Does Microtherm boost Pharmaceutical Stock Prices?

Chien-Chung Nieh* **Yu-Sheng Kao**** **Hannibal Sun*****

Abstract

The purpose of this study is to survey the relationship between the temperature factor and pharmaceutical capitalization returns by analyzing both the daily and weekly frequency data. The threshold regression model with the GJR-GARCH process was applied for examination in this study; we find that pharmaceutical capitalization returns can be boosted after exposure to extremely cold temperatures for a period of time. Besides, the delayed effect of cold weather is demonstrated to exist. This phenomenon can be illustrated by epidemiological evidence-related mental factors, not by traditional behavioral finance. Lower weekly average temperatures are beneficial for investors to gain weekly pharmaceutical capitalization returns. We are of the opinion that our findings offer an insightful suggestion for investors to buy pharmaceutical stocks at an opportune moment.

Keywords: Microtherm, Pharmaceutical Stock, Threshold Model, GJR-GARCH

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1. Introduction

The pharmaceutical industry is a knowledge-intensive industry where patents play a principal role in bringing new products to the market. The main characteristics of this industry consist of the following components: high capital input, high failure rates of lab products, long return periods, and monopoly protection. Since the 1970s, pharmaceutical manufacturing has become greatly concentrated with several large corporations holding a ruling position throughout the world and with a few firms making medicines within each country, which is due in part to the fact that only large enterprises can afford the high expenditures of pharmaceutical research and development (R&D) (Boldrin and Levine, 2006). The pharmaceutical industry contributes vastly to national health. The research, exploitation and effective exertion of drugs have improved many people's quality of life and rescued many lives from the threats of a variety of diseases and injuries. For such an important industry, a detailed exploration for its key success factors by the performance of pharmaceutical stocks is quite rational.

A few specific situations that can alter the trend of pharmaceutical stocks have been identified in the past. The pharmaceutical sector has had historically parallel or worse performance compared with the others in the market indices during the period of the collapse of the stock markets (Skrepnek *et al*. 2007), and potential threats of drug price regulation can adversely affect the performance of stock prices and firm-level R&D expenditures (Golec *et al*. 2010). The mean and the volatility of pharmaceutical sector returns will augment if a rightist party is about to hold the reins of a government (Bechtel *et al*. 2010). EU countries implement a more rigid pharmaceutical price control than the US, hence the US enterprises reap more benefits, spend more on R&D, and gain better stock returns (Golec *et al*. 2010). An important tendency displayed in previous research revealed that enhancement of annual medical demand in virtue of demographic changes correlated closely with increases of yearly returns of pharmaceutical stocks (Ammann *et al*. 2011). Negative news induced stronger reaction than positive news for pharmaceutical stock returns (Perez-Rodriguez *et al*. 2012).

Furthermore, some events or particular conditions were found to be able to make a huge impact on an individual pharmaceutical company. Delay announcements of product introduction could result in abnormal returns on assets, and further lead to depressed stock price performance (Hendricks *et al*. 2008); on the contrary, there would be a positive market reaction to detailed proclamations on innovative activities, especially for proclamations that received extensive media coverage (Koku, 1998). Exposure of deceptive marketing and advertising could cause significant and negative market returns (Wiles *et al*. 2010; Tipton *et al*. 2009), and direct-to-consumer advertising was related to lower systematic risks and higher stock returns (Osinga *et al*. 2011). U.S. investors castigated non-corporate social responsibility (non-CSR) active firms that executed pharmaceutical product recalls, but U.K. investors rewarded similar actions adopted by firms which were not ordinarily CSR-active (Cheah *et al*. 2007). Stock market losses from a failure of product approval were much larger in proportion than stock market gains from product development successes (Sharma *et al*. 2004). Moreover, abnormally large returns caused by Food and Drug Administration's approvals of new drugs were very rare (Perez-Rodriguez *et al*. 2012).

For the perspective of the management in drug companies, the drug companies whose stocks outmatched the industry often owned better product portfolios and distribution (Markovitch *et al*. 2005), and changes in cash compensation for top managers in the pharmaceutical industry were associated with lagged stock returns (Veliyath, 1999). From the point of view of the technological aspect, the market values of pharmaceutical firms will be raised if they possess higher patent counts, leading patent positions, and more patent citations (Chen *et al*. 2010). And there is a significant and positive relationship among pharmaceutical stock return volatility, R&D intensity and diverse patent related steps (Mazzucato *et al*. 2012). Walter (2012) reported that pharmaceutical companies could gain from both outward and inward licensing, e.g. the patents of some medicament, and then raise the returns of their own stocks.

