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# How trading volume responds to return in financial dynamics?

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## HIGHLIGHTS

- How trading volume responds to price return is investigated.
- A positive return–volume correlation is observed for the Chinese stock markets.
- A transition is found for the return–volume correlation of American stock markets.
- A retarded herding model is introduced.

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ABSTRACT

How trading volume responds to price return is investigated by the return–volume correlation dynamics, based on the daily data of two typical financial markets, i.e., the Chinese and the United States stock markets. Whereas the price returns being observed to be positively correlated with the trading volumes for the Chinese stock markets, a significant transition from the positive correlation to negative correlation is revealed for the United States stock markets. Leverage and anti-leverage effects of the return–volume correlations are found for the last decade of the United States stock markets and the Chinese stock markets, respectively. Nonlocal dynamics further suggests an adverse correlation for the two markets. A retarded herding model is introduced to describe the leverage and anti-leverage effects. Our work may shed a new light on the financial dynamics differing in the mature and emerging markets.



## 1. Introduction

Financial dynamics has attracted an extensive interest of scientists from different disciplines for tens of years, including physicists [1–9]. In the past years, physicists have paid a focal attention to the possible universality of the financial dynamics. Scaling behaviors of the probability distributions of the price returns have been found for different financial markets [1–4]. In the absence of the long-term correlations of the price returns, long-range time correlations have been revealed for the volatilities, which are measured as the magnitudes of the price changes [3,10]. Meanwhile, different models and theoretical

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approaches have been developed to understand the underlying mechanism of the financial dynamics, such as the herding models [11–13].

Besides these universal rules governing the financial markets [1,2,14,15], uncovering the non-universality of the market movements is receiving more and more interest from physicists [16–19], especially for those specific characteristics that differ in mature and emerging markets. A typical example is the so-called 'leverage effect', describing about more than ten-day negative correlations between the price returns and future volatilities. Such kind of leverage effect of the return–volatility correlations has been observed in a variety of mature financial markets, as well as some emerging markets [20]. However, an adverse effect, called anti-leverage effect, is found for the Chinese stock markets, where a more than ten-day positive return–volume correlation is observed [18,19]. The difference to an extent indicates the different driving forces of the trading activities between the Chinese stock markets and other mature markets.

In the process of understanding the financial dynamics, an effective method is to quantify the cross-correlation between different elements [21], which helps uncovering how one element responds to another. Based on the cross-correlation matrix, the economic sectors have been investigated [22–28], and hierarchical or network structures are revealed [29–33]. Some new methods are also proposed to quantify the dynamics of the cross-correlations, such as the detrended cross-correlation analysis [34–37].

As an important facet to understand the financial dynamics of the trading activities, it is essential to reveal how the trading volumes respond to the price returns for different markets. From economic literature, the price return or volatility has been taken as a basic indicator to measure the market risk, whereas the trading volume quantifies the market liquidity [37–44]. The liquidity of commodity is of great importance for the development and sometimes even the survival of a company. Therefore, how the price change drives the trading volume has raised a central interest from economists, and has received a wide discussion in economic literature [45–48]. Generally, it is deemed that there is a positive correlation between these two quantities [45–48], which also somehow coincides with our intuitions. If price drops, trading activities could decrease, leading to a small trading volume, and vice versa. However, the investigation from economic literature is usually based on small timescales. From the perspective of a long-term timescale, how the price returns correlate with the trading volumes? In recent years, physicists also devote to revealing the cross-correlations between the price returns and trading volumes [42,49,50]. It has been reported that there is a long-range time cross-correlation between the magnitude of the trading volume changes and the price changes [37]. But, one may still ask: should the correlation between the trading volumes and price returns always keep positive or not? and is the positive correlation universal for different markets?

In this article, we present a comparative study of the correlation dynamics between the price returns and trading volumes for two typical markets, i.e., the stock markets of the United States and the Chinese stock markets, based on the market daily data of decades of years. Our results show that, whereas the price returns being observed to be positively correlated with the trading volumes for the Chinese stock markets, the United States stock markets present a significant transition from the positive correlation to negative correlation. Leverage and anti-leverage effects are found for the last decade of the United States stock markets and the Chinese stock markets, respectively, which can be well described by a retarded herding model.

## 2. Return–volume correlations

### 2.1. Datasets

The datasets we analyzed are as follows. (1) The daily data of the Standard & Poor's 500 Index (*S&P*500), and the Dow Jones Industrial Average (*DJIA*) for the United States stock markets. The time period is from January, 1960 to December, 2011, including 13087 data points for the *S&P*500 and 13082 data points for the *DJIA*. (2) The daily data of the Shanghai Composite Index (*SH*) and the Shenzhen Component Index (*SZ*) for the Chinese stock markets. The time period is from January, 1992 to December, 2011, including 4891 data points for the *SH* and 4876 data points for the *SZ*.

### 2.2. Synchronized return–volume correlations

We start by studying a synchronized return–volume correlation. Let us define the price return $r(t')$ as the logarithmic change of the daily close price $p(t')$ over a one-day interval,

$$r(t') = \ln \frac{p(t')}{p(t'-1)}. \tag{1}$$

The synchronized correlation $C$ between the price return $r$ and trading volume $q$ is then defined as,

$$C(r,q) = \frac{\langle (r_{t'} - \langle r \rangle_{t'})(q_{t'} - \langle q \rangle_{t'}) \rangle_{t'}}{\sigma_r \sigma_q} \tag{2}$$

where $t' = 1, \ldots, T$, with $T$ to be the investigated time length, $\sigma_r = \sqrt{\frac{1}{T}\sum_{t'=1}^{T}(r_{t'} - \langle r \rangle_{t'})^2}$, $\sigma_q = \sqrt{\frac{1}{T}\sum_{t'=1}^{T}(q_{t'} - \langle q \rangle_{t'})^2}$, and $\langle \ldots \rangle$ is taken an average over $t'$.

To investigate the dynamical behavior of the synchronized return–volume correlation $C$, we compute $C$ for every two years. As shown in Fig. 1, for both the *S&P*500 and *DJIA* of the United States, the return–volume correlations $C$ are positive at the early stage from the year 1960 to 1992, except the year 1987 when the financial crisis happened. The results are similar