International Journal of Innovative
Computing, Information and Control
Volume **14**, Number **2**, April **2018**

 ISSN 1349-4198
pp. **629–645**

THE PLASTICITY AND ELASTICITY OF STOCK PRICE VARIATIONS – PART 2: MODEL ANALYSIS AND APPLICATION

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Received May 2017; revised September 2017

Abstract. *This paper studies the problem of the locked quantity of stocks by means of the stock price plasticity model and obtains the theoretical formula of the locked quantity of stocks and the basic stock price plasticity equation. Based on the characteristic of plasticity and elasticity of stock price, the relation between the stock price plasticity coefficient and the stock price is carefully examined and several statistical conclusions of the qualitative prediction of the stock prices are proposed. This paper also uses the stock price plasticity model to compare the international stock markets and gets some instructive results.*

Keywords: Stock markets, Stock price plasticity, Stock price elasticity, Locked quantity of stocks, Qualitative prediction

1. **Introduction.** In the stock market, two indexes which are the stock price and the trading volume are the basis of the technical analysis. The theories about the price-volume analysis of stock place emphasis on the intrinsic laws shown by the price and trading volume sequences of stocks. Although the price-volume relation of stock has been studied for a long time, it is still the hot topic in the field of microfinance. The research about stock price mainly focuses on such aspects as the relation between trading volumes and stock price variations, and the casual relation between stock prices and trading volumes [1]. Research findings show that the relation between stock price variations and trading volumes is synchronous, and may not be monotonous and that the relation between trading volumes and the absolute value of stock price variations may not be linear [2-4]. Goodman conducts an empirical study of 50 stocks randomly selected from the New York Stock Exchange (NYSE) and the American Stock Exchange (AMEX). The conclusion is that the absolute value of the change of stock price is positively correlated with the trading volumes [3]. Martikainen et al.'s empirical study shows that there is a positive correlation between the trading volume and the changes of stock price [2]. Jegadeesh and Titman reveal the effect of stock price momentum and the conclusion shows that the pre-profitable portfolio is still good for the next three to twelve months [5]. Lee and Swaminthan study the relationship between trading volume and stock price momentum, and find that the previous volume can be helpful for predicting the future price momentum. The profit portfolio with large volume or the loss portfolio with small volume tends to show a faster reversal [6]. Based on the stock market data of nine developed countries, Chen et al. use the Granger causality test method to detect the dynamic relationship between stock price and volume and the results show that there is a positive correlation between the volume and the absolute change in stock price [7]. Chordia and Bhaskaran test the relationship between trading volume and the predictability of short-term returns

of stocks and the results show that the daily rate of return of stocks with large volume is higher than that of the daily rate of return of stocks with a forecasting method given for the price trend under the condition of the large volume [8]. There are some studies which combine the stock price-volume analysis with the stock price forecasting method. Stádník et al. use the Fourier analysis on stock price forecasting [9]. Kohara et al. use the prior knowledge and neural networks model for stock price prediction [10]. Louangrath uses the extreme value theory to analyze the stock price [11]. Ariyo et al. use the ARIMA model to develop better predictive models for stock price [12]. Scholars have been getting more concerned with the combinations between technical analysis and portfolio strategy in recent years [13-16].

There are a large number of research papers on the relationship among stock prices, trading volume and stock price volatility, but we have not seen a paper that uses the concept of plasticity and elasticity of stock price to analyze the stock prices. Quantitative analysis of the locked quantity of stocks by means of the stock price plasticity model is an innovation of this paper. The locked quantity of stocks is an indicator that investor shows great concern, but convincing theoretical research on the locked quantity of stocks is rarely seen in top academic journals. Relative contents may be found in the technical analysis of stock prices, but these contents generally lack of strict theoretical analysis and lack of a solid foundation of statistical tests.

The rise and fall of the stock price under the action of trading volumes is similar to the motion process of the stretched or compressed spring with plasticity. For a spring with plasticity, the larger the external force is, the farther from the balanced position it is, and when the external force is decreased or removed, the spring will move from the current position to the balanced position as a result of its elasticity; however, because of the existence of plasticity, the balanced position of the spring changes with its load and deformation, it cannot move back to its original balanced position after the external force is removed. The larger the external force is (the spring is farther from the balanced position) and the longer the external force lasts, the larger its plastic deformation is and the farther away the new balanced position from the original balanced position is. This spring with plasticity will form a new balanced position in every moment. If a small and quick force is exerted on the spring, the spring mainly shows its elasticity, that is, it oscillates around its balanced position; if a large and slow continuous force whose direction is constant is exerted on the spring, the spring will stay in the position where it is stretched or compressed for a long time which is embodied in its plasticity.

As for the stock price, corresponding to the balanced position of the spring, it means that there is a balanced price of stock in every moment. Driven by the ever-increasing trading volume, the stock price rises and remains high for some time. The stock price often falls back slightly when trading volume shrinks and this pullback to the balanced price is the embodiment of the elasticity of the stock price. However, the stock price can seldom fall back to the original balanced price, and instead, to a price which is higher than the original balanced price, that is, the balanced price rises, which shows the plasticity of the stock price. Similarly, driven by the ever-increasing trading volume, the stock price falls and remains low for some time, the stock price often rallies when the trading volume shrinks, and this rally to the balanced price is the embodiment of the elasticity of the stock price. However, the stock price can seldom rise to the original balanced price, instead, rise to a price which is lower than the original balanced price, that is, the balanced price decreases, which shows the plasticity of the stock price.

We have proposed the concepts of the balanced price of stock, stock price plasticity and stock price elasticity, built several stock price plasticity and elasticity models and made detailed econometric tests on these models [17]. As the continuation of the research

work, this paper discusses the stock price plasticity models more in depth and especially studies the intrinsic laws of the stock price variation based on the change of the stock price plasticity coefficient.

The locked quantity of stocks seems a self-evident concept, but the concept of the locked quantity of stocks is difficult to define clearly. Moreover, the research on the locked quantity of stocks can easily arouse controversy. On the other hand, it is certain that the locked quantity of stocks is one of the indexes that investors pay most attention to. This paper uses the stock price plasticity model to study this topic and discuss and analyze the related problems, including the definition of the locked quantity of stocks, the composition analysis of the locked quantity of stocks, the relation between the locked quantity of stocks and the stock price plasticity coefficient. Meanwhile, this paper proposes the theoretical formula of the locked quantity of stocks and presents the basic stock price plasticity equation.

Based on the stock price plasticity model and the elasticity of stock price, this paper researches the close correlation between the variation of the stock price plasticity coefficient (SPPC) and the variation of the stock price and then presents some results of the qualitative prediction of the stock price based on the characteristic of plasticity and elasticity of stock price. Moreover, the transaction data of US stock market, Hong Kong stock market and Shenzhen & Shanghai stock market are chosen to compare these stock markets through the stock price plasticity model. These results are inspirational, indicating the potential for application of the concept of stock price plasticity and stock price elasticity.

Section 2 discusses the locking phenomenon in stock markets, distinguishes active locking and passive locking and analyzes some main reasons for stock being locked. Section 3 explores the property of the stock price plasticity coefficient when the locked quantity of stocks is 0. Section 4 obtains the theoretical formula of the locked quantity of stocks and on this basis, proposes the basic stock price plasticity equation. Based on the stock price plasticity model and the characteristic of elasticity of stock price, Section 5 draws several conclusions about the qualitative prediction of the stock price. Section 6 uses the stock price plasticity model to compare different stock markets. The last section is the conclusion.

