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On the performance of the tick test

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ABSTRACT

In financial research, the sign of a trade (or identity of trade aggressor) is not always available in the transaction dataset and it can be estimated using a simple set of rules called the tick test. In this paper we investigate the accuracy of the tick test from an analytical perspective by providing a closed formula for the performance of the prediction algorithm. By analyzing the derived equation, we provide formal arguments for the use of the tick test by proving that it is bounded to perform better than chance (50/50) and that the set of rules from the tick test provides an unbiased estimator of the trade signs. On the empirical side of the research, we compare the values from the analytical formula against the empirical performance of the tick test for fifteen heavily traded stocks in the Brazilian equity market. The results show that the formula is quite realistic in assessing the accuracy of the prediction algorithm in a real data situation.

1. Introduction

In the financial literature, the sign of a trade is important since it provides information on who in the trading process is the aggressor – that is, which side initiated the trade, the buyer or the seller. In other words, it gives information on who is the party demanding liquidity and who is the party offering it. Since liquidity is not free, the aggressor of a trade will pay for it in the form of a portion of the spread. The instant demand for liquidity has implications for microstructure theories. For instance, the proportion of buys and sells has an impact on the construction of a measure of the probability of informed trading (PIN)[1] and signed volume, which is typically used in the estimation of price impact models.[2]

The tick test is a simple algorithm which can be used to infer the sign of a trade when no quote data are available. While the origins of this method are still not clear, it was made popular in the work of Lee and Ready (1991). According to the authors, its simple implementation and the fact that quote data are sometimes hard to obtain attracted the academic community, market regulators and traders to use it for inferring the trade direction from a sample of traded prices.

The research in the present paper is directly related to the predictive power of the tick test. Many previous studies have investigated the empirical performance of the algorithm, but none have understood it as a simple stochastic problem. In this paper, we take an analytical approach in this matter. Based on a microstructure model, a closed form solution for the performance of the algorithm is derived.

The paper makes several contributions to the literature. First, it is the only study to analyze the tick test as a stochastic problem and to show that its performance (number of correct predictions) can be represented as a simple mathematical formula. As far as we are aware, we are also the first to provide formal arguments on the use of the tick test by showing that it is bound to perform better than chance (50% correct predictions) and that the set of rules underlying the algorithm provides a unbiased estimator of the trade signs. Second, we show that imposing a restriction in the underlying microstructure model allows the derivation of a simpler formula that can be used in the absence of quote data. This contributes to the literature (see Boehmer, Grammig, & Theissen, 2006; Tanggaard, 2003) which points out the consequences of the misclassification of trade signs with respect to the construction of variables commonly used in microstructure research. The formula derived in the paper can be directly applied for the analysis of the resulting bias in the case of the tick test.

The remainder of the paper is organized as follows. First, we present a brief literature review on the subject of the tick test. In the second part of the paper, we develop the theory and show the formula derived for the performance of the algorithm. This is followed by an empirical examination of the accuracy of the analytical formula for trading data in the Brazilian equity market. The paper finishes with the usual concluding remarks.

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[1] See De Jong and Rindi (2009) for details.
[2] See Hasbrouck (1991) and Hasbrouck (2007).

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2. Related literature

The use of the tick test and other types of trade inference algorithms in financial research is popular in the academic literature. Just to cite a few, Lee (1993), Chordia, Roll, and Subrahmanyam (2008), Chordia, Roll, and Subrahmanyam (2005), and Chakravarty (2001), among many others, have used these methods to assess the sign of trades in their research.

The performance of the tick test algorithm (hereafter referred to as TT) has been extensively tested using empirical data, generally with good results. Lee and Ready (1991) conclude that the price-based algorithm presented "remarkably accurate" performance when classifying a sample of trades from the NYSE market. They also highlight an issue with the time stamps from the quotes and introduce an alternative methodology for predicting the sign of a trade, which is commonly known as the Lee and Ready algorithm (hereafter referenced as LR). This paper is a seminal work in the literature as it was the first to formally study the inference of trade direction based on incomplete data.

