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Shanghai Stock Prices as Determined by the Present-Value Model[1]

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Derived from the present-value model of stock prices, our model implies that the log stock price is a linear function of expected log dividends and the expected rate of growth of dividends where expectations are formed adaptively. The model explains very well the prices of 47 stocks traded on the Shanghai Stock Exchange observed at the beginning of 1996, 1997, and 1998. The estimated parameters are remarkably similar to those reported for stocks traded on the Hong Kong Stock Exchange and the New York Stock Exchange. *J. Comp. Econom.,* September 1999, **27**(3), pp. 553–561. Princeton University, 203 Fisher Hall, Princeton, New Jersey 08544-1021 and Shandong University, People's Republic of China

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1. INTRODUCTION

Whether prices of stocks traded on the Shanghai Stock Market can be explained by the same theory as prices in mature markets such as the New York Stock Exchange and the Hong Kong Stock Exchange is an interesting question. Soon after the establishment of the People's Republic of China in 1949, trading of stocks ceased to exist. Stocks were first traded on the Shanghai Stock

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Exchange in 1992. From 1978, China was in the process of transformation from a planned economy to a market economy and 1992 was also the year in which the Central Committee of the Chinese Communist Party declared China's economy to be a socialist market economy. At the beginning of 1998, when the research reported in this paper began, there were only five full years from 1993 to 1997 to observe the behavior of stock prices in the Shanghai Stock Exchange. During this period, the market participants in China presumably were learning about the market. Skeptics of this research might argue that the Chinese investors were not well informed because they were not well educated or that the financial market data were insufficient or even inaccurate. However, one cannot argue against the application of the present-value model to the Shanghai stock market data on such a priori grounds. Whether or not a hypothesis is correct is determined by statistical testing. Hence, it is interesting to investigate whether the prices in Shanghai follow the same patterns as observed in mature markets by econometric analysis.

The model of stock price determination adopted in this paper was first used in Chow (1958). It is based on the present-value model that states that the price of a stock at the beginning of time t is the sum of the expected discounted values of all of its future dividends. Since future dividends are uncertain, Chow (1958) proposes to summarize them by only two parameters, namely the expected level $E_t d_t$ and the expected growth rate $E_t g_t$, where E_t denotes the expectation conditional on information available at the beginning of year t, d_t denotes the natural logarithm of dividend D_t distributed during year t, and g_t denotes $d_t - d_{t-1}$. These expectations are assumed to be formed adaptively using past data, as specified in Section 2 where the model of stock prices is formulated. Section 3 presents the empirical results for 47 stocks in the Shanghai Stock Exchange, most of which entered the market after 1992. Section 4 compares the results with those observed from the Hong Kong Stock Exchange as reported in Chow and Kwan (1997) and the New York Stock Exchange as reported in Lin (1998). Section 5 concludes.

2. A MODEL OF STOCK PRICE DETERMINATION

Our model of stock price determination can be derived from the present-value model as follows. Given a constant discount rate r, the present value model is

$$P_t = E_t \sum_{s=0}^{\infty} D_{t+s}/(1 + r)^{s+1},$$

where P_t is the price of a stock at the beginning of period t, D_t is the forthcoming dividend during period t, and E_t is the expectation conditioned on information at the beginning of period t. If the expected dividend is assumed to grow at a constant rate g so that $E_t D_{t+s} = (E_t D_t)(1 + g)^s$, the above model becomes

$$P_t = \sum_{s=0}^{\infty} (E_t D_t)(1 + g)^s/(1 + r)^{s+1} = (E_t D_t)/(r - g),$$

where the sum of the infinite geometric series with terms $[(1 + g)/(1 + r)]^s$ is finite if and only if $g < r$. This assumption is made because one cannot expect a permanent growth rate g to exceed the rate of discount r; otherwise the price of the stock would be infinite. Taking logarithms, we obtain, for values of $r - g$ much smaller than one,

$$\ln P_t = \ln(E_t D_t) - \ln(r - g) \simeq \ln(E_t D_t) - 1 - r + g,$$

where both $\ln(E_t D_t)$ and g have to be estimated.