2. The Locking Phenomenon of the Tradable Stocks in Stock Markets.

In stock markets, there are usually some tradable stocks that are not being traded in some time intervals and in a certain range of the stock price as if they are locked in a safe box. These tradable stocks that are not traded temporarily are called locked tradable stocks and the quantity of the locked tradable stocks is named the locked quantity of stocks. There are some reasons for the locked tradable stocks. After buying stocks, institutional investors implement buy-and-hold strategy based on the long-term investment philosophy and these stocks are the locked tradable stocks. Big investors hoard stocks for speculation, the stocks held by these big investors are locked temporarily. After locked in at a high price, some investors are unwilling to sell stocks but hold stocks to wait for unlocking, and these stocks are locked passively. Many confident investors who hold long positions wait to make a fortune; they will lock their stocks for a period of time.

Based on the different intentions of investors, the locking phenomenon of stocks can be divided into active locking and passive locking. Active locking means that investors lock their stocks for some purpose, though these stocks have brought investors huge profits or some losses. Or rather, active locking means that investors have many opportunities to sell off stocks for profits, but they lock these stocks for huger anticipated profits. Active locking can also be divided into three forms, which are the long-term investment locking,

speculation locking and shareholding locking. Long-term investment locking means that based on the sufficient analysis of the listed companies, investors believe the long-term development prospect of their stocks, then buy these stocks at a proper price according to a certain strategy and hold them for a long time. The transaction of these stocks is basically not influenced by the fluctuation of stock markets. Mature institutional investors are usually the main ones who choose long-term investment locking. Speculation locking means that, in order to earn stock returns, investors buy a large number of stocks actively and calmly at a relatively low price in a short time, and lock these stocks during the rise of the stock price and sell them when the stock price rises to a target price. The shareholding locking means that investors buy and hold stocks to become the shareholder and that these stocks will be locked before investors achieve their aims.

Passive locking means that investors predict the stock price will rise, but during the stock trading, the stock price falls continuously after investors buy stocks, that is, the stock price is lower than their carrying cost. Encountering the trading risk, investors fail to stop losses in time and have to hold the money-losing stocks for some time. If investors decide not to sell these stocks until the stock price rises to their carrying cost, the stocks held by investors are the passive locking stocks when the stock price falls or starts backing and filling at a low price. Passive locking for the individual investors often occurs at the end of the bull market and during the bear market where the stock price decreases sharply, institutional investors who fail to be a market maker usually choose passive locking. Because of the existence of the locked stocks, the actual quantity of tradable shares becomes smaller, which makes the relation between the stock price variation and the trading volume more like a stock with smaller quantity of tradable shares.

3. **The Stock Price Plasticity Coefficient When the Locked Quantity Equals 0.** The stock price plasticity power-exponential model is used as follows

$$\frac{B_{K+1}-B_K}{B_K}=\alpha\cdot\operatorname{sign}\left(\frac{\sum_{i=1}^{N}Q_K^i\left(P_K^i-B_K\right)}{Q_K^F B_K}\right)\cdot\left[abs\left(\frac{\sum_{i=1}^{N}Q_K^i\left(P_K^i-B_K\right)}{Q_K^F B_K}\right)\right]^{0.4}+\varepsilon_k \quad (1)$$

where B_K represents the balanced price of the Kth day, B_{K+1} the balanced price of the $K+1$th day, Q_K^i the trading volume of the ith transaction in the Kth day, P_K^i the price of the ith deal in the Kth day, Q_K^F the quantity of the total tradable shares of the stock in the Kth day, N the number of transactions in the Kth day, α the stock price plasticity coefficient and ε_k the random error term. For the purpose of convenience, the stock price plasticity coefficient α of model (1) is denoted by SPPC in this paper.

Let

$$SPPI=\frac{\sum_{i=1}^{N}Q_K^i\left(P_K^i-B_K\right)}{Q_K^F B_K},\quad VRBP=\frac{B_{K+1}-B_K}{B_K}$$

SPPI is called the stock price plasticity index, and the model (1) can be written in the following form:

$$VRBP=\alpha\cdot\operatorname{sign}\left(SPPI\right)[abs(SPPI)]^{0.4}+\varepsilon$$

When the data of a certain time window is used, the value of SPPC corresponding to this time window can be obtained. For a stock, if there are no locked shares in a certain time window, the corresponding SPPC is denoted as α^* which is called the SPPC with the locked quantity equal to 0. The SPPC α shows the size of the stock price plasticity:

the larger α is, the more the balanced price of stock changes under the drive of the same SPPI. The parameter α^* reflects the contribution rate of the SPPI to the balance price variation when the locked quantity is equal to 0, which shows the intrinsic properties of stocks. For every stock, α^* should be relatively stable and $\alpha^* < \alpha$, that is, α^* is the lower bound of the SPPC α at different time intervals.

In the stock price plasticity model (1), Q_K^F is the total quantity of the tradable shares of a stock in the Kth day. For a stock, it is a common situation that a part of its tradable shares are locked, which means that a part of Q_K^F cannot be traded. The number of these locked shares is denoted as Q_K^L. In stock markets, the real quantity of tradable shares is $Q_K^F - Q_K^L$, but Q_K^L is unknown. When setting the model, this paper directly chooses Q_K^F instead of $Q_K^F - Q_K^L$, $Q_K^F - Q_K^L$ should be used in a real case, so that a smaller quantity $Q_K^F - Q_K^L$ is replaced by a bigger one Q_K^F. Q_K^F is in the denominator of the expression of the SPPI, so the calculated value of the SPPI is relatively small, which causes the estimated α is greater than the theoretical value α^*. Theoretically, the variation of the locked quantity of a stock can be identified through the comparison of the SPPC in different time intervals.

If the studied time interval is long enough, some smaller SPPC can be observed. In this long-enough time intervals, the smallest SPPC can be approximately considered as the SPPC α^* with the locked quantity equal to 0. Assume that, there always exists a time period for each stock in which there are few locked shares and no market makers, and it means that there are not active locking and passive locking. At this moment, the SPPC should be α^*.

In the bear market, during the slump in the stock price and the subsequent backing and filling, the passive locked quantity must be large because many investors are locked in at a high price. Generally, α^* does not occur in this period. In the bull market, during the surge in the stock price, the active locked quantity must be very large because the institutional investors actively lock their stocks and common investors strongly expect the continuing rise of the stock price, α^* does not occur in this period. In the late period of the bull market, the stock price raises to a high position enough to unlock the long-locked shares. During this period, if the institutional investors sell off their shares secretly and let the stock price keep backing and filling at a high price for a long time without suppressing the stock price, the SPPC of this moment will be very close to α^*.

Of course, if many institutional investors think the price of a stock can increase and heavily hold this stock for a long time from its listing day, which means a part of shares have been locked for a long time, then it is impossible for us to obtain α^* through observing the SPPC for a long time. In the following theoretical analysis and empirical research, the low value of the SPPC of a stock in a relatively long time interval is approximately taken as the theoretical value of the α^*.

Figure 1 shows the curves of the change of the SPPC and stock price of Tsinghua Tongfang (600100) with time: the fine solid line represents the stock price and the bold solid line represents the SPPC. For the purpose of convenience, the value of the ordinate plus 9.0 equals the stock price. The x-axis of Figure 1 represents time, the symbol '199904' in Figure 1 means the time of April 1999, and the two consecutive symbols '199904' in Figure 1 mean two days in April 1999 separated by about 15 days. The SPPC is calculated through the stock price plasticity power-exponential model (1) with the use of the transaction data of the previous 20 trading days. It can be seen that the SPPC is variable when the stock price variation is in different stages. In the time interval shown in Figure 1, the range of the variation of the SPPC is $1 \leq \alpha \leq 5$ and the smallest value of SPPC is about 1.0.

