Chapter 57
Using Receiver Operating Characteristic (ROC) Analysis to Evaluate Information-Based Decision-Making

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ABSTRACT

Business operators and stakeholders often need to make decisions such as choosing between A and B, or between yes and no, and these decisions are often made by using a classification tool or a set of decision rules. Decision tools usually include scoring systems, predictive models, and quantitative test modalities. In this chapter, the authors introduce the receiver operating characteristic (ROC) curves and demonstrate, through an example of bank decision on granting loans to customers, how ROC curves can be used to evaluate decision making for information-based decision making. In addition, an extension to time-dependent ROC analysis is introduced in this chapter. The authors conclude this chapter by illustrating the application of ROC analysis in information-based decision making and providing the future trends of this topic.

INTRODUCTION

Business operators and stakeholders often need to make decisions such as choosing between A and B, or between yes and no. These decisions include, but are not limited to, whether to invest in project A versus project B, or whether to continue running a company. These are often made by using a classification tool or a set of decision rules. For example, banks often use credit scoring systems to classify lending companies or individuals into a high or low risk of default, thus helping to decide whether to grant a loan. One important question businesses need to answer is how accurate the information based on these classification tools can help them make a correct decision, or how correctly they can be used to discriminate between two groups of subjects. In this chapter, we address this important issue by pre-

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senting accuracy parameters for assessing classification tools such as test modalities, scoring systems, and prediction models. Specifically, we introduce the receiver operating characteristics (ROC) curve as a statistical tool to evaluate these modalities. The ROC curve is widely used in business optimization analysis, health policy making, clinical studies, and health economics (Kampfrath & Levinson, 2013). In the Background section, we give updated examples of using the ROC related methods for assessing decision-makings based on our most current literature review. In the Main Focus section of this chapter, we provide mathematical definitions of the classification accuracy parameters, and describe the procedure to obtain an ROC curve. In addition, we present recent statistical developments in ROC curve methodologies and applications of ROC analysis in a diversity of research areas.

BACKGROUND

Business classification tools include scoring systems, predictive models, and quantitative test modalities. A classification tool is useful in business analytics only if it is shown to distinguish entities with a certain condition from those without that condition. For instance, a credit scoring system is a valuable classification tool for bankers when it can accurately classify between companies with default status (cases) and without default status (controls). A perfect test modality would categorize all default companies as cases and all non-default companies as controls. However, in practice, almost none of the testing modalities can make such a perfect classification. This implies that misclassifications can always exist and the correct classification rate may vary from one test to another. Thus, assessing classification performance among different test modalities is always a necessary step in making important business-related decisions.

MAIN FOCUS

We first define accuracy parameters of binary classification tools, and then extend the evaluation method to test modalities with continuous or discrete ordinal values. By applying accuracy parameters and ROC analysis, business analysts can easily examine the expected downstream harms and benefits of positive and negative test results based on these test modalities, and directly link the classification accuracy to important decision making (Cornell, Mulrow & Localio, 2008).

Accuracy Parameters for Classification and Decision Making

The accuracy of decision making should be measured by comparing the decision taken by a business to the choice that would be taken in order to maximize its benefit. In this section, we introduce two basic accuracy parameters, sensitivity and specificity, and two misclassification measures, the false positive rate and false negative rate. We define accuracy parameters in the context of classifying the default status of borrowers (companies that apply for a loan). Let S denote the dichotomous true default status such that $S = 0$ represents “no default,” and $S = 1$ indicates “default.” Let Y be the value of a test modality or scoring system. We suppose that Y is also binary such that $Y = 1$ denotes the test positive for default, and $Y = 0$ indicates the test negative. In reality, companies with a positive test result are often refused for a