In spite of the plentiful research results, however, very little of the past literature focused on the influence of natural elements, such as temperature changes, on pharmaceutical stocks up to now. In fact, a few studies have demonstrated the harmful effects of temperature on mortality in the United States, Europe and developing countries (Basu, 2009, Anderson *et al*. 2009, Hajat *et al*. 2005). The effects of temperature upon morbidity outcomes like hospitalization, general practitioner consultations and emergency department visits were also documented by several other investigations (Green *et al*. 2010, Gascoigne *et al*. 2010, Knowlton *et al*. 2009, Schwartz *et al*. 2004). Episodes of extreme cold weather are relevant to peaks in visits of general practice, hospital admissions and cardiovascular events among the elderly (Gascoigne *et al*. 2010), and exposure to extreme heat is related to excess morbidity and mortality (Uejio at al. 2011). The noticeable increment of hospitalization rates or out-patient department visits will lead to a vast consumption of medical resources, and the expenditures of drugs may increase simultaneously. Accordingly, it seems to be a rational deduction that violent conditions of temperature are favorable to the whole pharmaceutical industry.

In the past, few studies indicated that stock market returns could vary due to mood changes related to the effects of cold or hot weather (Cao *et al*. 2005, Chang *et al*. 2006); the impact of temperature may abate in a highly efficient market (Yoon *et al*. 2009). These researches targeted principally on the changes of market indices associated with weather-related variables. For a particular sector of the economy, such as the pharmaceutical industry, the relevance of temperature to it remains unclear. The purpose of this study is to explore the relationship between temperature and market capitalization of pharmaceutical stocks. By conducting this research, we would like to disclose if certain kinds of news, frequently contacted but easily ignored, have the potential to help investors generate profits on pharmaceutical stocks.

By adopting a threshold model with the GJR-GARCH process proposed by Glosten *et al*. (1993) on error terms and stock market data of Taiwan, we attempt to elucidate the impact of temperature on Taiwanese pharmaceutical stocks. Based on the assumption that extremely cold or hot weather can play a key role in moving the directions of pharmaceutical stock prices, dummy variables will be created for those conditions to see if fringe conditions of temperature can produce more remarkable effects on pharmaceutical stock returns than temperature within a benign range can. It will be able to offer us further discernment for the influence of specific weather variables on pharmaceutical stocks. Besides, some time-series studies have showed that the exposure to extreme temperature endangers health for a period lasting several days since its occurrence (Braga *et al*. 2001, Gasparrini *et al*. 2010), hence we also investigate whether the delayed effects of environmental stressors for stock market returns exist or not.

2. Methodology

2.1 Advanced Nonlinear ESTAR Unit Root Test

Recently, there is a growing consensus that stock market price indices might be non-linear and that the conventional unit root test has lower power in detecting its mean reverting (stationary) tendency. As such, this article employs a newly developed non-linear stationary test advanced by Kapetanios *et al*. (2003) to determine if the stock market indices of this paper are non-linear stationary.

The KSS nonlinear stationary test is based on detecting the presence of non-stationarity against nonlinear but a globally stationary exponential smooth transition autoregressive model (ESTAR) process:

$$\Delta Y_t = \theta Y_{t-1}[1-\exp(-\gamma Y_{t-1}^2)] + \varepsilon_t \tag{1}$$

where Y_t is the data series of the variable considered, ε_t is an independently identically distributed (i.i.d.) error with a zero mean and constant variance, and $\gamma \geq 0$ is known as the transition parameter or smooth parameter of the ESTAR model that governs the speed of transition. We are now interested in testing the null hypothesis of $\gamma = 0$ against the alternative of $\gamma > 0$. Under the null hypothesis, Y_t follows a linear unit root process, whereas it's a nonlinear stationary ESTAR process under the alternative. However, the parameter θ isn't indentified under the null hypothesis. Kapetanios *et al*. (2003) followed Luukkonen *et al*. (1988) to compute a first-order Taylor series approximation to the $[1-\exp(-\gamma Y_{t-1}^2)]$ under the null of $\gamma = 0$, and approximated Eqn. (1) by the following auxiliary regression:

$$\Delta Y_t = \alpha + \delta Y_{t-1}^3 + \sum_{i=1}^{P-1} \beta_i \Delta Y_{t-d} + \upsilon_t, \qquad \mathrm{t} = 1, 2, ... , \mathrm{T} \tag{2}$$

Then, the null hypothesis and alternative hypothesis are expressed as $\delta = 0$ (non stationarity) against $\delta < 0$ (nonlinear stationarity).