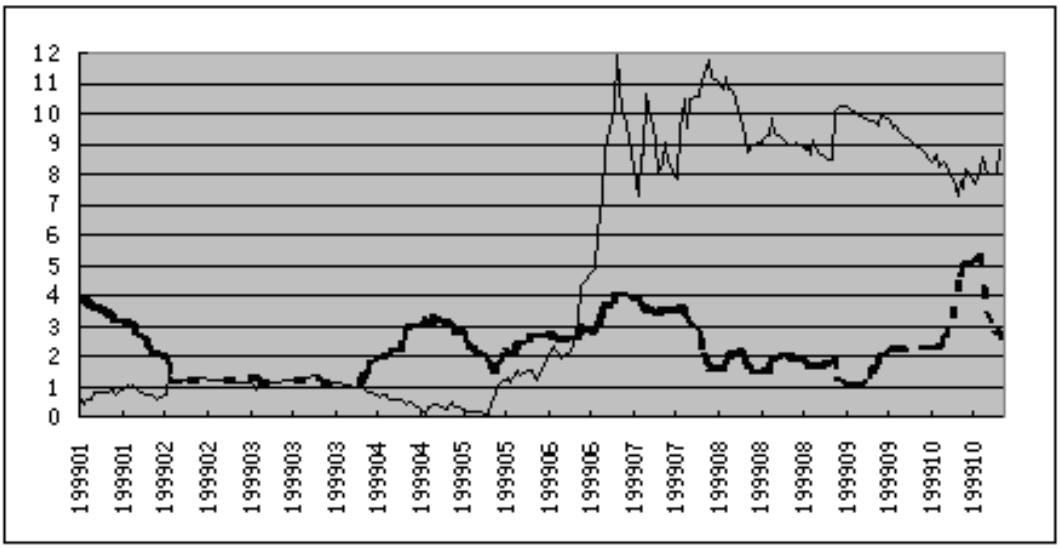

FIGURE 1. The curves of the SPPC and stock price of Tsinghua Tongfang (600100) with time

4. **The Theoretical Formula of the Locked Quantity of Stocks and the Basic Stock Price Plasticity Equation.** In this section, the theoretical formula of the locked quantity of stocks will be deduced. The stock price plasticity power-exponential model (1) is used and the total quantity of tradable shares of a stock in the stock market is taken as Q_K^F. The regression analysis is made on the model and the SPPC α is acquired, that is

$$\frac{B_{K+1}-B_K}{B_K}=\alpha\cdot\operatorname{sign}\left(\frac{\sum\limits_{i=1}^{N}Q_K^i\left(P_K^i-B_K\right)}{Q_K^F B_K}\right)\cdot\left[abs\left(\frac{\sum\limits_{i=1}^{N}Q_K^i\left(P_K^i-B_K\right)}{Q_K^F B_K}\right)\right]^{0.4}$$

Because $Q_K^F>0$, the above expression can be rewritten as:

$$\frac{B_{K+1}-B_K}{B_K}=\frac{\alpha}{\left(Q_K^F\right)^{0.4}}\cdot\operatorname{sign}\left(\frac{\sum\limits_{i=1}^{N}Q_K^i\left(P_K^i-B_K\right)}{Q_K^F B_K}\right)\cdot\left[abs\left(\frac{\sum\limits_{i=1}^{N}Q_K^i\left(P_K^i-B_K\right)}{B_K}\right)\right]^{0.4}$$

The total quantity of tradable shares minus the quantity of locked tradable shares is $Q_K^F-Q_K^L$ which is used to replace Q_K^F in model (1), and then the regression analysis is made on the model (1). The quantity of the locked tradable shares Q_K^L has been subtracted, so theoretically, there are no locked shares. At this moment, the SPPC α^* with the locked quantity equal to 0 can be acquired through the model, that is

$$\frac{B_{K+1}-B_K}{B_K}=\alpha^*\operatorname{sign}\left(\frac{\sum\limits_{i=1}^{N}Q_K^i\left(P_K^i-B_K\right)}{\left(Q_K^F-Q_K^L\right)B_K}\right)\cdot\left[abs\left(\frac{\sum\limits_{i=1}^{N}Q_K^i\left(P_K^i-B_K\right)}{\left(Q_K^F-Q_K^L\right)B_K}\right)\right]^{0.4}$$

Because $Q_K^F - Q_K^L > 0$, the above expression can be rewritten as:

$$\frac{B_{K+1} - B_K}{B_K} = \frac{\alpha^*}{\left(Q_K^F - Q_K^L\right)^{0.4}} \operatorname{sign}\left(\frac{\sum_{i=1}^{N} Q_K^i \left(P_K^i - B_K\right)}{\left(Q_K^F - Q_K^L\right) B_K}\right) \cdot \left[abs\left(\frac{\sum_{i=1}^{N} Q_K^i \left(P_K^i - B_K\right)}{B_K}\right)\right]^{0.4}$$

Through the comparison of the above formulas, the following expression can be obtained:

$$\frac{\alpha}{\left(Q_K^F\right)^{0.4}} = \frac{\alpha^*}{\left(Q_K^F - Q_K^L\right)^{0.4}}$$

Rewrite the above expression, and then it can be obtained that

$$\alpha = \alpha^* \left(\frac{Q_K^F}{Q_K^F - Q_K^L}\right)^{0.4} \tag{2}$$

According to the expression (2), we have $\alpha > \alpha^*$, and the larger the locked quantity Q_K^L is, the bigger the value of α is; on the contrary, the smaller Q_K^L is, the smaller the value of α is. The SPPC and the locked quantity show the positive correlation. When $Q_K^L = 0$, we have $\alpha = \alpha^*$. The change of Q_K^L will inevitably cause the variation of the SPPC.

The ratio of the locked quantity Q_K^L and the quantity of tradable shares Q_K^F is the locked ratio of stocks. Rewrite the expression (2), and the theoretical formula of the locked ratio which is determined by α and α^* can be acquired:

$$\frac{Q_K^L}{Q_K^F} = 1 - \left(\frac{\alpha^*}{\alpha}\right)^{2.5} \tag{3}$$

The locked ratio times the total quantity of tradable shares equals the locked quantity Q_K^L, and the theoretical formula is as follows:

$$Q_K^L = \left[1 - \left(\frac{\alpha^*}{\alpha}\right)^{2.5}\right] Q_K^F \tag{4}$$

The SPPC α^* and the SPPC α of every trading day should be worked out firstly, so that the locked ratio of a stock can be calculated through the expression (3).

Theoretically, it is difficult to measure the locked ratio of every stock in a certain moment accurately. Even though you are able to investigate every investor who holds a certain stock and assume that all investigated investors tell the truth, it is impossible to find out the true locked quantity because the shares which are locked by some investors may be sold off due to some information that is not related to this stock, or the shares which are not locked by some investors may be not traded and held for a long time. However, it is possible to estimate the locked ratio qualitatively or roughly. If the locked ratio of a stock is high, the price-volume property of this stock is more like that of the stock whose quantity of tradable shares is smaller than its real quantity; similarly, if the locked ratio of a stock is low, the price-volume property of this stock is more like that of the stock whose quantity of tradable shares is normal.

