Electronic Commerce Research and Applications 9 (2010) 400–409

Contents lists available at ScienceDirect

Electronic Commerce Research and Applications

journal homepage: www.elsevier.com/locate/ecra

# Price efficiency in futures and spot trading: The role of information technology

Martin Wagener [a,*], Dennis Kundisch [b], Ryan Riordan [a], Fethi Rabhi [c], Philipp Herrmann [b], Christof Weinhardt [a]

[a] School of Economics and Business Engineering, Karlsruhe Institute of Technology, Karlsruhe 76131, Germany
[b] School of Business Administration and Economics, University of Paderborn, Paderborn 33100, Germany
[c] School of Computer Science and Engineering, University of New South Wales, Sydney 2052, Australia

ARTICLE INFO

*Article history:*
Received 8 February 2010
Received in revised form 3 April 2010
Accepted 3 April 2010
Available online 11 April 2010

*Keywords:*
Electronic trading
Spot market
Futures market
Price efficiency
Event study
Infrastructure upgrade

ABSTRACT

During the last years information technology has had a profound impact on financial markets. The speed of trading and the amount of available information has increased substantially. Nearly all exchanges have upgraded their trading systems to meet the demand of investors and enhance their competitive position. However, the impact on liquidity and price efficiency remains unclear. In this paper we present an event study to examine the effects of an infrastructure change at the Deutsche Börse in Germany. On April 23, 2007, Deutsche Börse released an upgraded version of their electronic trading system Xetra. We study the impact that this upgrade had on the efficiency of prices, measured as the pricing gaps between the observed futures prices and their theoretical values based on the underlying cash market. Our results suggest that the system upgrade reduced the pricing gapand thus improved price efficiency.



## 1. Introduction

Securities exchanges are becoming increasingly automated. Stock and derivative exchanges around the world have introduced fully automated and transparent electronic trading systems, replacing their trading floors on which brokers manually match orders using an open-outcry system. For example, Lucas et al. (2009) provide a detailed analysis of how information and communication technologies changed trading on the New York Stock Exchange (NYSE). In 1980 a trade execution on the NYSE trading floor took 3–5 min. Since 2006 it has become possible to bypass the trading floor completely. Electronic trading systems today allow for order times of less than 10 ms. Over the course of the past 5 years most major exchanges have further upgraded their trading infrastructure to accommodate the increase in algorithmic trading (Hendershott et al. forthcoming). Algorithmic trading is commonly defined as the use of computer algorithms to manage the trading process. The increase in algorithmic trading is the reason most often cited for the corresponding increased trading volume in securities (Hasbrouck and Saar 2009). Interestingly, few if any studies in the information systems (IS) and finance literature have focused on the effect of system upgrades on transaction costs (spreads, brokerage, and commissions paid by investors), transparency, and price discovery.

This study focuses on the effect an infrastructure upgrade in one market – the Xetra stock market – has on the pricing discrepancies with the Eurex derivatives market. In modern markets, algorithms are used to identify deviations of prices from fair values and implement the trading decisions. Assuming that an index future is priced too high compared to its theoretical price, an algorithmic trader could exploit the divergence while selling the stock index future and simultaneously buying the underlying stocks of that index. As profit of the arbitrage strategy, she gains the temporarily inflated pricing gap between these two baskets. Since the cost of trading in the spot and futures markets differs, the amount of information impounded may differ. As a result, the predictions of the efficient market hypothesis (Fama 1970) may not always hold. Our study provides new evidence that reduced latency[1] of electronic trading systems improves the price discovery process, thus producing more efficient prices.

The efficient market hypothesis states that asset prices should reflect all available information. It further breaks efficiency into

* Corresponding author. Address: Karlsruhe Institute of Technology, School of Economics and Business Engineering, Institute of Information Systems and Management (IISM), Englerstr. 14, 76131 Karlsruhe, Germany. Tel.: +49 721 608 8370; fax: +49 721 608 8399.
*E-mail addresses:* wagener@kit.edu (M. Wagener), dennis.kundisch@wiwi.uni-paderborn.de (D. Kundisch), riordan@kit.edu (R. Riordan), fethir@cse.unsw.edu.au (F. Rabhi), philipp.herrmann@wiwi.uni-paderborn.de (P. Herrmann), weinhardt@kit.edu (C. Weinhardt).

[1] In the context of this article, *latency* is defined as the time required for an order to travel from the client system, across the network to the exchange backend and for confirmation of the order to be sent back to the client (round-trip).

1567-4223/$ - see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.elerap.2010.04.002

three forms: weak, semi-strong, and strong. The most important form of efficiency, in the context of this study, is the weak form. Weak form efficiency states that future prices cannot be predicted with past realization of public information including trades, quotes, and volumes. The infrastructure upgrade we study effectively improves the provision of public information in one market over another. By providing more timely prices, the market prices should deviate less from the efficient price. We implicitly test this relationship below.

The two markets under analysis are both owned and operated by Deutsche Börse AG. Xetra and Eurex are linked in two important ways: they both operate on a similar underlying trading system, and the derivatives listed on Eurex have Xetra traded securities as their underlying financial instruments. Due to this unique market structure we can measure the exact pricing gap between the two markets. This feature is a contrast to other studies of spot and futures index deviations in electronic markets.

