



# Detecting biotechnology industry's earnings management using Bayesian network, principal component analysis, back propagation neural network, and decision tree



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## ABSTRACT

The characteristic of long value chain, high-risk, high cost of research and development are belong to high knowledge based content in the biotech medical industry, and the reliability of biotechnology industry's financial statements and the earnings management behavior conducted by the management in their accrual manipulation have been a critical issue. In recent years, some studies have used the data mining technique to detect earnings management, with which the accuracy has therefore risen. As such, this study attempts to diagnose the detecting biotechnology industry earnings management by integrating suitable computing models, we first screened the earnings management variables with the principal component analysis (PCA) and Bayesian network (BN), followed by further constructing the integrated model with the back propagation neural network (BPN) and C5.0 (decision tree) to detect if a company's earnings were seriously manipulated. The empirical results show that combining the BN screening method with C5.0 decision tree has the best performance with an accuracy rate of 98.51%. From the rules set in the final additional testing of the study, it is also found that an enterprise's prior period discretionary accruals play an important role in affecting the serious degree of accrual earnings management.

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## 1. Introduction

Nowadays biotechnology is not only a burgeoning industry but also a newest target of investors in the universe. More and more people tend to rely on biotechnology for extending life expectancy or maintaining youth; the potential of the biotechnology industry has greatly improved. Biotechnology industry is characterized of a complicated system, a long value chain, specialized divisions of labor, and a prolonged timeline of product development. The biotechnology company's performance is more difficult to accurately evaluate from traditional financial reports (Kessel and Frank, 2007). Earnings are commonly deemed to be the status of an enterprise's past business performance. Given the fact that the stakeholders of an enterprise (usually including investors, creditors, analysts and customers) cannot be directly aware of the enterprise's operating performance, most of them regard corporate earnings as an important index. As a result, earnings management has turned out to be the major impetus for the management.

Nevertheless, if earnings management becomes a norm, financial statement users are very likely to have bias in their judgment on financial statements, which could further lead them to make wrong decisions. Earnings management refers to some method or procedure used by the management in order to have accounting earnings to attain expected goals (Doyle et al., 2013). As such, Schipper (1989) defined earnings management to be the process where the management forcefully intervenes the preparation of financial statements based on economic consideration and motive, and the right conferred by the generally accepted accounting principle to achieve the earnings goal within a lawful range. On the other hand, Healy and Wahlen (1999) considered earnings management to be the management's attempt to affect the content of financial statements with their power, so as to further mislead stakeholders in their understanding of the actual corporate operating performance. In other words, earnings management could be either legal or illegal. The earnings management beyond a certain boundary could possibly turn out to be the management's corruption.

As pointed out by Watts and Zimmerman, the bonus plan hypothesis (Watts and Zimmerman, 1990) is the impetus for management personnel to conduct earnings management, in which the company implementing the bonus plan by using the employee bonus mechanism based on accounting earnings as the bonus basis may lead to moral risk. The reason for it is that the reward of the management is related to net income, i.e.,

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with the motive of self-interest, the management may increase the earnings reported in the current period through their accounting policy selection. Healy (1985) indicated that, if a company's earnings level is too low in the current year and the level cannot be elevated through any kind of manipulation, the management may bring forward the future incidents unfavorable for earnings to the current year. In so doing, the earnings in the future could substantially increase, which is the so-called "big bath" theory. According to Healy and Wahlen (1999), the earnings management motives come in capital market motive, contract motive and law and regulation motive. Also, in most cases, earnings manipulation is generally made from selection of the accounting method, accrual management and control of the time of transaction occurrence.

In the past, most earnings management related studies explored the correlation of earnings management with other items. For instance, Schipper (1989) pointed out that a lack of sufficient communication and information asymmetry could result in earnings management, and that is the correlation between earnings management and information transparency, or the studies which explore the correlation between earnings management and auditing quality (Cohen et al., 2008) and the correlation between earnings quality and corporate social responsibilities (Pyo and Lee, 2013). Currently, fewer studies have been conducted for detection of earnings management level. In the past, Jones Model (Jones, 1991), Modified Jones Model (Dechow et al., 1995) and Kothari et al. Model (Kotharia et al., 2005) have commonly been used as the models to evaluate if an enterprise conducts earnings management. Only very few studies have been conducted to detect earnings management levels, and most of the studies have adopted conventional statistical methods, such as regression, univariate statistical methods, multiple discriminant analysis (MDA), and logit and probit analyses in investigation. These conventional statistical methods, however, have some restrictive assumptions such as linearity, normality, and independence of predictor or input variables. Considering that the violation of these assumptions occurs frequently within financial data, the methods have intrinsic limitations in terms of effectiveness and validity. According to Höglund (2012), the earnings management model is actually not a linear model. Hence, the study has adopted the data mining method to detect earnings management.