2.2 Threshold Model with the GJR-GARCH Process

In order to examine the “asymmetric” or “non-linear” effects from the daily and weekly average temperatures upon the daily and weekly returns of total market capitalization of pharmaceutical companies in Taiwan, we employed the non-linear threshold model with the GJR-GARCH (1,1) process proposed by Glosten *et al*. (1993) to investigate the relationships between the temperature and pharmaceutical stock returns. While the previous literature focused on the linear models, we firmly believe that the non-linear model is a better method to examine the relationships at the heart of our article. We first used the traditional linear model to test the general relationships between the temperatures and pharmaceutical stock returns, and then further examined the issue by using the non-linear threshold model.

Furthermore, to answer whether the threshold effects of extreme lagged temperatures for the total market capitalization returns of pharmaceutical companies subsisted or not, the AR(1) model with the GJR-GARCH (1,1) process modified from the models developed by Narayan *et al*. (2011) was employed to explore the relationship between the temperature and the market capitalization returns of pharmaceutical companies, the model in our article was set as follows:

$$R_t^l = \alpha + \sum_{i=1}^{n} \delta_i R_{t-i}^l + \rho_1 T_{t^*} I^+ + \rho_2 T_{t^*} I^- + \sum_{k=0}^{m} \beta_k R_{M,t-k}^l + \nu_t \quad (3)$$

$$\nu_t \middle| \Omega_{t-1} \sim N(0, h_t) \quad (4)$$

$$h_t = \beta + \theta\, h_{t-1} + \lambda \nu_{t-1}^2 + \gamma \nu_{t-1}^2 I_{t-1} \quad (5)$$

where R_t and R_{t-i} represented the contemporaneous and lagged returns of market capitalization of nine pharmaceutical companies in Taiwan, respectively. l = 1 and 2, represented the daily and weekly frequency data, respectively. T_{t^*} represented the daily and weekly temperatures while t^* represented period $t-1$ to period $t-7$ for the daily frequency data (one trading day lagged until seven trading days lagged) but period t for weekly frequency data in Taipei City with the time lag of the trading day which had to be considered, and $R_{M,t}$ and $R_{M,t-k}$ represented the contemporaneous and lagged returns of the stock market. Both I^+ and I^- were the dummy variables, $I^+ = 1$ when T_{t^*} was above c_i or r, while $I^- = 1$ when T_{t^*} was below c_i or r, and c_i and r denoted the unknown threshold values for the daily and weekly temperatures, respectively.[1] Since a dummy variable was not an economically elucidative variable, we converted the temperature into one in order to make sure that the temperature threshold set by us can be an appropriate divide between the lower temperature and higher temperature. ν_t was the residual of the white-noise disturbance, Ω_{t-1} was the information set on period $t-1$, I_{t-1} was also the dummy variable, where $I_{t-1} = 1$ when ν_{t-1} was below 0 and $I_{t-1} = 0$ when ν_{t-1} was above 0. Several restrictions on the above equations should be noted: $\beta > 0$, $\theta \geq 0$, $\lambda \geq 0$

[1] The threshold value was endogenously determined by using the Chan's (1993) grid search method to find the consistent estimate of the threshold. This method arranged the values, $\{T_{t^*}\}$, in an ascending order and excluded the smallest and largest 15 percent, and the consistent estimate of the threshold was the parameter that yielded the smallest residual of sum squares (RSS) over the remaining 70 percent.

and $\lambda + \gamma \geq 0$. If γ was significant ($\gamma \neq 0$), there would be an asymmetric effect on the conditional heteroskedasticity variance.

The reason for adopting the GJR-GARCH model as opposed to EGARCH in our article was due to the fact that the parameterization of the GJR-GARCH model made it the more promising approach. (please refer to Nelson, 1991, Engle and Ng, 1993, Glosten *et al*., 1993, and Chang *et al*., 2006).

