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How does electronic trading affect efficiency of stock market and conditional volatility? Evidence from Toronto Stock Exchange☆

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A B S T R A C T

The present paper investigates informational efficiency and changes in conditional volatility of the TSX before and after the implementation of an automated trading system on April 23, 1997. Using a battery of unit root, stationarity, as well as linear tests, we find that the introduction of electronic trading led to an increase in linearity dependence in TSX daily returns. In addition, when we examined the nonlinearity dependences using powerful econometric tests, we find that electronic trading has increased nonlinear dependencies in return series, which is the main cause of rejecting the Random Walk Hypothesis (RWH). Our results suggest that the automated trading system has negatively affected informational efficiency of the TSX. We also find evidence of long memory following automation which suggests that the introduction of electronic trading has increased the level of persistence of information and trading shocks.

1. Introduction

Operating in increasingly competitive global environments, stock markets have undergone several major changes in their market-microstructures aimed at enhancing trade transparency and efficiency. This race for higher market quality was fuelled by the spectacular advances in information technology over the last few decades. One of the major features of this worldwide stock-market restructuring is the replacement of floor trading systems by electronic trading systems. The implementation of electronic trading by major stock market exchanges has generated great debate among both practitioners and academicians on the advantages and disadvantages of adopting such systems. Opponents of electronic trading argue that it leads to lower market liquidity and increases transaction cost (see, for instance, Grossman and Miller, 1986; Miller, 1991). Advocates of electronic trading systems argue that it leads to lower bid-ask spread and higher volume transactions than floor trading systems (Blennerhassett and Bowman, 1998; Frino et al., 1998, among others).

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The present paper aims to investigate informational efficiency and changes in conditional volatility of the Toronto Stock Exchange (TSX) before and after the implementation of an automated trading system. Created on October 25, 1861, the TSX has gradually shifted its trading system from floor to automated trading system. In 1977 the TSX introduced the world's first computer-assisted trading system (CATS) to quote less liquid equities, but continued to use a floor trading system until April 23, 1997 when it became the second-largest fully automated stock exchange in North America, after the NYSE.

Several factors argue for such study. First, to the best of our knowledge, this study is the first to examine simultaneously the information efficiency and conditional volatility of the TSX before and after April 23, 1997. Previous studies focuses on the information efficiency of the TSX without taking into consideration the effect of the implementation of an automated trading system. For example, Alexeev and Tapon (2011) test the weak form efficiency using all security traded on Toronto Stock Exchange from 1980 to 2010. Although, they do not focus on the sample period prior and post implementation of the electronic trading system, they fail to reject the null hypothesis of weak form efficiency on the TSX. Second, most of the analyses are based on U.S. data, and Canadian studies are almost nonexistent (Domowitz, 1990, 1993; Beelders and Massey, 2002; Fung et al., 2005; Alexeev and Tapon, 2011). Finally, we examine trends in the daily returns series based on serial correlation and nonlinear dynamics before and after automation.

The importance of examining nonlinear dynamics in financial time series is better appreciated through its implications for the field of finance at the theoretical and empirical levels. Indeed, Evidence of nonlinear dependence has very important implications for academicians and for practitioners. For academicians, the existence of nonlinearity in financial series casts serious doubt on the adequacy of statistical models of asset pricing that implicitly take a linear form, as well as empirical tests of the weak-form market efficiency, tests of causality, tests of stationarity and tests of co-integration. For practitioners, evidence of nonlinear dependency directly affects the widely debated issue of predictability of financial time series, which has been examined mainly through a linear approach. Moreover, nonlinear models have important implications for portfolio management techniques, hedging and pricing of derivatives (such as volatility index), and allow for superior out-of-sample forecasts of financial series.

The remainder of the paper is organized as follows: Section 2 outlines our research methodology; Section 3 describes our data set; Section 4 discusses the empirical findings and Section 5 concludes the paper.

2. Theory and research methodology

2.1. Random Walk hypothesis

Fama (1970) argues that efficient stock market prices fully reflect all available and relevant information, meaning an absence of excess-profit opportunities. Share price changes are therefore independent and fluctuate only in response to the random flow of news. Trading strategies based on past and current information are useless in generating excess-profit opportunities.[1] This implies a random walk market, where a random walk model best describes stock prices. There are three different versions of the random walk model: Random Walk I, Random Walk II, and Random Walk III. The Random Walk I or *strict white noise process* requires sequences of price changes to be independent and identically distributed. If we assume sequences of price changes to be independent and drop the identically distributed assumption, we get the version of Random Walk II. Finally, the Random Walk III or *white noise process* is obtained by relaxing the independent and the identically distributed assumption.[2]

Harvey (1993) argues that non-linear models may have the *white noise* property although they are dependent and identically distributed. Given the growing theoretical and empirical studies showing that share price changes are inherently non-linear, evidence of uncorrelated share price changes are not sufficient conditions for a market to be efficient. Therefore, we examine the assumption of *i.i.d* share price changes, which is the most restrictive version of the random walk hypothesis, but most appropriate to test the efficient market hypothesis. Let P_t be the level of the TSX index at time t, and define $P_t \equiv Ln(P_t)$ as a stochastic process given by the recursive relation:[3]

$$p_t = \mu + p_{t-1} + \omega_t \quad (1)$$

The continuously compounded return for the period $t-1$ to t is expressed as

$$r_t \equiv \Delta p_t = \mu + \omega_t \quad (2)$$

where μ is the expected price change or drift and ω_t are represents the residuals.

Eq. (1) describes the random walk model with a drift. Under the random walk hypothesis, the drift should be insignificantly different from zero, the distribution of returns should be stationary over time ($r_t \sim I(0)$), and the residuals should be *i.i.d*

[1] Samuelson (1965) also shows that share prices, in an efficient stock market, fluctuate randomly and only in response to the arrival of new information.
[2] A white noise process is a sequence of uncorrelated random variables with constant mean and variance: for any $s \neq 0$ $E(\varepsilon_t \varepsilon_t - s) = 0$, and for $s = 0$, $E(\varepsilon_t) = 0$, and $E(\varepsilon_t \varepsilon_s) = \sigma^2{}_t$
[3] We use the natural logarithm of prices in order to make the process generating the times series to be independent of the actual price levels. Furthermore, p_t has favourable econometric properties in comparison to P_t (see Campbell et al., 1997).

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