Specifically, we study the effect of the upgrade of the Xetra system on the pricing gap between the theoretical futures prices based on the price of the German blue chip stock index DAX and observed futures prices on this index. The DAX is calculated using real-time trade prices in the underlying stocks. Moreover, we use trade prices of the most liquid DAX futures. In theory the observed futures prices should always be equal to the theoretical futures prices. Empirically, we often observe discrepancies in the pricing relationship between these two prices. We call these discrepancies pricing gaps and measure the effect of an IT-infrastructure upgrade on these. Due to faster, lower-risk arbitrage, we expect that the infrastructure upgrade should reduce these gaps.

The paper is organized as follows: In Section 2 we discuss related work in the IS and finance literature. Section 3 covers the market microstructure that is relevant for our study. The data and methodology are presented in Sections 4 and 5, respectively. We discuss and interpret the results in Section 6 and conclude with a summary and provide an outlook for further research.

## 2. Related work

As noted above, there is a strong link between the efficient market hypothesis and our study. The efficient market hypothesis is often tested in an event study framework (MacKinlay 1997) similar to the one we use. Event studies generally test for event returns that are significantly different than zero and attribute these to the event being studied. Event studies are also used to test for the impact of events on variables other than returns, and therefore not as direct tests of the efficient market hypothesis. Examples of these include Hendershott et al. (forthcoming) and Riordan and Storkenmaier (2009); these types of studies are usually used with natural experiments, like system upgrades or regulatory changes. Since the late 1960s, the event study methodology has been widely used to explain potential effects of corporate events, for example, shifts in corporate strategies or changes in top management. Event studies are applied in many research areas like accounting, finance, and strategic management (McWilliams and Siegel 1997).

### 2.1. IS literature

Event studies have recently gained importance in the IS literature. In general, event studies in IS can be grouped into four categories: IT investment (e.g., in ERP software, EAI, e-commerce activities), IT security, IT outsourcing, and other IT-related topics. See Roztocki and Weistroffer (2009) for a review of event studies in IS. Thus far, there have been relatively few studies that analyze the effect of IT investments on financial market efficiency and market integration using the event study methodology. This is surprising, especially considering the recent explosion in IT investment by securities exchanges and financial intermediaries (Domowitz, 2002). New order types, fully automated trading systems, and other features have been introduced at most securities exchanges worldwide.

There are a number of studies that do not use the event study methodology, but rather look at the effects of IT and IT investments of exchanges and financial intermediaries. The structure and competition of financial markets have been analyzed by Bakos et al. (2005). Strategic decision choices for electronic trading systems (Levecq and Weber 2002), the role of intermediaries and risk management in modern financial markets (Clemons and Weber 1997) as well as liquidity effects of electronic limit order books (Hmaied et al. 2006) have also been research topics of interest. Lucas et al. (2009) further discuss how NYSE as incumbent stock market could defend its market position against new innovative competitors.

To date, there are very few papers studying the issue of the integration of two financial markets from an IS perspective. Kempf and Korn (1998) are concerned with the lead–lag relationship when the stocks are floor traded while the futures are screen traded. Grünbichler et al. (1994) look at the relative advantages of floor and screen trading systems using a similar approach to ours. Their results show that electronic trading results in a more rapid price discovery process.

Still, none of these contributions look at the question of the effects of IT investments on the integration of two electronic financial markets. Specifically, we examine the contribution of IT investments on the integration of the futures and the spot market with respect to an infrastructure upgrade. This situation promises relevant results since the theoretical relation between these two markets has already been examined extensively in the finance literature. We also contribute to the "internationalization" of event studies in IS called for by Roztocki and Weistroffer (2009). They find that only five of the analyzed IS-related event studies use non-US stock data.

### 2.2. Finance literature

According to Cornell and French (1983), the theoretical value of an index futures contract is equal to the price of the underlying spot index plus the cost of carrying the spot index over the remaining life of the contract (cost of carry (COC) model). The cost of carrying consists of deferred interest payments paid on the stock index minus the deferred value of the dividend payments that accrue to the holders of the individual market constituents. The fair price of the index futures contract is determined based on the assumption that spot markets are frictionless. That is, there are no taxes or transaction costs and all market participants have equal access to financing at the risk-free rate. The value of a futures contract is expressed as follows:

$$F_{t,T} = S_t e^{r(T-t)-D_{t,T}} \tag{1}$$

where $F_{t,T}$ equals the futures price at time $t$ for a contract that matures at time $T$, $S_t$ equals the spot index value at time $t$, $D_{t,T}$ equals the time $T$ value of dividends paid on the component stocks between $t$ and $T$, and $r(T-t)$ equals the risk-free interest rate spanning the period from $t$ to $T$. If dividends are not relevant, the formula can be simplified to:

$$F_{t,T} = S_t e^{r(T-t)} \tag{2}$$

Since the late 70s, the relation between futures and spot prices has been extensively studied in the finance literature. These articles can be broadly grouped into four categories. The first body of literature looks at the question whether one market leads and the other market lags (e.g., Kawaller et al. 1987). A general finding