conditional table of each node given its parents. BNs provide an inferential engine to make inference on the parameters and the structure of the model. Finally, they are interactive models that can be easily updated with new information.

2 Bayesian Networks for Distress Analysis

We consider a data-set of 1137 unlisted medium/large sized Italian firms observed in the period 2004-2012. Only a part of them faced some form of financial distress (“critical situation”) during the period of observation. The data have been extracted from the AIDA database, the Italian Digital Database of Companies, https://aida.bvinfo.com/. AIDA is one of the Bureau Van Dijk databases, and it constitutes the most complete and reliable source of financial information about unlisted companies. It contains detailed accounts following the scheme of the 4th EU Directive (introduced in Italy with the D.lgs. n 127/91) for up to ten years, basic information, shareholders, industrial sector and, in the case of medium-large firms, Chief Executive Officer (CEO) and board composition.

When identifying the population under study, we imposed the selection restrictions described below on industry characterisation and size. We chose operative firms with a registered company office in Italy, with legal entity of limited liability company, or joint-stock company. We restricted attention to non-financial companies to avoid the effect of financial sector regulation and peculiarities on firms’ financing decisions. We selected firms with a minimum revenue of €40,000,000 in at least one year between 2004 and 2012, and accounting data available for at least four years.

As quantitative variables we took into account, the balance sheet data and
financial accounting indicators for size, liquidity, capital structure, asset coverage, financial coverage, performance and turnover. As qualitative characteristics we considered industry, environment, ownership, management and board composition.

The population under investigation is stratified in two groups, a small set of firms under financial distress and a larger one not in distress. The first group consists of firms subject to one of the following five registered proceedings: merger, restructuring, voluntary liquidation, insolvency; composition with creditors before bankruptcy.

The network modeling the dependence structure among the examined variables has been constructed following the procedure described below:

**Step 1:** For each firm subject to a registered proceeding, the final statement referring to the year it enters the proceeding is considered. For years 2013-2014 we considered the report of 2012. For the other firms we considered the last available report.

**Step 2:** Balance sheet data have been discretised considering as cut-points reference values used for Italian firm assessment.

**Step 3:** We learnt the network structure from the data using the software Hugin (www.hugin.com). We run the PC algorithm by Spierres et al. (2000) including logical constraints, such as target variable having no outgoing arrows towards any of the other variables. In order to complete the construction of our model, we estimated the conditional distributions via the version of EM algorithm for BNs proposed by Lauritzen (1995). In this way we also took into account the presence of missing data.

The network in Figure 1 represents the structure learned from the data. The target variable in the network is “Critical Situation”, having states “0” (not in distress) “1” (in distress). Different colours are used to identify the group of variables (fuchsia for the target variable, light blue for balance sheet data, ownership characteristics in blue, and management aspects in violet). By moving through the network we can identify which are the variables that influence, directly and indirectly, our target variable (critical situation).

### 3 Concluding remarks

In this work we presented some preliminary results regarding the use of BNs as a tool for firm performance evaluation. The network can be used to easily simulate and evaluate different distress scenarios. We are currently working on the development of a dynamic version of the model.
References