3. Data

The definition of a pharmaceutical company is a company that sells and produces pharmaceuticals as its major business items. This study was conducted by using nine major pharmaceutical companies in Taiwan.[2] Our original data for the market capitalization of the nine pharmaceutical companies and the closing price indices of Taiwan Stock Exchange Corporation (TSEC) Weighted Index were obtained from the database of Taiwan Economic Journal (TEJ) and the websites of Taiwan Stock Exchange Corporation, and the data of the average temperatures in Taipei City, which were measured in degrees Celsius, were gained from the Central Weather Bureau of Taiwan (CWB). The entire sample period was from January 1, 2004 to December 31, 2010 for a total of 1732 daily frequency observations and 357 weekly frequency observations. The total market capitalization of these nine corporations was used to reflect the changes of the whole pharmaceutical industry, which were recorded day by day. The daily and weekly returns of the market capitalization of the nine pharmaceutical companies and the daily and weekly returns of the TSEC Weighted Index were calculated as follows:

$$R_t^i = (\ln IP_t^i - \ln IP_{t-1}^i) \times 100 \qquad i = daily, weekly$$

$$R_{M,t}^j = (\ln IP_{M,t}^j - \ln IP_{M,t-1}^j) \times 100 \qquad j = daily, weekly$$

Where R_t^i represented the daily and weekly returns of the total market capitalization of the nine pharmaceutical companies, $\ln IP_t^i$ were logarithms of the daily and weekly frequency

[2] The nine pharmaceutical companies are as follows: China Chemical & Pharmaceutical Co., Ltd. (C.C.P.C), Standard Chemical & Pharmaceutical Co., Ltd. (S.C.P.C), Maywufa Co., Ltd. (MAYWUFA), Sinphar Pharmaceutical Co., Ltd. (SINPHAR), TTY Biopharm Co., Ltd. (TTY), Chi Sheng Chemical Corp. (CHI SHENG), Synmosa Biopharma Corp. (SYNMOSA), Orient Europharma Co., Ltd. (ORIENT EUROPHARMA), and Center Laboratories, Inc. (CENTER LAB.)

data of the market capitalization of the nine pharmaceutical companies, and $R^{j}_{M,t}$ represented the daily and weekly returns of the TSEC Weighted Index, and $\ln IP^{j}_{M,t}$ were logarithms of the daily and weekly data of TSEC Weighted Index. Table 1 presented the summary statistics for all the variable series in our study, and the results of Table 1 showed that the series data exhibit skewness and excess kurtosis relative to the normal distribution, and they did not conform to the normal distribution at the 1 % level of significance by using the Jarque-Bera test; the serial auto-correlation with significance up to 24 lags existed in all of the variables at the 10 % level by using the Ljung-Box Q test. Figures 1 to 3 showed the time trends of all the series, Figures 4 to 6 showed the volatilities of all the series,[3] and from Figures 4 and 5, there was substantial increase in the volatilities of returns of the total market capitalization of the nine pharmaceutical companies and the TSEC Weighted Index (daily and weekly) during the period between the second half of 2007 and the first half of 2009, which showed that higher and persistent fluctuations could be observed since the eruption of the Subprime Mortgage Crisis.

4. The Empirical Results

The results of the three traditional unit root tests, Augmented Dickey and Fuller (ADF; 1984), Phillips and Perron (PP; 1988) and Kwiatkowski *et al*. (KPSS; 1992), were summarized in Table 2. The results of Table 2 showed that all the variables were the $I(0)$ type series at the 1% significance level. Table 3 represented the results of the KSS (2003) nonlinear ESTAR unit root test, which shows that all of the variables in this study were nonlinear $I(0)$ series at the 1% significance level.

Tables 4 and 5 represented the results of linear regression between the pharmaceutical capitalization returns and temperature factors for the daily data and weekly data, respectively. The results of Table 4 represented that there were non-significant linear relationships between the pharmaceutical capitalization returns and temperature factors on period $t-1$ (one trading day lag) to period $t-7$ (seven trading days lag), and Table 5 represented that there was also a non-significant linear relationship between the market capitalization returns of the nine pharmaceutical companies and temperature factors for the weekly data. Since

[3] The volatilities of the returns of market capitalization of the nine pharmaceutical companies, the returns of the TSEC Weighted Index and the average temperatures are measured by the conditional variances from the ARMA(p,q)-GARCH(1,1) model, the lag-lengths of the ARMA(p,q) model selected by minimizing AIC.

the results in Tables 4 and 5 showed that the temperature factors did not have a significant influence on the pharmaceutical capitalization returns, which showed that the real relationships between the pharmaceutical capitalization returns and temperature factors could not be clarified by using the linear regression model, accordingly, the threshold regression method with the GJR-GARCH model was applied to examine the relationships between the market capitalization returns and temperature factors in our study.

