International Review of Financial Analysis 19 (2010) 35–46

Contents lists available at ScienceDirect

International Review of Financial Analysis

Phase-transition behavior in the emerging market: Evidence from the KOSPI200 futures market

Keunho Hwang [a], Jangkoo Kang [a], Doojin Ryu [b,*]

[a] KAIST Business School, Seoul, Republic of Korea
[b] National Pension Service (NPRI), Seoul, Republic of Korea

ARTICLE INFO

Article history:
Received 26 June 2009
Received in revised form 6 November 2009
Accepted 10 November 2009
Available online 17 November 2009

Keywords:
Econophysics
KOSPI200 futures market
Phase-transition behavior
Two-phase phenomenon

ABSTRACT

This study examines the phase-transition behavior of the KOSPI200 futures market and discusses empirical findings in the context of the unique characteristics of that market. We study the two qualitatively different phases of the market based on two related measures: the volume-imbalance measure proposed by Plerou et al. (2003) and the return-related measure. The empirical simulations carried out in this study suggest that a peculiar distribution of trading volume—which possibly reflects dominant individual trading, the nature of informed trading, and/or investor behavior in the KOSPI200 futures market—plays a critical role in generating the two-phase phenomenon. The simulation results also imply that neither the serial correlation of trade indicator variable nor that of (signed) trade volume causes the bifurcation of the conditional probability density of the volume-imbalance measure, which otherwise typically implies a phase transition.

1. Introduction

Changes in trading behavior caused by qualitative changes or regime (phase) shifts in financial markets have been one of the interesting and ongoing research topics in the literature of financial economics. One strand of research in this area focuses on how financial markets react and investors behave when information shocks occur in the markets under the assumption that the markets undergo substantial changes after the shocks hit. Related empirical studies examine these changes and the reactions of the markets on the basis of variations of market-microstructure variables such as price, volatility, bid/ask spreads, and trading volume owing to the information shocks. Ederington and Lee (1993) investigate price and volatility changes after a macroeconomic shock in interest rate markets and foreign exchange futures markets. Fleming and Remolona (1999) also examine the process of price, spread, and transaction volume adjustments caused by public information shocks. Ahn, Cai, and Cheung (2002) insist that macroeconomic announcements from the United States and Germany affect the volatility of German 10-year Bund futures price. Pyun, Lee, and Nam (2000) find that a high-rate of information arrival reduces the volatility persistence of stock returns in the Korean equity market.

On the other hand, recent studies in econophysics propose another framework to describe market behavior following an information shock. Just as physical materials exhibit solid, liquid, or gas phases depending on combinations of temperature and pressure, some studies look to describe the state or phase changes in the financial markets, which are defined by endogenous and/or exogenous market environments.[1] They explain that an information shock that arrives in a market generates a large imbalance between supply and demand, which can result in considerable price movement; as a result, the phase of the market is completely changed. The most representative and pioneering work to apply this approach is that of Plerou, Gopikrishnan, and Stanley (2003), who introduce the concept of phase-transition behavior to financial economics to describe a situation in which a financial market undergoes a shift from one state to another. They explain that markets have two phases, an "equilibrium state" and an "out-of-equilibrium state," depending on which type of trading dominates, i.e., informed trading or uninformed trading; they term this phenomenon "two-phase behavior." According to their argument, the property of each phase is dramatically different in the sense that uninformed traders or noise traders, who provide liquidity to the market, dominate in the equilibrium phase, whereas informed traders, who consume liquidity, are major players in the out-of-equilibrium phase. They examine the distribution of trading volume imbalance in the New York Stock Exchange (NYSE) within a fixed time interval and find that the distribution of the volume-imbalance measure changes from a unimodal distribution to a bimodal distribution as the variation in the trading volume imbalance increases. Plerou et al. (2003) interpret this phenomenon as being symptomatic of the movement of the NYSE market between the equilibrium and out-of-equilibrium states.

* Corresponding author. National Pension Service (NPRI), 4-15, Nonhyeon-Dong, Gangnam-Gu, Seoul, 135-911, Republic of Korea. Tel.: +82 2 3218 8665; fax: +82 2 3446 0239.
E-mail address: doojin.ryu@gmail.com (D. Ryu).

[1] Yalamova and McKelvey (2009) provide a sound survey and summary of the previous literature.

1057-5219/$ – see front matter © 2009 Elsevier Inc. All rights reserved.
doi:10.1016/j.irfa.2009.11.003

Motivated by Plerou et al. (2003) and related research that follows,[2] this study examines phase-transition behavior in the KOSPI200 futures market, one of the most remarkable derivative markets in the world. In mainstream financial economics, of course, the issues of structural change within a financial market and related changes in trading behavior have been widely studied and depicted using econometrical techniques that use regime-switching models, among others. Utilizing the Markov regime-switching technique, Moore and Wang (2007) show that the stock markets of eastern European countries often move from being high-volatility regimes to low-volatility ones. Hess (2003) compares the empirical performance of competing Markov regime-switching specifications and finds that the model reflecting memory effect and containing a constant autoregressive parameter performs best in the Swiss equity market. Besides the Markov regime-switching model, the iterated cumulative sums of squares (ICSS) algorithm is used to examine structural changes in market variables. Using the ICSS method, Hammoudeh and Li (2008) examine sudden changes in volatility among Gulf Arab stock markets.