We assume that $\ln(E_t D_t)$ is a linear function of the adaptive expectation of $\ln D_t = d_t$ for the forthcoming period and that the permanent expected growth rate g is a linear function of the adaptive expectation of $g_t = d_t = d_{t-1}$ for the forthcoming period. The adaptive expectations for the forthcoming period are formed by

$$E_t d_t = E_{t-1} d_{t-1} + c(d_{t-1} - E_{t-1} d_{t-1}) = c[1 - (1 - c)L]^{-1} d_{t-1}$$

$$E_t g_t = E_{t-1} g_{t-1} + b(g_{t-1} - E_{t-1} g_{t-1}) = b[1 - (1 - b)L]^{-1} g_{t-1}, \quad (1)$$

where L denotes the lag operator, $L d_t = d_{t-1}$. Under our assumptions, the present-value model for the logarithm p_t of stock price at the beginning of period t becomes

$$p_t = \delta \cdot E_t d_t + \alpha \cdot E_t g_t + \gamma^*. \quad (2)$$

The coefficient α in Eq. (2) is expected to be smaller than the coefficient δ because g_t is the growth rate for only one year whereas g in the original model represents a permanent expected growth rate.

Multiplying Eq. (2) by $[1 - (1 - b)L][1 - (1 - c)L]$ and substituting for $E_t d_t$ and $E_t g_t$ from Eq. (1), one obtains the following model for p_t.

$$p_t = \beta_1 p_{t-1} + \beta_2 p_{t-2} + \beta_3 d_{t-1} + \beta_4 d_{t-2} + \beta_5 d_{t-3} + \gamma \quad (3)$$

where $\gamma = \gamma^* bc$, $\beta_1 = (1 - c) + (1 - b)$, $\beta_2 = -(1 - c)(1 - b)$, $\beta_3 = c\delta + b\alpha$, $\beta_4 = -c\delta(1 - b) - b\alpha(2 - c)$, and $\beta_5 = b\alpha(1 - c)$. Note that all data on stock prices and dividends are in constant prices, which are formed by dividing data in current prices by an appropriate general price index. Since the five coefficients $(\beta_1, \beta_2, \ldots, \beta_5)$ in (3) are derived from four structural parameters, b, c, δ, and α, there is one nonlinear restriction on the coefficients $(\beta_1, \ldots, \beta_5)$. Equation (3) is a linear function of the five coefficients $(\beta_1, \ldots, \beta_5)$ but a nonlinear function of the four parameters (b, c, δ, α). It will be estimated by the method of nonlinear least squares, which minimizes the sum of

squared residuals with respect to the four parameters. The nonlinear restriction will also be tested.

The literature on the present-value model relevant to the above formulation includes, among others, Chow (1958), Gordon (1962), Campbell and Shiller (1987), Chow (1989), Barsky and Delong (1993), and Donaldson and Kamstra (1996). Chow (1958) proposes and estimates Eq. (2). Gordon (1962) studies an equation $D_t/(r - g_t)$ where D_t is current dividend, whereas our formula is based on expected dividend E_tD_t. The remaining four references all combine the present-value model with a particular model for the time series of dividends under rational expectations. While both Campbell and Shiller (1987) and Chow (1989) find strong statistical evidence for rejecting such a model, Chow (1989) also finds strong statistical evidence in support of the present-value model combined with adaptive expectations. This paper reports additional evidence on the present-value model combined with adaptive expectations.[2] Note that the time series on dividends for Shanghai stocks are very short, making it difficult to estimate time-series models for dividends under rational expectations.

3. EMPIRICAL FINDINGS FROM THE SHANGHAI STOCK EXCHANGE

For a Chinese enterprise to issue stocks to be traded on the Shanghai or the Shenzhen Stock Exchange, an application has to be submitted to the Stock Exchange Regulation Commission in Beijing for approval. The application contains important financial data about the enterprise, including balance sheet data and profit and loss statements to the extent available. The application must first be approved by a provincial or local authority before submission to the above commission. The main criteria for approving the application are the company's performance, the clarity and reliability of its financial reporting, and the need for its financing according to the objectives of China's economic development program. Hence, the opening of the Shanghai Stock Exchange is part of the Chinese economic reform and economic development process. One important aspect of enterprise reform has been to restructure the state enterprises into modern corporations. The large and well-managed ones have shares that are traded publicly. Many medium-size state enterprises have become share-holding companies but their shares are traded only internally among staff and workers of the enterprises. Most state enterprises are not qualified according to the above mentioned criteria to be traded on the Shanghai Stock Exchange, as admission to the Exchange is very strict. According to the authors' conversations with many enterprise managers, many more enterprises wish to raise capital by issuing stocks than are approved by the authorities. The criteria for admission were determined in order to promote China's economic reform and development. In

[2] Data are available upon request for readers who wish to apply rational expectations.