According to the deduction of related formulas in this section, the following equation can be obtained:

$$\frac{B_{K+1} - B_K}{B_K} = \frac{\alpha^* \left(Q_K^F\right)^{0.4}}{\left(Q_K^F - Q_K^L\right)^{0.4}} \operatorname{sign}\left(\frac{\sum_{i=1}^{N} Q_K^i \left(P_K^i - B_K\right)}{Q_K^F B_K}\right) \cdot \left[abs\left(\frac{\sum_{i=1}^{N} Q_K^i \left(P_K^i - B_K\right)}{Q_K^F B_K}\right)\right]^{0.4}$$

Some symbols can be substituted into the above expression and it can be rewritten as

$$VRBP = \alpha^* \left(\frac{Q_K^F}{Q_K^F - Q_K^L} \right)^{0.4} \cdot \operatorname{sign}(SPPI) \cdot [abs(SPPI)]^{0.4} \tag{5}$$

Equation (5) is called the basic stock price plasticity equation. In Equation (5), the important parameters α^*, B_K, B_{K+1}, Q_K^i, P_K^i, Q_K^F, Q_K^L are included in one equation. We believe that Equation (5) has good application value. After α^* is determined, the locked quantity Q_K^L can be worked out through the estimated SPPC α and then the future possible trend of the stock price can be determined.

Equation (5) is named as the basic stock price plasticity equation because of the following fact: numerous calculated results show that the values of α^* are similar, that is, $\alpha^* \approx 0.85$ for most stocks. The assumption that α^* is a constant is suitable on the statistical basis.

5. **The Qualitative Prediction of the Stock Price Based on the Characteristic of Plasticity and Elasticity of Stocks.** We have built the stock price plasticity power-exponential model in [17] as follows

$$\frac{B_{K+1} - B_K}{B_K} = \alpha \cdot \operatorname{sign} \left(\frac{\sum_i^N Q_K^i (P_K^i - B_K)}{Q_K^F B_K} \right) \cdot \left[abs \left(\frac{\sum_i^N Q_K^i (P_K^i - B_K)}{Q_K^F B_K} \right) \right]^{0.4} + \varepsilon_k \tag{6}$$

The meanings of the parameters of model (6) are described in Section 3. Model (6) can be rewritten in the following simple form:

$$VRBP = \alpha \cdot \operatorname{sign}(SPPI) \cdot [abs(SPPI)]^{0.4} + \varepsilon \tag{7}$$

We can know from the expression of SPPI that there are three conditions for a relatively significant change in the balanced stock price. One is the stock price plasticity coefficient α taking a relatively larger value. The second is the relatively larger trading volume. The third is the stock prices deviated from the balanced price more ($P_K^i - B_K$ take a relatively larger value). At this time the stock price changes mainly reflect the plastic properties. In obvious long market and short market these three conditions are generally satisfied. If the stock price plasticity coefficient α and the stock price plasticity index (SPPI) take a relatively small value, the change of balanced price of stocks is relatively insignificant. A smaller SPPI means less trading volume or less deviate of the stock price from the balanced price ($P_K^i - B_K$ take a relatively small value). At this situation, the change of the stock price mainly reflects its elasticity characteristic.

We have built the stock price elasticity model in [17] as follows

$$\frac{P_{K+1} - P_K}{P_K} = \beta \frac{P_K - B_K}{P_K} + \varepsilon_K \tag{8}$$

In the model (8), P_{K+1} is the average price of the $K+1$th day, P_K the average price of the Kth day, B_K the balanced price of the Kth day, β the regression parameter and ε_K the random error term. The left side of the model (8) is the variation rate of the average price which is denoted as VRP. $(P_K - B_K)/P_K$ is the stock price elasticity index which is denoted as SPEI. The model (8) can be simplified as follows:

$$VRP = \beta \cdot SPEI + \varepsilon \tag{9}$$

The parameter β shows the size of the stock elasticity and is called the stock price elasticity coefficient. Econometric test results show in the smaller trading volume of the market and especially when the SPPC takes smaller value $\beta < 0$. This shows that the future stock

price P_{K+1} tends to move towards the balanced price B_K. If $P_K > B_K$ then $P_{K+1} < P_K$ in the statistical sense, stock prices will fall; if $P_K < B_K$ then $P_{K+1} > P_K$ in the statistical sense, stock prices will rise. At this moment, the stock balanced price changes very little and the stock price elasticity plays a major role.

Take Yian Tech (000008) for example. 20 trading days are chosen as the time window and the stock price plasticity power-exponential model (1) is also selected to calculate the SPPC α. The smallest α of the stock in a long-enough time intervals is taken as α^* and the daily locked ratio of the stock can be worked out through Formula (3). The stock price, the SPPC and the locked ratio are included in the same coordinate system so that their properties can be analyzed.

The fine solid line refers to the stock price, the imaginary line represents the decuple SPPC and the bold solid line is decuple locked ratio calculated through Formula (3). The x-axis of Figure 2 represents time, and the symbol '200007' in Figure 2 means the time of July 2000. The x-axis of the figures later in this article represents time either. The value of α^* is 0.9. From Figure 2, it can be seen that with the fluctuation of the stock price, the SPPC changed sharply. Before the stock price rises sharply, the SPPC has increased from 1.0-1.3 to 2.5-3.0 and the locked ratio has reached over 0.8; during the process where the stock price increases from 30 yuan per share to 120 yuan per share, the SPPC does not change a lot; after the stock price decreases to 75 yuan per share, the SPPC is still 3.0 before May, 2000; during the 4 months after May, the SPPC drops down to around 1.0 with a concave occurring, the stock price keeps backing and filling at a high price, and the corresponding locked ratio fluctuates and drops to round 0.3. During the steep fall of the stock price followed, the SPPC increases from 1.0 to around 2.0 and the locked ratio also rises rapidly.

Combined with the research on the stock price-volume relation, the SPPC and the locked ratio, several stocks in their up-trend are analyzed, so that some conclusions can be drawn. Figures 3-6 show some typical curves. The analysis results show that before the rise of the stock price, the SPPC increases from low values to high values, which reflects that investors are reluctant to sell their shares and that a large proportion of shares are still locked; during the dramatic rise of the stock price, the locked ratio is high, which

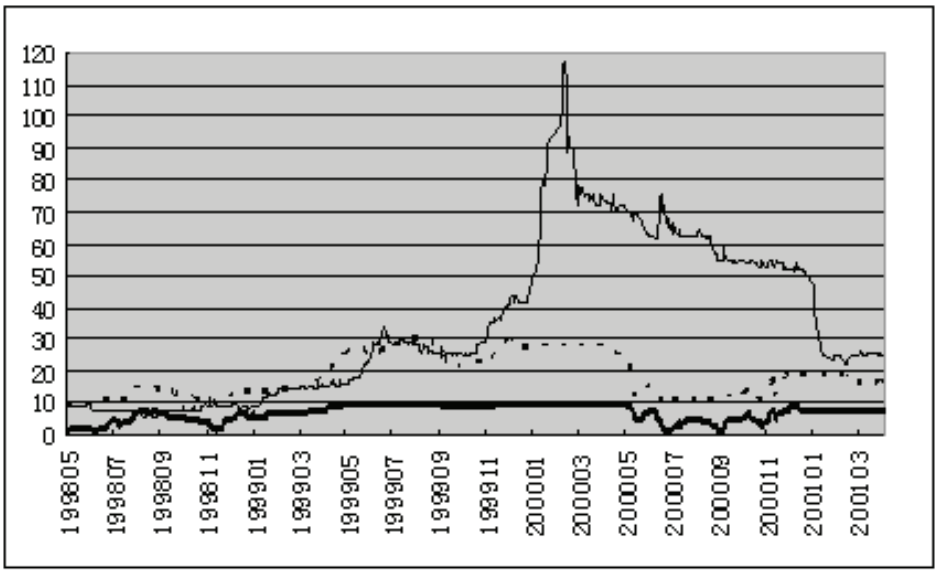

FIGURE 2. The variation curves of the stock price, the SPPC and the locked ratio of Yian Tech (000008)