Table 6 represented the results of the threshold model for the daily data. First, from the coefficients of R_{t-1}^{daily}, $R_{M,t}^{daily}$, $R_{M,t-1}^{daily}$ and $R_{M,t-2}^{daily}$ in this table, it was evident that the stock market returns had strong effects on the capitalization returns of the nine pharmaceutical companies, which might be partly explained by the price limits in the Taiwan stock market. These results were highly consistent with those reported in previous studies, thus signifying that strong auto-correlations existed in the market capitalization returns of the pharmaceutical companies. Moreover, from Table 6, when the daily average temperatures were above the threshold values of $9.80\,^0C$, $9.30\,^0C$ and $11.40\,^0C$, the coefficients were -2.1809e-05, -3.3465e-05 and -6.0412e-06 on periods $t-1$, $t-3$ and $t-4$, respectively. And when the daily average temperatures were below the threshold values, the coefficients were 4.9791e-04, 0.0108 and 8.9227e-04 on periods $t-1$, $t-3$ and $t-4$, respectively. The results of Table 6 showed that the temperature factors had a non-significant negative influence on the market capitalization returns of the pharmaceutical companies when the daily average temperatures were above the threshold values, and the temperature factors had a significant positive influence on the market capitalization returns of the pharmaceutical companies when the daily average temperatures were below the threshold values. In addition, by further observations of the F_A statistics in Table 6, the statistics were 4.7245, 12.3788 and 8.6195 on periods $t-1$, $t-3$ and $t-4$, respectively. Therefore, we found that the asymmetric relationships truly existed between the daily average temperatures and the market capitalization returns of the pharmaceutical companies at the 5% significance level, which showed that the temperature factors had significant asymmetric or threshold effects on the market capitalization returns of the pharmaceutical companies on periods $t-1$, $t-3$ and $t-4$.

Table 7 represented the results of the GJR-GARCH (1,1) model for the daily data, according to Bollerslev (1986) and Glosten *et al*. (1993), θ reflected the impact of past variance on the market capitalization returns of the nine pharmaceutical companies, and λ could be viewed as the "good news" coefficient, with higher values implying that more recent good news had a greater impact on the market capitalization returns, and γ could be viewed as the "bad news" coefficient, with higher values implying that more recent bad news had a greater impact on the market capitalization returns, while $\theta+\lambda$ measured the persistence of volatility, and the results in Table 7 indicated that both θ and λ were significant at the 1% significance level. In addition, the significant test statistics for the γ coefficient on period $t-4$ further indicated that the asymmetric effect existed in the conditional variance model in our study.

Table 8 represented the results of the threshold model for the weekly data, which showed that when the weekly average temperature was above the threshold value of $12.214\,^{0}C$, the temperature factor would have a significant negative influence (-0.00068) on pharmaceutical capitalization returns, and the temperature factor would have significant positive influence (0.0052) on pharmaceutical capitalization returns when the weekly average temperature was below the threshold value. The F_A statistic in Table 8 was 8.8589, which showed that the temperature factor also had a significant threshold effect on the market capitalization returns of the nine pharmaceutical companies for the weekly frequency data.

Table 9 represented the results of the GJR-GARCH (1,1) model for the weekly data, which showed that both θ and λ were significant at the 1% significance level, and the significant test statistics for the γ coefficient further indicated that the asymmetric effect also existed in the conditional variance model for the weekly data. The conditional volatility on the market capitalization returns of the pharmaceutical companies tended to be higher when the news of the weather was unfavorable. A possible explanation for this phenomenon was that investors (especially institutional investors) tended to be more pessimistic and they would sell a lot of pharmaceutical stocks when unexpected negative weather information, e.g. microtherm, arrived in the market for fear of a further loss. However, other investors expected that the lower temperature would cause the occurrence of several peaks of doctor visits and medicine consumptions, and they would buy pharmaceutical stocks at this moment. Thus, the volatilities of trading volumes and stock return would tend to be higher.

5. Conclusion and Discussion

Past literature in the field of epidemiology indicated that once people were attacked by low temperatures, there would be a notable increase in all-cause mortality after a period of several days. In addition, the degree of increase in all-cause mortality was in proportion to the degree of decrease in mean temperature (Hashizume *et al*. 2009, McMichael *et al*. 2008). Under a low temperature environment, the mortality would be raised over a shorter lag period (0 - 1day) and a longer lag period (0-13 days), and the most obvious effects of microtherm appeared at lags 3 - 4 days (Hashizume *et al*. 2009).