TABLE 1

List of Companies and Observation Numbers

	Companies	'96	'97	'98		Companies	'96	'97	'98
1	Tsingtao Brew	3	2	1	25	Shanghai Hero		39	
2	Shanghai Pechem		5	4	26	Guangzhou Ship		41	40
3	Qingdao Haier		7	6	27	Yuyuan Tourist	44	43	42
4	Fujian Cement		9	8	28	Huallian Corp		46	45
5	N. China Pharm		11	10	29	Pudong Da Taxi		48	47
6	Changhong Elec		12		30	Jinqiao Export		50	49
7	Jiangsu Chunlan			13	31	Wai Gao Qiao			51
8	Tonghua Dongbao		14		32	Harbin Pharm			52
9	Yizhen Chem			15	33	Jinan Qinqi			53
10	Guomai Ind Co		17	16	34	Tianjin Global			54
11	Shen Ergy Co		19	18	35	Dongfang Elec			55
12	AJ Co		21	20	36	Tibet Pearl			56
13	Eastern Comms			22	37	Star Lake			57
14	Mei Yan		24	23	38	Meng Dian			58
15	Xinjiang Tebian			25	39	Shanghai Haixin		60	59
16	Guangzhou Steel			26	40	Urban & Rural			61
17	First Provision		28	27	41	P&T Equip Co			62
18	Hangzhou Jiefang		30	29	42	Xiamen Eng Mach			63
19	Lansheng Corp			31	43	Kunming Machine			64
20	Wangfujing Group			32	44	Maanshan Iron		66	65
21	Lujiazui Develop			33	45	Chlor Al Kali	69	68	67
22	Dazhong Taxi	36	35	34	46	Shanghai 3F			70
23	East China Computer		37		47	Tian Qiao Dept		72	71
24	Shanghai Tongji		38						

practice, however, there could be political influence or even corruption as in any situation requiring approval of government officials; there could also be falsification of data. Yet the strict admission standard has the effect of making the information on the enterprise's performance available to the public and thus enabling the investors to make decisions according to the present-value model.

There is a Shanghai Index of 30 representative stocks, similar to the Hang Seng index of the Hong Kong Stock Exchange and the Dow Jones Index for industrial stocks of the New York Stock Exchange. All three indices consist of blue-chip stocks. We decided to include in our sample only the stocks listed in the Shanghai index for the purpose of comparing the results of our study with similar studies using the stocks included in the other two indices. In the first stage of our study, we were able to obtain data for only 22 of the 30 companies included in the above Shanghai index. These are the first 22 companies listed in Table 1, which provided data for at least 3 years prior to the beginning of 1998 as required by Eq. (3) with three lagged dependent variables. According to Eq. (3), dividend data for at least the years 1995, 1996, and 1997 are required to

explain the price of a stock at the beginning of 1998. Only two of these 22 companies have data from 1993 on, which provides three observations for each. Two observations are available for each of 10 companies and one observation only is available for the remaining 10. Hence, the total number of observations from the first stage of our study is 36. The results obtained using these 36 observations were similar to those reported in column one of Table 2 and supported the present-value model as formulated here but the standard errors of the estimates were larger because of the small sample size. Therefore, in the second stage, we decided to obtain more data. Many companies are excluded from our sample because they did not declare any dividends for three consecutive years in the period we study, as required in the estimation of Eq. (3). We succeeded in obtaining data for 25 additional companies, i.e., those listed in Table 1 after number 23, consisting of 36 observations. Hence, the total number of observations is 72. All data are divided by the retail price index for conversion to constant price figures.