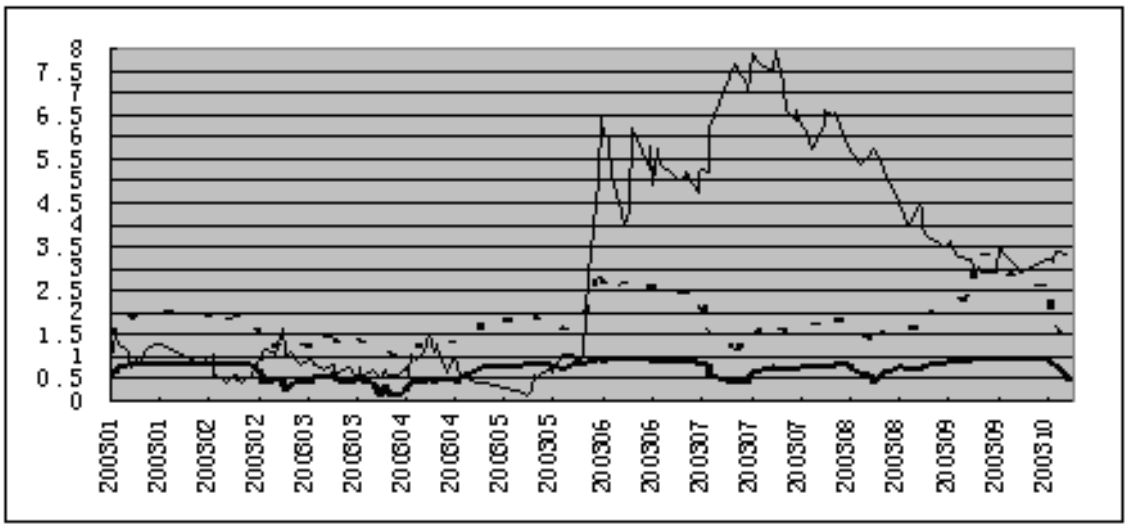

FIGURE 3. The variation curves of the stock price, the SPPC and the locked ratio of USTC Chuangxin (600551)

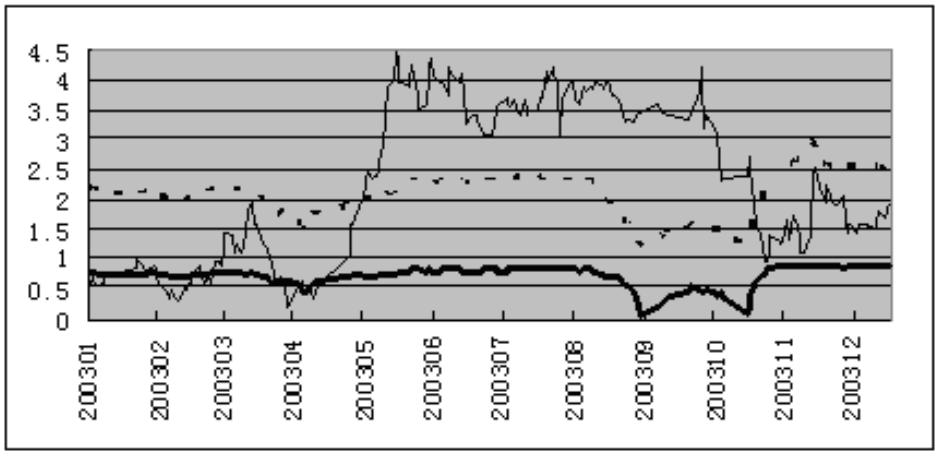

FIGURE 4. The variation curves of the stock price, the SPPC and the locked ratio of Luckyfilm (600135)

reflects the determination of investors to lock their shares. The curve of the SPPC ascends to the high position before the curve of the stock price does, and then the stock price rises while the curve of the SPPC keeps at a high level. During the fluctuation of the stock price at a high level, if the SPPC decreases dramatically all of a sudden, in most cases the stock price will drop sharply later and the SPPC will increase no matter what the price-volume trend is, and an obvious concave curve of SPPC occurs in its left position; if the SPPC does not decrease dramatically and the locked ratio is still high, usually the stock price will not slump but continue to rise. In the early stage of the bear market, the SPPC is relatively large because of the passive locking caused by the large-scale lock-in; during the long-term backing and filling at a low level, the SPPC will decrease gradually and fluctuate at a relatively low level.

Based on the plasticity and elasticity of the stock price, some qualitative prediction methods of the stock price are explored in this section using the stock price plasticity model and summarizing the calculated results of the model. The qualitative prediction is to predict the future variation trend of the stock price, including whether the stock price

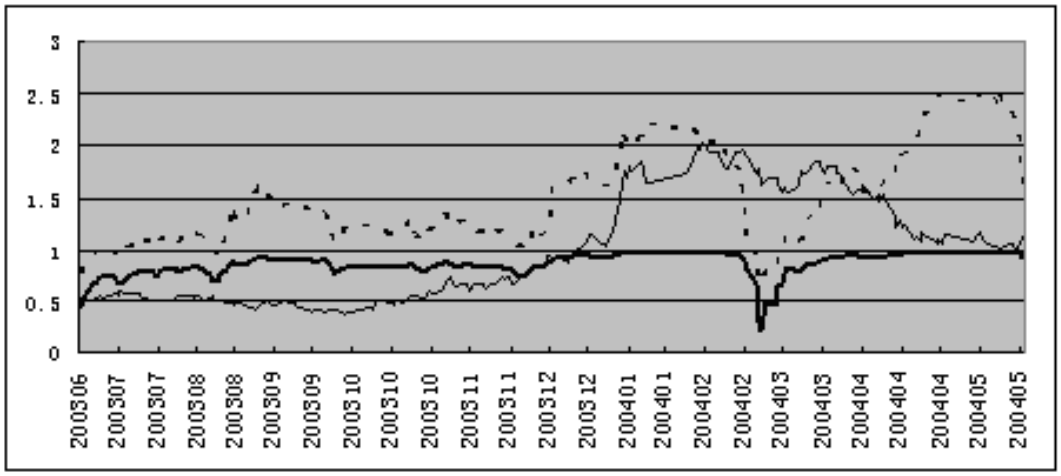

FIGURE 5. The variation curves of the stock price, the SPPC and the locked ratio of China Unicom (600050)

