A NEURAL FUZZY SYSTEM APPROACH TO ASSESSING THE RISK OF EARNINGS RESTATEMENTS

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ABSTRACT

Recent high-profiled accounting scandals (e.g., Enron and WorldCom) have called into question the quality of financial reporting in the U.S. These accounting scandals have resulted in massive restatements of corporate earnings and market value losses to investors. While earnings restatements have become more prevalent and costly in recent years, detection or prediction of earnings restatement has been badly lagging. Several recent studies have evaluated the usefulness of various computer technologies such as fuzzy logic and neural networks in business and industrial applications. The purpose of this paper is to evaluate the utility of an integrated neural fuzzy system (NFS) in assessing the risk of earning restatements. The integrated NFS outperforms a baseline Logit model, especially in the prediction of restatement cases.

Keywords: earnings restatement or management, neural networks, fuzzy logic, decision support systems, and data mining.

INTRODUCTION

High-quality financial reporting has been considered a cornerstone of the U.S. capital markets. Because of the financial reporting quality, most observers agree that the U.S. capital markets are one of the most efficient in the world. However, recent accounting scandals involving “earnings management” have called into question the quality of financial reporting in the U.S. In fact, an increasing number of firms have engaged in “management” of their earnings, which subsequently have to be restated to comply with the generally accepted accounting principles. Restatements of earnings suggest the breakdown of internal controls as well as governmental or other external regulations over the corporate financial reporting processes. These restatement cases have resulted in market value losses to investors in the tens of billions of dollars (18). It is, therefore, not surprising that companies often face rash of suits after revelation of earnings restatements. These accounting scandals have also put the role of independent auditors in ensuring the quality of corporate earnings under considerable scrutiny. Since independent auditors are responsible for detecting material misstatements in their client’s financial statements, regardless of whether the misstatements are caused by error or fraud, the Securities and Exchange Commission (SEC) regards earnings restatements to be audit failures (22). Such audit failures can result in damages to the auditor’s reputation and substantial financial losses due to investor litigations and/or SEC enforcement actions against the auditor. Clearly, all interested parties (including users, corporate management, and auditors) in corporate financial reporting need better tools to help them more effectively and efficiently assess the risk of earnings management.
Several recent studies have examined the feasibility of hybrid intelligent systems in business and industrial applications. Li (13) developed a hybrid system for developing marketing strategies. Combining the strengths of expert systems, fuzzy logic and neural networks, this system supports the process of marketing strategy development and analysis. Vukadinovic, Teodorovic, and Pavkovic (23) applied neurofuzzy modeling to the vehicle assignment problem. They developed a fuzzy system based on rules obtained from the dispatcher. The system was then refined via supervised learning to achieve a better performance. Li, Ang, and Gray (14) developed an intelligent business forecaster for strategic planning. This is a multi-layered fuzzy rule-based neural network that integrated a fuzzy logic inference into a neural network structure. The system was shown to achieve better learning speed and forecasting accuracy than two commercial products. Kuo and Xue (12) developed an FNN for sales forecasting. A Fuzzy Neural Network (FNN) was developed first to learn fuzzy rules obtained from marketing experts. The result from the FNN was then integrated with the forecast from Artificial Neural Network (ANN). The hybrid system outperformed both conventional statistical methods and a single ANN. The purpose of this study is to evaluate the utility of an integrated NFS in a new domain: assessing the risk of earnings restatements.

**RESEARCH METHODOLOGY**

**Sample Selection**

The initial sample firms consist of 267 publicly-held corporations that restated their reported earnings for the fiscal year 2000 and are identified by using keyword searches of Lexis-Nexis on the words "income or earnings restatement" and their variations. These firms are then screened for availability of requisite financial statement data on Research Insight (i.e., Compustat for Windows) and data on fees paid to external auditors disclosed in proxy statements. The restatement sample includes 117 firms, after deleting 106 firms due to incomplete financial data and 44 firms due to missing auditor fee data. We match each restatement sample firm with two non-restatement firms based on industry classification and firm size. All control sample firms are screened for earnings restatement (or a lack of). This results in a final sample of 351 firms. The one-to-two match approach better reflects the proportion of restatement firms relative to non-restatement firms in practice than the one-to-one match typically used in prior prediction studies. Fiscal year 2000 is the focus of this study because it is the first year that publicly-held companies are required by the SEC to disclose annual fees paid to external auditors for audit and non-audit services. This presents a first opportunity that allows the examination of the association between non-audit fees (and audit fees) and quality of reported earnings. Restatements of earnings for fiscal year 2001 and thereafter are excluded because there is a considerable time lag between original reporting and subsequent restatement of earnings for the same fiscal year. This sample screening criterion provides reasonable assurance that no control firm restated its earnings for fiscal year 2000.