Many companies in the sample did not issue dividends in cash. When dividends were issued in the form of stocks, the market value of the stock-dividend after the issue was treated as the dividend. The price of the stock itself was adjusted to reflect the larger number of shares. For example, if there were one million shares selling at \$10 per share before the issue of stock-dividend, and two shares were given for 100 old shares, the price after the issue would be close to \$10/1.02 and the dividend per share was treated as 0.02 (\$10/1.02). The price per old share was converted to (10/1.02), or whatever the market price of the post-dividend share was, times 102/100. In the above example, if the same stock dividend were conditioned on the share owner paying \$0.01 for each share issued, the value of dividend per share would be 0.02 (\$10/1.02)-0.01. Many such calculations were made in the data. After the dividend data are divided by the retail price index, many companies show decreasing dividends in constant prices, because the retail price index at the end of 1993 to 1997 were respectively 1.132, 1.378, 1.582, 1.687, and 1.695, showing an increasing trend. However, this does not affect the testing of our hypothesis that the logarithm of stock price is positively correlated with the expected growth in log dividend.

Using the 72 observations on the prices of stocks of 47 companies at the beginning of possibly 1996, 1997, and 1998, we estimate seven parameters, i.e., b, c, δ, α, and three year dummies, and the residual variance of the nonlinear regression function (3), where γ was changed to γ('96), γ('97), and γ('98) to capture the time effect. The nonlinear regression routine minimizes the sum of squared residuals of the regression function (3) including three time dummy variables with respect to (b, c, δ, α, $\gamma(96)$, $\gamma(97)$, $\gamma(98)$). The coefficients ($\beta_1, \ldots, \beta_5$) are found by the relations given below Eq. (3).

Table 2 summarizes the results from estimating the nonlinear regression function (3) using the 72 observations on stocks traded on the Shanghai Stock Exchange. It also presents the results of Chow and Kwan (1997) from estimating

TABLE 2

Estimates of Paramaters of Eq. (3) Explaining Log Stock Price

Shanghai 1996–1998 (47 firms; 72 observations)	Hong Kong 1982–1993[a] (17 firms; 204 observations)	United States 1953–1998[b] (30 firms; 1380 observations)
$b = 0.9321$ (.1221)	$b = 0.8695$ (.1281)	$b = 0.8690$ (.0352)
$c = 0.2993$ (.0845)	$c = 0.5708$ (.1081)	$c = 0.1520$ (.0352)
$\alpha = 0.0569$ (.0495)	$\alpha = -0.0115$ (.0532)	$\alpha = 0.1809$ (.0367)
$\delta = 0.5722$ (.1687)	$\delta = 0.5668$ (.0696)	$\delta = 0.7323$ (.0675)
$\beta_1 = 0.7636$	$\beta_1 = 0.5597$	$\beta_1 = 0.9332$
$\beta_2 = -0.0731$	$\beta_2 = -0.0560$	$\beta_2 = -0.0723$
$\beta_3 = 0.1847$	$\beta_3 = 0.3135$	$\beta_3 = 0.3192$
$\beta_4 = -0.0702$	$\beta_4 = -0.0279$	$\beta_4 = -0.2957$
$\beta_5 = 0.0977$	$\beta_5 = -0.0043$	$\beta_5 = 0.0696$
$R^2 = 0.7848$ $s = .2635$	$R^2 = 0.7011$ $s = .2177$	$R^2 = 0.9112$

[a] Chow and Kwan (1997, Tables 1 and 2).
[b] Lin (1998, Tables 3-3 and 3-4).

the same regression function using data on 15 companies for the years 1985 to 1993 traded on the Hong Kong Stock Exchange and included in the Hang Seng Stock Price index, with a total of 112 observations and including additional company dummy variables, each for one of the 14 companies. Table 2 also includes results of Lin (1998) from estimating the same regression using data on 30 companies included in the Dow Jones Industrial Average in January 1998 for the years 1953–1998 with a total of 1380 observations and including both time and company dummy variables. In the Shanghai sample, there are simply not sufficient observations to introduce company dummy variables. The standard deviation of regression residuals, s, is slightly lower for Hong Kong partly because there are company dummy variables.

From the first column of Table 2, one observes that both adjustment coefficients b and c in the adaptive formation of expected rate of growth and expected level of log dividend, respectively, are between zero and one. Both expected variables have a positive effect on log stock price, as our model predicts. The standard errors of the parameter estimates are given in parentheses. The relative weights of expected growth and expected level of dividends in the determination of log stock price are as given by α and δ. The estimate of α is much smaller than the estimate of δ, as theory predicts. The point estimates of the β_i coefficients are unconstrained least squares estimates provided for reference. Although our sample is small compared with the samples in the other two studies, Table 2 shows that the parameters are fairly precisely estimated as judged by the standard errors. Our results show that the present-value model, as formulated in this paper, explains the data well.