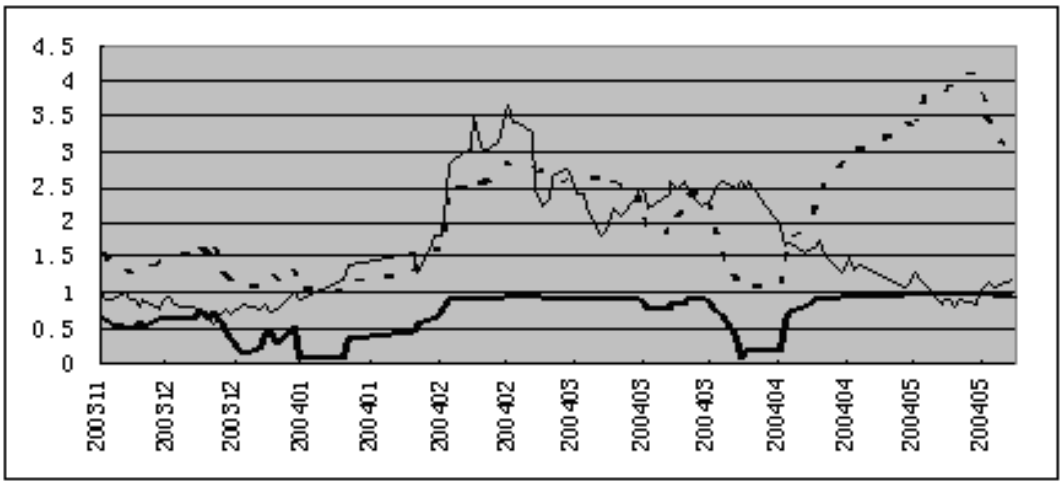

FIGURE 6. The variation curves of the stock price, the SPPC and the locked ratio of Sichuan Changhong (600839)

will rise, whether the stock price will continue to rise, whether the stock price will fall and whether the stock price will continue to fall. Every qualitative prediction result is under some conditions which are given based on the historical transaction data and the analysis of these data through plasticity and elasticity models. Several conclusions of the qualitative prediction of the stock price are listed as follows.

(1) Assume the stock price stays low and has been kept backing and filling for a long time and that the value of the SPPC is relatively small ($\alpha < 1.5$). If the trading volume increases and meanwhile the value of the SPPC stays small over a period of time, then the stock price will still keep backing and filling instead of rising sharply, despite the occurrence of the price-volume deviation that is the stock price keeps backing and filling in a tight range while the trading volume increases gradually. Under this situation, the elasticity of the stock price works.

(2) Assume the stock price stays low and has been kept backing and filling for a long time and that the value of the SPPC is relatively small. If the trading volume increases and meanwhile the value of the SPPC rises gradually over a period of time and stays high, such as $\alpha > 2.0$, then the stock price may rise sharply at any time.

(3) The surge in the stock price is nearly always accompanied with the characteristic that "the SPPC stays high and stable". If the SPPC increases and stays high and meanwhile the stock price starts to rise, then either the stock price continues to rise or the stock price keeps backing and filling at a high level. It is almost impossible for the stock price to slump.

(4) After rising for some time, the stock price becomes weak, some of the stock shares are sold off and the stock price falls back slightly or keeps backing and filling at a high level. If the value of the SPPC is still high ($\alpha > 2.5$), the stock price will not slump suddenly and it is usually a start of a stronger sharp rise.

(5) After rising sharply for some time, the stock price becomes weak, some of the stock shares are sold off and the stock price falls back slightly or keeps backing and filling at a high level. After the stock price keeps backing and filling for some time or drops slightly, if the stock price fluctuates in a tight range and the SPPC decreases dramatically and stays low, investors should be on high alert and pay attention to the duration in which the value of the SPPC is small, because it probably means the end of the bull market. If the value of the SPPC is small and the duration is longer, at the same time the stock price stays high, the phenomenon that the SPPC raises sharply and rapidly is usually an omen of the slump of the stock price. There is a meaningful phenomenon that for nearly every entire up-trend, an obvious concave curve of the SPPC will always occur before the stock price slumps.

(6) If the stock price drops continuously and the SPPC rises rapidly, the stock price will continue to drop regardless of whether the trading volume increases effectively or not; if a concave of the curve with large depth and large time width occurs in the recent period, this means institutional investors have sold off their shares at high price and the stock price will probably start a downtrend.

(7) During the backing and filling at the low level, the stock price often rises or falls slightly suddenly and there is no effective increase in the trading volume. If only the SPPC still stays low, then the rise or fall of the stock price will last for several days but end soon, that is, the rising stock price will fall back or the falling stock price will rally. Under this situation, the elasticity of the stock price works and the strong rise of the stock price usually does not occur. Before the start of the up-trend, it is nearly inevitable that a sharp rise in the SPPC will occur firstly.

6. **The Comparison among Different Stock Markets through the Stock Price Plasticity Model.**

In this section, the concept of plasticity and elasticity of the stock price and their models are used to compare the change laws of the stock price and the SPPC in different stock markets, including the quantitative calculation and qualitative analysis. Additionally, this section also explains the similarities and obvious differences on different stock markets.

With a long history, US stock market and Hong Kong stock market have relatively normative market operation and sound systems. Moreover, in these stock markets, institutional investors are the leading force and their comprehensive quality is relatively high. Therefore, US stock market and Hong Kong stock market are mature capital markets. Chinese stock market is a burgeoning capital market and the size of Chinese stock market realizes the hyper-normal rapid development. There must be many differences between Chinese stock market and mature stock markets. The SPPC and locked ratio calculated by the stock price plasticity model are used to compare Chinese stock market and mature stock markets.

In mature stock markets, the long-term investment strategy of big institutional investors accounts for the larger proportion of the locked quantity of stocks, especially those blue

chip stocks. In mature stock markets, dramatic fluctuations in the stock price should reflect the change of many factors in the economic field. As a burgeoning capital market, Chinese stock market has many speculation opportunities and most locked shares are the ones hoarded by the short-term market makers to manipulate stock prices. Therefore, the locked quantity of manipulated stocks shows periodic dramatic fluctuations.

From the perspective of the theoretical analysis, the following conclusion can be drawn: in the stock market with an obvious speculative atmosphere, the connection between the stock price and economic factors is relatively weak, it is easy for the prices of the stocks to rise or fall together, the prices of the stocks which are generally considered better may stay low for a long time and the prices of the stocks which are generally considered worse may often increase sharply; investors are keen on pursuing hotspots, following market makers and making short-term trading, the long-term investment strategy is considered unwise; the stocks are continuously locked at high proportion and then sold off, which is embodied in the phenomenon that the SPPC changes more frequently and sharply. In the mature stock markets without an obvious speculative atmosphere, such as US and Hong Kong stock markets, the connection between the stock price and economic factors is relatively strong, it is not easy for the prices of the stocks to rise or fall together and the potential investment value and risks of listed companies are explored continuously. The value discovery and risk distribution of the stock markets are embodied in the reasonable adjustment of the stock price, and the genuine blue chip stocks will continue to rise steadily in the bull market and have strong ability to resist the slump of the stock price in the bear market. In the mature stock market, the locked ratio of stocks is stable, which indicates that the SPPC changes slowly and slightly. Especially for those blue chip stocks, the locked ratio should possess more obvious characteristics.