Though these well-known econometric techniques are useful in describing the time-dependent dynamics of financial-market property, we have several reasons to analyze the index futures market within the framework of phase-transition behavior and describe the transitions of a financial market among heterogeneous states, which is triggered by external shocks or endogenous changes in the market. First, the phase-transition behavior approach has an advantage over classical econometrical methods, in that it contains less model risk. Second, the static and physical properties of a financial market are possibly better explained using the phase-transition behavior approach, especially if the trading activity in the market is substantially affected by interdependent trader behavior. In a financial market where interdependent trading is prevalent, an initially small variation and/or small shock to the market that may not be detected by econometric models can cause substantial changes in market property. Third, the approach makes possible the construction of a new paradigm in which financial anomalies, which are not explained under the efficient market hypothesis (EMH) first proposed by Fama (1970) to become well-established financial theory, can be explained. For instance, the stock market crash in 1987 occurred without a prelusively large exogenous shock such as the September 11 terrorist attacks or shocking economic news such as the liquidity crisis of 2007. Within the framework of phase-transition behavior and econophysics, we can explain these anomalies by describing the nature of a financial market as being similar to that of a physical material or complex system. Just as ice (a solid) can be transformed into water (a liquid) around the melting point (a critical point) with a small change in temperature, the financial market can undergo qualitative change without noticeable and/or large information shocks; indeed, shocks related to small events can affect the market severely if the market is in an endogenously unstable state. In addition, small differences in initial conditions can move a chaotic system to a vastly different phase-space. By applying such chaos theory to finance, we can presume that small shocks to the market can sometimes scale up, depending on the nature of the current state of the market, although they often die out.

The characteristics of the KOSPI200 futures trading make it an ideal setting in which to apply and study the phase-transition behavior approach. Individuals regarded as noise traders and who participate in the futures market for speculative reasons dominate the trading activity in the futures market. In addition, the extremely short maturity of the index futures contracts and the lack of an alternative derivative market induce more speculative trading.[3] The noisy and/or speculative trading and the prevalent herding behavior inherent in the futures market[4] enlarge the interdependency among investors, possibly making the state of the futures market unstable and placing them near so-called "critical points." For these reasons, we expect to find more prominent phase-transition behavior in the futures market. The KOSPI200 futures market is also known to be a very volatile market, due to its noisy and overly speculative trading; the volatility or fluctuation of the futures return might be related to dispersions of opinion held by investors, as pointed out by Harris and Raviv (1993) and Ahn, Kang, and Ryu (2008). Heterogeneous belief amongst investors can lead a market into an unstable state and bring about a complex endogenous price movement, such as that seen in chaotic fluctuation (Brock & Hommes, 1998; Chen, Lux, & Marchesi, 2001; Gaunersdorfer, 2000; Lux, 1995, 1998).

Considering that Plerou et al. (2003) is certainly the groundbreaking study whose methodology many later studies in this field adopt, we basically examine the phase-transition behavior of the futures market, using this framework. However, Plerou et al. propose only one measure to investigate phase-transition behavior and do not provide enough economic reasoning and explanation; these shortcomings are also found in related studies. Furthermore, these studies also do not extend and generalize the phase-transition approach, in that they deal only with the equity markets of developed countries. Our study fills this research gap and contributes to the literature as follows. First, to the best of our knowledge, this study is the first to apply the phase-transition approach to one of the most remarkable and volatile derivative market, the KOSPI200 futures market. Second, while Plerou et al. (2003) investigate the phase-transition behavior of the NYSE market using only the trading volume-imbalance measure, we propose the use of another measure: the return of transaction price. Our study examines whether distributions of volume-imbalance and price return undergo a modal change from unimodal distributions to bimodal distributions, as their variance increases. Third, we explore the cause of phase-transition behavior, if it exists in the futures market; to do so, we look into the statistical properties of trading-activity-related variables such as the number of transactions and trade size. We also estimate the serial correlation of trade indicator variable and that of (signed) trade volume, which describe the characteristics of trading behavior in the futures market, to perform empirical simulations; in this way, we investigate which factors generate phase-transition behavior. Fourth, this study looks to provide economics-based intuition, and to interpret phase-transition behavior by relating it to the trading behavior of market participants and the unique nature of the futures market. There is a dearth of such attempts in econophysics literature.

The balance of this paper is organized as follows. Section 2 explains our interest in the phase-transition behavior of the KOSPI200 futures market and how we constructed our sample data. Section 3 shows that phase-transition behavior exists in the futures market, using the method of Plerou et al. (2003). We present the statistical properties of the market-microstructure variables, as well as some estimates from this market, in Section 4. In Section 5, we attempt to investigate the possible cause of phase-transition behavior in the KOSPI200 futures market, using simulation methods based on the statistical properties of the futures market. Section 6 proposes an alternative measure—return from transaction prices—that can be used to investigate phase-transition behavior in financial markets; the properties of the return

[2] See Matia and Yamasaki (2005), Plerou, Gopikrishnan and Stanley (2005), and Lim, Kim, Kim, Lee and Park (2007), among others.

[3] During the sample period of this study, the only actively traded index derivatives related to the overall state of the Korean macro-economy are KOSPI200 options. It is also well-known that speculative trading is also prevalent in the options market, due to the high leverage and short maturity involved.

[4] Kang, Kim, Lee, and Moon (2005) examine herding behavior and the positive feedback trading strategy of day-traders in the KOSPI200 futures market.