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Does security transaction volume–price behavior resemble a probability wave?

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Abstract

Motivated by how transaction amount constrain trading volume and price volatility in stock market, we, in this paper, study the relation between volume and price if amount of transaction is given. We find that accumulative trading volume gradually emerges a kurtosis near the price mean value over a trading price range when it takes a longer trading time, regardless of actual price fluctuation path, time series, or total transaction volume in the time interval. To explain the volume–price behavior, we, in terms of physics, propose a transaction energy hypothesis, derive a time-independent transaction volume–price probability wave equation, and get two sets of analytical volume distribution eigenfunctions over a trading price range. By empiric test, we show the existence of coherence in stock market and demonstrate the model validation at this early stage. The volume–price behaves like a probability wave.

Keywords: Price volatility; Volume kurtosis; Volume–price behavior; Coherence; Probability wave

1. Introduction

Although there are many trading price models in financial market, none of them has the explicit price formation mechanism that is expressed by an analytical expression. Fama [1] and Ross [2] launched efficient market hypothesis and arbitrage pricing theory, respectively, based on rational trading assumption. Black and Scholes [3], together with Merton [4], derived a Black–Scholes–Merton model in terms of Samuelson's log-normal process or economic Brownian motion [5] that could be traced to Bachelier's dissertation regarding an option pricing problem [6]. In addition, Engle [7] formulated ARCH model, which was later developed to GARCH model by Bollerslev [8], to estimate price volatility error or non-linear item. In recent years, some econophysicists begin using formulation in physics to develop asset pricing models in financial market. For example, McCauley and Gunaratne [9] showed how the Fokker-Plank formulation of fluctuations can be used with a local volatility to generate an exponential distribution for asset return.

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In the past 20 years, there was a growing body of research studying price and volume. Gallant et al. [10] undertook a comprehensive investigation of price and volume co-movement using daily New York Stock Exchange data from 1928 to 1987. Gervais et al. [11] claimed the existence of high-volume return premium in stock market. Moreover, Zhang [12], an econophysicist, presented an argument for a square-root relationship between price changes and demand. Over the last few years, spin models are used in studying price and volume as the most popular models in econophysics [13]. Plerou et al. [14] applied a spin model and empirically addressed how stock prices respond to changes in demand. They found that large price fluctuations occur when demand is very small.

Ausloos and Ivanova [15] studied price and volume by introducing the notion of a generalized kinetic energy. A generalized momentum is also borrowed from classical mechanics. It is defined as the product of normalized volume transaction and the average rate of price change during a price moving average period. They emphasized at the close that these concepts might also serve in a dynamic equation framework. Wang and Pandey [16] followed the same terminology with somewhat different definitions. They defined trading momentum as the product of relative price velocity and a time-dependent "mass", a normalized trading volume in a time interval, i.e., the volume liquidity. Up to date, the literature on price and volume mainly focuses on the correlation between return and total volume (over a trading price range) in a given time interval.

Some scholars attempted to explain the behavior of price and volume. Admati and Pfleiderer [17] developed a theory in which concentrated-trading patterns arise endogenously as a result of the strategic behavior of liquidity traders and informed traders. Wang [18] used ICAPM to establish a theoretical links between prices and volume. Econophysicists, for example, Gabaix et al. [19] proposed a theory to provide a unified way to understand the power-law tailed distributions of return and volume, the non-normal distributions that have been caught much attention by econophysicists since Mandelbrot's finding [20]. Current theories credited the correlation between price and volume to a variety of factors, for examples (optimal) trading motive and information quality etc. "What is surprising is how little we really know about trading volume" [21].

Soros [22] guessed: In natural sciences, the phenomenon most similar to that in financial economics probably exists in quantum physics, in which scientific observation generates Heisenberg's uncertainty principle… Unfortunately, he added, it is impossible for economics to become science…

Among econophysicists, however, Schaden [23] prudently discussed the possible generic aspects of quantum finance to model secondary financial markets and the challenges we probably had to face in this potential interdisciplinary field. Piotrowski and Sladkowski [24] published a series of papers on quantum finance and currently proposed the price model that uses complex amplitudes whose squared modules describe price movement probabilities, inspired by quantum mechanical evolution of physical particles. Kleinert [25] applied path integrals to the price fluctuation of assets, considering the prices as a function of time. Baaquie et al. [26] developed a derivative pricing model based on a Hamiltonian formulation, and wrote that it was too difficult to solve Merton–Garman Hamiltonian analytically in most pricing problems [27]. Jimenez and Moya [28], on the other hand, showed that it is possible to obtain quantum mechanics principles using information and game theory, etc. These researches are based on existed formulation and principle in quantum mechanics.

There is a celebrated dictum in Walls Street: Cash is king. Inspired by Soros's guess and motivated by how transaction amount constrain trading volume and price volatility in stock market, we study the relation between volume and price through amount of transaction in terms of physics.

Stock market appears a complex system because of a variety of interacted and coupled trading agents in this open and fully competitive market. Thus, it is probably a key for us to model it successfully how we observe the system and find a simplified methodology.

Price is volatile upward and downward to its mean value in intraday transactions on individual stock. We observe that accumulative trading volume gradually emerges a kurtosis near the price mean value over a trading price range when it takes a longer trading time, regardless of actual price fluctuation path, time series, or total transaction volume in the time interval [29,30]. Moreover, the volumes are not distributed normally. Whereas some of the distributions appear to be normal, others appear to be wave, and the others exhibit to be exponent. These phenomena cannot be explained by a current economic and finance mainstream theory—both a rational trading assumption and a price volatility random walk hypothesis.