The large-scale and good-liquidity stocks in Chinese mainland stock market, US stock market and Hong Kong stock market are selected to conduct empirical research. Table 1

TABLE 1. The sample stocks of Chinese mainland stocks, US stocks and Hong Kong stocks

	Ticker symbol	Stock name	The quantity of current tradable shares
Chinese mainland stocks	600002	Qilu Petrochemical Corp.	350,000,000
	600030	CITIC Securities	400,000,000
	600050	China Unicom	6,500,000,000
	600005	Wuhan Iron & Steel	1,896,000,000
	600036	China Merchants Bank	1,800,000,000
	600812	North China Pharmaceutical Group	469,268,600
US stocks	intc	Intel Corporation	6,322,999,300
	jpm	JP Morgan Chase & Co.	3,562,463,000
	dis	Walt Disney Company	2,054,585,100
	ba	Boeing Co.	839,597,100
	hd	The Home Depot, Inc.	2,195,954,900
	gm	General Motors Corporation	565,502,976
Hong Kong stocks	0002	CLP HOLDINGS	2,408,245,900
	0005	HSBC HOLDINGS	11,190,097,119
	0006	HK ELECTRIC	2,134,261,654
	0293	CATHAY PACIFIC AIR	3,372,326,848

lists all the stocks used in this section: the Chinese mainland stocks are all selected from the sample stocks of the SSE 50 index and the US stocks are all selected from the sample stocks of the Dow Jones index.

The historical transaction data of Chinese mainland stocks and US stocks from Dec. 1, 2003 to Nov. 26, 2004 are selected, 20 trading days are chosen as the time window, the balanced price is replaced by the 10-day average price, and the stock price plasticity power-exponential model is used to estimate the SPPC. The historical transaction data of Hong Kong stocks from Jun. 23, 2003 to Jun. 23, 2004 are chosen to estimate the SPPC. According to the calculated results, the SPPC α of all sample stocks can pass the t-test and satisfy $\alpha > 0$, that is, all of them can pass the economic test, and the goodness of fit of the model is around 0.6, which indicate that the stock price plasticity power-exponential model can be applied to the US stock market and Hong Kong stock market.

The research work about the comparison among different stock markets through the stock price plasticity model has been done in 2005; however, these results have not been published. Considering the stability of the relationship between the stock price and the trading volume in stock market, we did not do these research works again using the data of recent years.

The overall trends of the SPPC of Chinese mainland stocks, US stocks and Hong Kong stocks over time are shown in Figures 7-11.

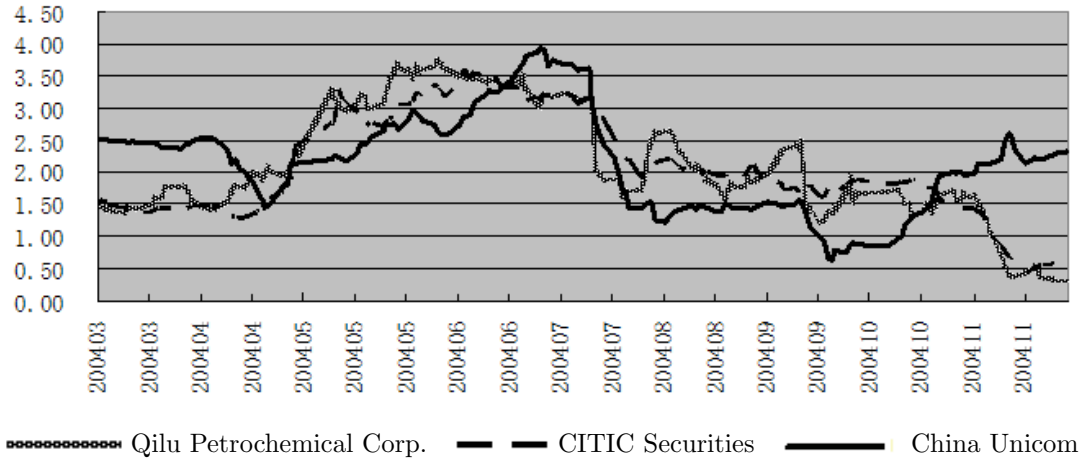

FIGURE 7. The curve of the SPPC of some Chinese mainland stocks

The characteristics of the SPPC of US stocks are studied first from Figures 9 and 10. There is a rise of the stock market in the researched time interval, but the variation range of the SPPC is not large and the variation is relatively stable. The SPPC of JP Morgan Chase & Co. is mainly in the range of 2.5 to 3.5 and its average value is greater than that of the other US stocks. According to the conclusion drawn in the analysis of the locked quantity, the long-term locked ratio of JP Morgan Chase & Co. is higher than that of the other US stocks. The SPPC of General Motors Corporation is mainly in the range of 1.3 to 2.5 and its average value is less than that of the other US stocks, which means that the long-term locked ratio of General Motors Corporation is lower than that of the other US stocks.

The characteristics of the SPPC of several Hong Kong stocks are studied from Figure 11. The SPPC of HSBC is obviously greater than that of the other Hong Kong stocks, which indicates that the long-term locked ratio of HSBC is higher than that of the other stocks, which means that stock HSBC is the one heavily held by many institutional investors for