**Selection of Variables**

Currently, there are no formal theoretical guidelines for selecting variables to assess the risk of materially misstated earnings due to earnings management. The following variables are selected based on a review of practice and empirical literature in auditing. All of these variables are
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based on data publicly available for a wide audience of researchers. They are related to audit quality, financial and market characteristics of the sample companies.

Prior studies contend that higher fees paid to auditors increase economic bond and thus impair auditor independence (e.g., 2; 8). The impaired independence results in poor audit quality and allows for greater earnings management (resulting in lower earnings quality). This study uses auditor fees disclosed in proxy statements to develop three alternative measures of the auditor fee variable as used in prior studies (8; 11; 20): log of total fees paid to auditors, log of respective fees for audit and non-audit services, and the ratio of non-audit fees to total fees.

In addition to the auditor fee variable, this study includes two more variables as proxies for audit quality. Prior studies suggest that Big-5 auditors are less likely to allow earnings management than non-Big-5 auditors (e.g., 4; 7). Another variable is auditor tenure, measured in the number of years the same auditor has audited the client’s financial statements. Prior research suggests that auditor independence decreases as the length of auditor tenure increases (3; 15). On the other hand, others claim that as auditor tenure increases, the auditor is better at assessing risk of material misstatements by gaining insights into the client’s operations and business strategies (e.g., 1).

This study also includes several variables based on a firm’s financial and market characteristics commonly used in prior research that may influence management’s incentives to manage or manipulate reported earnings. Several measures of firm performance are reported to be correlated with earning management (or earnings quality) in prior studies (e.g., 6; 8; 19): cash flows from operations deflated by average total assets, the absolute value of cash flows from operations deflated by average total assets, total accruals deflated by average total assets, the absolute value of total accruals deflated by average total assets, annual stock returns, and an indicator variable equal to 1 if the firm reports a loss for fiscal year 2000, and equal to 0, otherwise. In addition, Matsumoto (17) suggests that firms with higher growth prospects are more likely to manage earnings. Growth prospects are measured by the market-to-book value ratio. This study also includes leverage, measured as the ratio of total liabilities to total assets, and a financing indicator variable equal to 1 if the firm issued equity or debt securities during 2000, and equal to 0, otherwise. Prior studies find leverage and need for external financing are related to earning management (3; 5). Finally, this study controls for firm size measured as the natural log transformation of market value of equity.

A Fuzzy Model Based on Fuzzy Clustering

NFSs are a class of hybrid intelligent systems that integrate fuzzy logic with ANNs. Fuzzy logic is a logical system used to operate on fuzzy sets. Fuzzy logic has the key advantage of being able to describe the desired system behavior with simple heuristics or IF-THEN rules. However, such rules are difficult to identify by manual inspection and therefore are usually derived from observed data using techniques known collectively as fuzzy clustering. The purpose of fuzzy clustering is to identify the number of clusters that exist in a given data set. Similar to traditional clustering procedures, a user can specify the expected number of clusters or let the system "find" the likely number of clusters from input data.
In this study, we use the GENFIS2 function of the Fuzzy Logic Toolbox (9). This function can extract a set of rules by clustering data to generate an initial fuzzy model that describes the data behavior. The general format of the GENFIS2 function is:

\[
Fismat = \text{genfis2} (\text{Xin}, \text{Xout}, \text{radius}),
\]

where \(Fismat\) is the fuzzy model estimation, \(\text{Xin}\) is the input data set (i.e., financial ratios), \(\text{Xout}\) is the output data set (earning restatement prediction), and \(\text{radius}\) specifies a cluster center’s range of influence on each variable. A large radius results in fewer rules and clusters, whereas a small radius results in more rules and clusters.

Since, ideally, the data should form two clusters (i.e., restatement and non-restatement groups), a large weight is used for the GENFIS2 function. The resulting fuzzy model includes two membership functions for each input variable. The fuzzy model also includes two fuzzy rules that take the following form:

\[
\text{if } x \text{ is in } A \text{ and } y \text{ is in } B \text{ then } z = p*x + q*y + r,
\]

where \(A\) and \(B\) are fuzzy sets (of input variables); \(p\), \(q\), and \(r\) are constants estimated by the model; and \(z\) is the output variable; i.e., restatement prediction. The consequent of the rules is a linear function rather than a fuzzy set. A fuzzy model that has this type of fuzzy rules is known as a Sugeno fuzzy model (21), which is easier to work with than the other type, the Mamdani fuzzy model (16), because the output is a crisp number that needs not be defuzzified.

**Improving the Fuzzy Model with Adaptive Learning**

The fuzzy model developed from the first step was then improved through an iterative adaptive learning process. The training algorithm was developed by Jang (10) and is referred to as the ANFIS or Adaptive Neuro-Fuzzy Inference System. Basically, ANFIS takes a fuzzy model and tunes it by means of a backpropagation algorithm. During each epoch, an error measure, usually defined as the sum of the squared difference between actual and desired output, is reduced. Training stops when either the predefined epoch number or error rate is obtained.