Data mining is a process to transform data into knowledge, which is one of the most active ways in research, development and application in the field of data processing. As implied by its name, data mining is to find implied, regular and potentially useful information and knowledge which can be finally comprehensive from the massive, incomplete and fuzzy information (Gupta and Modise, 2012). In other words, data mining may present some kind of models left in the remaining data, in which the models can be collected together and defined to be a data mining model. The advantage to exploring earnings management with the data mining method is to set up a non-linear model which does not require hypotheses as what is required by the conventional method (Höglund, 2012).

Recently, back propagation neural network have been extensively used in finance (Wang et al., 2011). Using the concepts, the original data are first decomposed into multiple layers by the wavelet transform. Each layer has a low-frequency and a high-frequency signal component. Then a back propagation (BP) neural network model is established by the low-frequency signal of each layer for predicting the future value. Recently, it has been found that its applications in a wide variety of fields include forecasting economic growth (Feng and Zhang, 2014), stock market prediction (Zhang and Wu, 2009) and stock index (Wang et al., 2011). Moreover the non-parametric prediction method known as decision tree (DT) has been used in an attempt to bypass the above mentioned assumptions in MDA and logit (Kim and Upneja, 2014).

DT models for earnings management prediction are set up based on the following advantages. First, a DT does not require any statistical assumptions concerning the data in a training sample. Second, a DT model can handle incomplete and qualitative data. Third, a DT is useful for exploring data to find the relationship between a large number of candidate input variables and the target variable. Finally, the DT model

provides a meaningful way of representing acquired knowledge and is easily understood because it yields human comprehensible binary 'if-then' rules (Kim and Upneja, 2014; Hajaizadeh et al., 2010).

In order to help corporate stakeholders, such as investors, creditors, analysts, and customers better understand the degree of biotechnology industry's accrual earnings management, avoid them to suffer a great loss in the stock market as a result of manager's earnings management, offer auditors a new method to probe earnings management and understand how an enterprise manipulates its earnings management, it is necessary to develop a model which is able to predict the level of earnings management. Therefore, we attempt to investigate the effectiveness of back propagation neural network (BPN) and DT approach in conducting the earnings management prediction tasks and to predict the characteristics of earnings management, so decision-makers can understand the rules of earnings management. Regarding the above purpose, this paper proposes a novel hybrid model for earnings management prediction by integrating the Bayesian network (BN), principal component analysis (PCA), BPN and DT techniques. BN and PCA methods are used for variable selection in order to obtain the significant independent variables, while BPN and DT are used to generate meaningful rules for earnings management. In order to evaluate the performance of the proposed framework, comparative experiments are conducted other than considering Type I and Type II errors.

## 2. Literature review

Following the years of development, earnings management has been classified into the three categories of accrual earnings management put forth by Schipper (1989), real earnings management (Cohen and Zarowin, 2010) and classification shifting proposed by McVay (2006). The accrual earnings management is that, without violating the generally accepted accounting principle (GAAP), the manager can use discretionary accruals to freely give decision. In this way, the management may be flexible in doing their earnings management. It, however, will affect the figures shown on financial statements. According to Roychowdhury (2006), real earnings management is the way to help a company break away from the normal financial statement operation rule. Its purpose is to have a company's shareholders consider the achievement of the earnings goal through price discount, increase of sales income by providing a longer credit period or cut-down of the sales cost by mass production or reduction of discretionary expenses.

The disadvantage of real earnings management is that earlier execution is required and an enterprise's real value and real economic activities will be affected. Classification change refers to financial statements' vertical moves, with which the errors are classified according to how investors value an accounting title, so as to elevate an enterprise's valuation and further mislead financial statement users' judgment. Since the figures shown on financial statements are not affected, and classification per se is a subjective matter, it is not likely to raise any doubts from auditing personnel. Given that accrual earnings management can be determined by the management within the range allowed by the GAAP, it can be flexibly adjusted and easily implemented. Furthermore, most prior studies were conducted to explore accrual earnings management (Schipper, 1989; Healy and Wahlen, 1999; Healy, 1985; Jones, 1991; Dechow et al., 1995, 2012; Kotharia et al., 2005; Höglund, 2012), so the study has been conducted to mainly explore detection of accrual earnings management.

### 2.1. Accrual earnings management

Dechow et al. (2012) considered accrual earnings management to have the reversal characteristic and not to involve real economic activities. The accounting accruals are divided into discretionary accruals and non-discretionary accruals. With discretionary accruals, managers may freely give decision while not violating the GAAP, e.g., set aside the bad debt ratio for account receivables. On the other hand, non-discretionary accruals are mainly related to an enterprise's normal business activities.

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