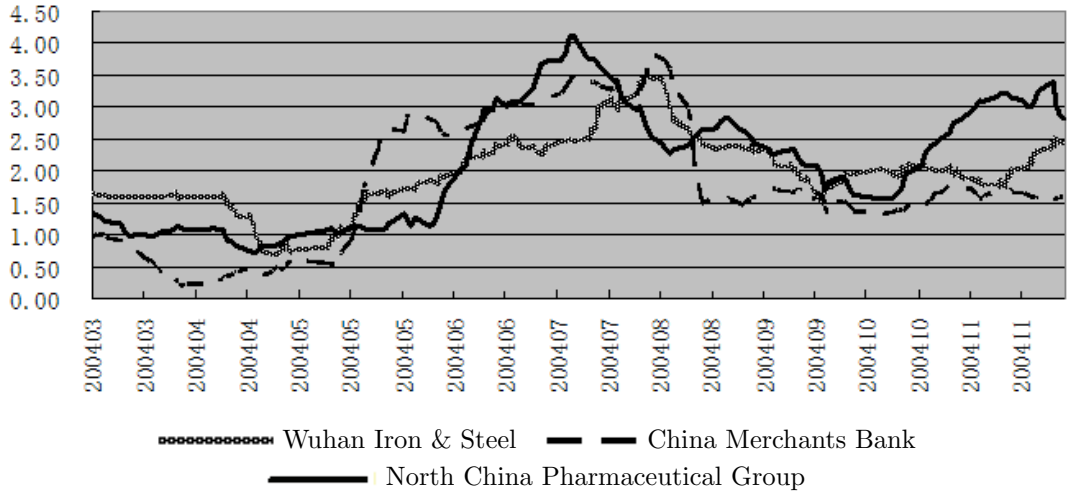

FIGURE 8. The curve of the SPPC of some Chinese mainland stocks

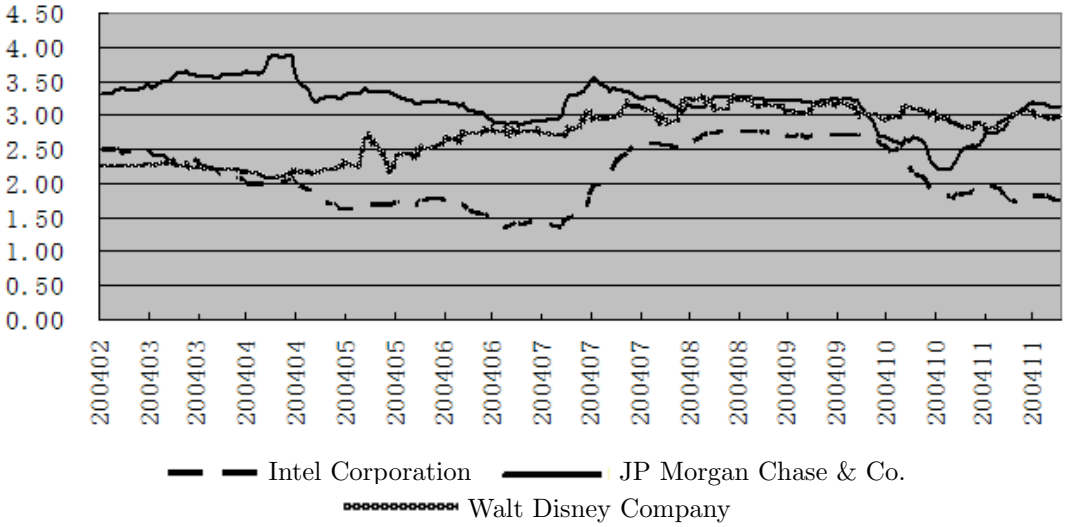

FIGURE 9. The curve of the SPPC of some US stocks

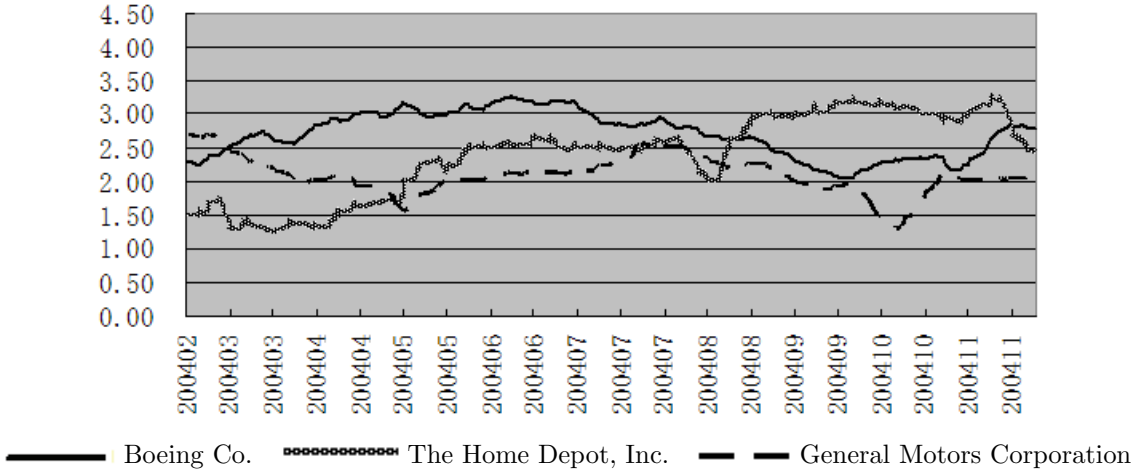

FIGURE 10. The curve of the SPPC of some US stocks

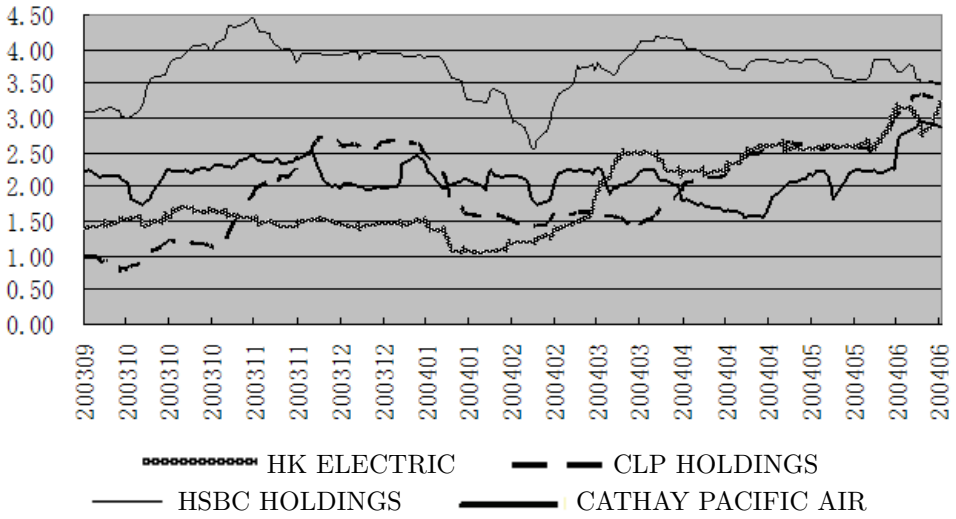

FIGURE 11. The curve of the SPPC of some Hong Kong stocks

a long time. The SPPC of CATHAY PACIFIC AIR fluctuates slightly and is in the range of 1.5 to 3.0, which shows that there are few speculation opportunities. In contrast, the fluctuation range of the SPPC of the other two Hong Kong stocks CLP HOLDINGS and HK ELECTRIC is larger, which indicates that a certain amount of speculative capital is being operated.

The characteristics of the SPPC of the six Chinese mainland stocks are very obvious from Figures 7 and 8, that is, they share the similar fluctuation patterns and have a large amplitude and have similar fluctuation ranges (0.8-4.0), which means that the differences among them are small, the speculative atmosphere is obvious and is no sign that any one of them is heavily held by many institutional investors for a long time.

According to the analysis and summary of calculated results of the SPPC of Chinese mainland stocks, US stocks and Hong Kong stocks, the SPPC of US stocks and Hong Kong stocks are relatively stable. There are obvious differences in the variation trends of the SPPC of different sample stocks. The SPPC of Chinese mainland stocks fluctuates sharply and the variation trends of the SPPC of different sample stocks are similar. Institutional investors are the leading force in US and Hong Kong stock markets and the locked quantity of stocks is mainly caused by the buy-and-hold strategy of institutional investors, so the locked quantity is relatively stable. Moreover, different stocks differ in performance and the share proportions of institutional investors are different. So there are big differences in the locked quantity of these stocks. In Chinese mainland stock market, there are many speculation opportunities and the locked quantity of stocks is mainly caused by the short-term buy of market makers, so the locked quantity fluctuates sharply. In addition, the locked quantity of stocks generally changes with the market situation instead of the performance of listed companies, and thus the variation trends of the locked quantities of different sample stocks are basically the same. The calculated results of the SPPC of Chinese mainland stocks, US stocks and Hong Kong stocks are relatively consistent with the results of the theoretical analysis.

7. **Conclusion.** By using the stock price plasticity power-exponential model and the computing method of sliding time window, the locked quantity of stocks is studied in this paper, the composition of the locked quantity is analyzed carefully, the properties with the locked quantity equal to 0 are discussed, and the theoretical formula of the locked quantity of stocks is obtained. The theoretical formula reflects the positive correlation between the

locked quantity and the SPPC. Based on the formula of the locked quantity, the basic stock price plasticity equation is proposed. In addition, according to many calculated results of models, several statistical conclusions of the qualitative prediction of the stock prices are put forward. These qualitative prediction conclusions are based on the relation between the stock price and the SPPC and the characteristic of plasticity and elasticity of stock price. This paper also uses the stock price plasticity power-exponential model to compare the international stock markets. It indicates that, compared with the mature stock markets, Chinese mainland stock has obvious speculative nature, while some stocks are characterized by the long-term investment in mature stock markets. Some further research work needs to do for the basic stock price plasticity equation about the stability of the SPPC with the locked quantity equal to 0 for different stocks.

Acknowledgment. The authors gratefully acknowledge the helpful comments and suggestions of the reviewers, which have improved the presentation.

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