One can test the hypothesis that our model of stock price determination is

correct by testing that the set of nonlinear restrictions on the coefficients of regression function (3) is correct. The sum of squared residuals of the unrestricted linear regression with $\beta_1, \ldots, \beta_5$ $\gamma(96)$, $\gamma(97)$, $\gamma(98)$ as coefficients, denoted B, equals 4.3893 with $72 - 5 - 3 = 64$ degrees of freedom. The sum of squared residuals of the restricted nonlinear regression (3) with the same three year dummies, denoted A, equals 4.5128 with $72 - 4 - 3 = 65$ degrees of freedom. Assuming normally distributed residuals, the statistic $(A - B)/(B/64)$ is distributed as $F(1,64)$. Since the observed value is $(4.5128 - 4.3893)/(4.3893/64)$ or 1.801, smaller than the critical value for rejecting the null hypothesis at an 18% level, we find statistical evidence supporting our model of stock price formation. The year dummies $\gamma(t)$ for the beginning of 1996, 1997, and 1998 are, respectively, .852, 1.229, and .524. These are the time effects on the prices of Shanghai stocks net of the dividend effects. They reflect the optimism at the beginning of 1997 as compared with 1998, and the pessimism of 1998 as compared with even 1996.

4. COMPARISON WITH FINDINGS FOR HONG KONG AND NEW YORK STOCKS

As pointed out, Table 2 also presents estimates of Eq. (3) using the data on stocks traded on the Hong Kong Stock Exchange and on the New York Stock Exchange. First, we note the remarkable similarity in the three sets of estimates of the unrestricted β coefficients and the four structural parameters. The behaviors of these markets are strikingly similar according to our model in spite of their institutional differences. The adjustment coefficient b in forming expectation for the growth rate g is high in all three cases, reflecting the importance of the most recent growth rate. The smaller adjustment coefficient c in forming expectations for the level of log dividend in all three cases reflects the importance of past levels. The coefficient δ of $E_t d_t$ is in all cases larger than the coefficient α of $E_t g_t$ as expected from our theory because the latter should not have a large influence on the permanent expected growth rate g. Perhaps the estimate of α, which measures the importance of the projected rate of growth of dividends is slightly lower for Hong Kong than for Shanghai, although not significantly so. This may reflect the lack of confidence on the part of investors that past growth in dividends of a Hong Kong company, which contributes to a positive expected growth variable in our model, could not be projected into the future as the transfer of sovereignty of Hong Kong to the Chinese government in 1997 approached. The estimate of α for Shanghai is low as compared with the estimate for the U.S., possibly reflecting the uncertainty on the part of investors in projecting a short-history of growth rates for the newly listed companies in Shanghai into the future, whereas in a mature and stable economy like the U.S., dividend behavior of the companies included in the Dow Jones Industrial

Average was observed for a long time and could serve as a reliable indicator for future divident growth.

5. CONCLUSION

The main purpose of this paper is to provide an explanation of prices of stocks traded in the Shanghai Stock Exchange. From Table 2, our results are remarkably consistent with the present-value model of stock prices as implemented by choosing $E_t \log D_t$ and $E_t \Delta \log D_t$ as the two most important parameters and assuming that these expectations are formed adaptively. The results are encouraging because the Shanghai Stock Exchange is new, starting only in 1992, and because Chinese investors have been allowed to buy stocks only since the early 1990's. This same model, which explains prices of stocks traded in mature stock markets in Hong Kong in the 1980's and 1990's as reported in Chow and Kwan (1997) and in the United States as reported in Chow (1958) and in Lin (1998) is found to be applicable to prices of stocks traded in a developing economy where investors are just beginning to learn how to buy stocks and the economic institutions are otherwise very different. For future research, it would be interesting to find out whether the prices of the B shares of the same companies traded in Shanghai, insofar as these B shares exist, and of the shares traded in the Shenzhen Stock Exchange reveal similar behavior.

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