A subsequent paper on the topic is by Aitken and Frino (1996). Using data for the Australian stock market, the authors find that the tick test produces approximately 74% correct predictions for the sign of a trade. The study also points out that periods with high volatility have a tendency to reduce the performance of the prediction algorithm. Following this study, we have the work of Theissen (2000). Using data on the Frankfurt Stock Exchange, he finds that the accuracy of both algorithms (LR and TT) is comparable. The LR method produces 72.8% correct classifications while the tick test achieves 72.2% correct classification. He also shows the impact of the mis-classification of trades with respect to the estimation of the effective spread and the PIN.[3]

Further analysis of the empirical performance of the tick test is available in Ellis, Michaely, and O'Hara (2000). The authors study the performance of distinct trade classification algorithms, including the quote rule, the LR rule and the tick test, for the NASDAQ market. This study also reports a positive performance of the trade inference algorithms for the sample data, which corroborates the results of Theissen (2000). Further analysis undertaken in this paper also suggests that the performance of the classification rules decreases for large trades and also for periods of rapid trading (a small time interval between previous trades and quotes).

A more detailed analysis on the performance of the different trade sign forecasting methods is provided in Finucane (2000). This study shows that trade size, spread and frequency of trades and quotes all affect the accuracy of prediction algorithms such as the LR rule and the tick test. The authors also report that, on average, the tick rule and the LR approach give very similar performance. Notice that the work of Finucane (2000) already shows some of the findings presented in this paper, specifically that the spread will contribute in a positive way to the performance of the tick test (i.e., the higher the spread, the higher the accuracy of this particular method of prediction of the sign of a trade). However, we take the analysis a stage further and consider a wider range of variables.

In the same vein of the empirical analysis of trade inference algorithms, we have the work of Asquith, Oman, and Safaya (2008). This paper argues that the Lee and Ready algorithm is most likely to fail when short sales are classified. The authors point out that short sales constitute a significant portion of the trading data for the US market, meaning that the estimates calculated based on the LR algorithm are very likely to have a significant bias.[4]

In a recent work, Rosenthal (2012) discusses an econometric based approach for trade sign prediction. The author of this study provides a statistical framework for improving the prediction of trade signs by allowing a flexible logit model to take into account the explanatory power of different metrics. The study reports an average increase of 1–2% in the prediction performance when comparing to other methods.

While many studies have investigated the empirical performance of the different trade inference algorithms, another interesting focus of research in this particular area of market microstructure theory is the bias resulting from the use of estimated trade signs for the construction of different variables. This bias is a natural consequence of the fact that the estimated trade signs have a degree of uncertainty, meaning that the predicted signs of trades are subject to errors (e.g., a buy misclassified as a sell). One of the studies on this topic is Boehmer et al. (2006), which shows that estimates of the PIN variable are downward biased in the presence of inaccurate classifications of trade signals. We also have the study of Tanggaard (2003). In this paper, the author investigates the bias that trade classification errors can spur in the regression-type models typically used in market microstructure research. The author argues that this bias is probably even worse than the literature suggests, posing the question as to whether previous empirical results based on trade sign inference should be taken seriously.

The present paper extends some of this previous research by providing a simple way to assess the performance of the tick test. For example, Boehmer et al. (2006) and Tanggaard (2003) present a formal analysis on the bias from using trade inference methods in the construction of variables by using a measure for the probability of an incorrect inference for a trading sign. While the authors assume in their analysis that such a probability is given, the present paper can provide an easy way to estimate it from empirical data, at least for the case of the tick test.

Some of the empirical results already in the literature corroborate the findings in this study. As we will show later, two parameters that define the performance of the tick test are the spread and the volatility of price innovations. In the work of Aitken and Frino (1996), it is found that an increase in market volatility will reduce the performance of the trade inference algorithms. This is similar to the findings of Ellis et al. (2000), but the authors explicitly test for a relationship between trading frequency (which is related to the arrival of news and volatility) and the performance of the tick test.

Our contribution to the literature lies in looking into the tick test algorithm from an analytical point of view. Besides showing the properties of the performance of this algorithm, we also point out that the derived formula, under certain restrictions, can be used even in the absence of quote data. With the use of the formula we provide, a researcher will be able to assess the implied performance of the tick test based only on the variance and autocovariance of trade price differences. In the next section, we present formal derivations of the results presented in this research.

3. The performance of the tick test

3.1. A microstructure model of trading

Consider a microstructure model comprising of the following set of equations:

$$m_t = m_{t-1} + \Gamma_t \epsilon_t \tag{1}$$

$$P_t = m_t + b_t \frac{S}{2} \tag{2}$$

[3] The calculation of the PIN measure was introduced by Easley, Kiefer, O'Hara, and Paperman (1996).

[4] See also Odders-White (2000) and Peterson and Sirri (2003).