The ANFIS technique is implemented in Fuzzy Logic Toolbox as a function with the following format:

\[
\text{Fismat1}, \text{TrnErr}, \text{StepSize}, \text{Fismat2}, \text{ChkErr} = \text{Anfis} (\text{TrnData}, \text{Fismat}, \text{ChkData})
\]

where \(\text{Fismat}\) is the fuzzy model to be trained, \(\text{TrnData}\) is the training data set and \(\text{ChkData}\) is the test data set. \(\text{Fismat1}\) is the resulting fuzzy model that records the minimum training error and \(\text{Fismat2}\) is the resulting fuzzy model that records the minimum test error. As the number of epochs increases, both the training and test errors are reduced. At 200 epochs, the training and test errors are both 0.32 for model 1, 0.33 for model 2, and 0.19 for model 3. Further training does not reduce either the training or test error. Thus, it is concluded that the optimal performance of this system was achieved. \(\text{Fismat2}\) is then used to compute predictions. The results are compared with a common statistical procedure, Logit, in the next section.
EMPIRICAL RESULTS

The first logit model (measuring auditor fee variable by total auditor fees) correctly classifies 215 of the 234 non-restatement cases, achieving an impressive hit ratio (accuracy rate) of 91.9%. The first logit model, however, correctly classifies only 29 of the 117 restatement cases, resulting in a hit ratio of 24.8%. The overall (combined) prediction accuracy is at 69.5%. Similarly, the second logit model (using respective fees for audit and non-audit services for auditor fee variable) achieves a hit ratio of 93.2% in predicting non-restatement cases (correctly classifying 218 out of 234 cases), a hit ratio of 29.9% in predicting restatement cases (correctly classifying 35 of 117 cases), and a combined hit ratio of 72.1%. The third logit model (using auditor fee ratio measured as non-audit service fee relative to total fees paid to the auditor) achieves a hit ratio of 93.6% in predicting non-restatement cases (correctly classifying 219 out of 234 cases), a hit ratio of 12.0% in predicting restatement cases (correctly classifying 14 of 117 cases), and a combined hit ratio of 66.4%. Overall, the logit models are quite successful in predicting non-restatement cases but they have a very limited ability in predicting restatement cases.

The first NFS model (using total auditor fee variable) correctly classifies 217 of the 234 non-restatement cases, achieving a hit ratio of 92.7% and it correctly predicts 80 of the 117 restatement cases, resulting in a hit ratio of 68.3%. The combined prediction accuracy is 84.6%. These accuracy rates compare very favorably with the first logit model, especially in the prediction of restatement cases. The results for the second NFS model (using respective fees for audit and non-audit services) are comparable to those for the first NFS model. It achieves an accuracy rate of 94.0% in predicting non-restatement cases (correctly classifying 220 of the 234 cases), an accuracy rate of 67.5% in predicting restatement cases (accurately classifying 79 of the 117 cases), and a combined accuracy rate of 85.2%. The third NFS model (using auditor fee ratio) is equally successful in predicting non-restatement cases as are the first two NFS models (with an accuracy rate of 98.3% as compared to 92.7% and 94.0%), but it performs significantly better in predicting restatement cases than do the first two NFS models (with an accuracy rate of 94.9% as compared to 68.3% and 67.5%).

Overall, using the same data set, both the logit and NFS models are very successful in classifying non-restatement cases. In contrast, for the restatement cases, the NFS models achieve significantly higher accuracy rates than do their corresponding logit models, especially for the third model when auditor independence (audit quality) is measured by the ratio of non-audit service fee to the total fees paid to the auditor. These results suggest that the prediction of earnings restatements could benefit from an integration of fuzzy logic and neural network technologies.

SUMMARY AND CONCLUSIONS

The purpose of this study is to develop an integrated NFS to assess the risk of earnings management that results in subsequent restatement of reported earnings. The performance of NFS models is also compared with that of baseline logit models. Using a matched sample of restatement and non-restatement firms, both types of models are found to have a significant predictive ability in classifying non-restatement cases. However, more importantly, the NFS models achieve significantly higher accuracy in predicting restatement cases than do their
counterpart logit models. That is, the NFS approach is better at alerting users of corporate financial reports when it is necessary to conduct additional financial analyses to assess the risk of earnings management that may lead to restatement of reported earnings. Overall, our results suggest that an NFS model (or one developed using a similar procedure), along with traditional statistical techniques, can improve the usefulness of analytical financial analyses. Such combined approaches offer great potential for improving decision making of users of corporate financial reports. Management Information System researchers are encouraged to extend this line of research to further develop intelligent support systems and apply them to new domains.

REFERENCES