The aforementioned reports offer us good clues to establish our ratiocination. Tremendous increment of morbidity and mortality in cold weather may lead to depletion of a great volume of medical resources and then boost pharmaceutical stock returns. The area of Taiwan is only about 14400 square miles; when a low temperature occurs in Taipei City, a nationwide low ambient temperature often betides simultaneously. It will uplift the incidence of country-wide deaths and diseases; therefore, both visits of emergency departments and general practice and hospitalization will rise in a short period of time, which will bring about great consumption of medicine. This phenomenon can be easily observed by employees of medical institutions, drug companies, Bureau of National Health Insurance (BNHI) and other corporations familiar with the pharmaceutical industry.

Various diseases can be induced after exposure to extremely low temperatures, and different clinical onsets of a variety of symptoms will result in several peaks of doctor visits and medicine usage. They will lead to persistent increment of revenues of pharmaceutical firms in the next few days after the arrival of cold weather. Corporations choose to buy pharmaceutical stocks consecutively during this period because they expect that the revenues of pharmaceutical companies can benefit from severe cold. Their purchase behavior contributes to the increase of the market values of pharmaceutical stocks, which makes pharmaceutical stock returns move up more than once, hence the effect of bitter cold upon pharmaceutical shares can be observed over a lag of several days. This delayed effect can not be efficaciously clarified in terms of traditional behavioral finance, but it can be realized from the viewpoint of epidemiological evidence-related mental factors.

Compared with a very low daily mean temperature, a lower weekly average temperature exerts a similar influence on pharmaceutical stocks in the meantime. It may suggest a sustained lower but not too low temperature is enough to increase morbidity and revenues of pharmaceutical companies. This phenomenon attracts visions of corporations, and then buy orders emerge in large numbers. To verify our conjecture that the incomes of pharmaceutical firms can derive benefits both from a single bitter cold day and a chilly period lasting for several days, a detailed shipment record of this industry is necessary, but it can not be acquired for the moment.

In terms of meteorological economics, temperature is an everlasting factor in our environment. It is hard to manipulate, but its impact on our life can be predicted. The duration and the onset of an extreme temperature can be roughly estimated by a weather forecast, so we are able to pursue the good and evade the evil through the messages broadcast in the mass media. An extreme temperature not only changes people's mental states but also destroys human bodies' homeostasis. It elevates medical demand and then pushes the supply of medicine to increase. Having a good command of knowledge about weather-related laws of demand and supply can help people make a more precise investment.

We contribute to current literature by proving that some kinds of natural elements, like temperature can alter the trend of pharmaceutical stocks. The outcome of our study may be strongly associated with the increment of temperature-related morbidity and mortality. We have some practical suggestions for institutional investors of pharmaceutical stocks. In a small populous country with many domestic market oriented drug companies, when an extremely low temperature is about to prevail over the whole country and a bullish stock market is expected to begin, institutional investors should pay attention to medical news and buy pharmaceutical stocks. These shares must be held for 3 to 4 days after the end of a cold current. This strategy can help institutional investors earn more profits. We deem that careful observation of sales of cold resistance equipment is beneficial to institutional investors' decisions.

Table 1. Summary statistics

	T_t^{daily}	T_t^{weekly}	R_t^{daily}	R_t^{weekly}	$R_{M,t}^{daily}$	$R_{M,t}^{weekly}$
Mean	23.59	23.54	0.00082	0.0040	0.00023	0.00102
Max.	32.80	32.07	0.1149	0.2116	0.0652	0.0941
Min.	9.30	10.93	-0.0731	-0.1672	-0.0691	-0.1126
S. D.	5.2645	4.9576	0.0203	0.0480	0.0140	0.0305
Skewness	-0.3524***	-0.2383*	0.1622***	0.2696**	-0.4221***	-0.7720***
Kurtosis	0.8426**	1.0818**	2.5087*	3.3958**	3.1145*	1.6371*
Jarque-Bera	87.136***	20.845***	461.77***	175.86***	751.45***	75.333***
L-B Q (24)	53.594***	48.930***	34.389*	33.897*	38.601**	36.211*
Obs.	1732	357	1732	357	1732	357

Notes: 1. T_t^{daily} and T_t^{weekly} denoted daily and weekly average temperatures in Taipei City, respectively. R_t^{daily} and R_t^{weekly} denoted daily and weekly returns of the market capitalization of the nine pharmaceutical companies in Taiwan, respectively, and $R_{M,t}^{daily}$ and $R_{M,t}^{weekly}$ denoted daily and weekly returns of the TSEC Weighted Index, respectively.

2. *, ** and *** denoted significance at 10%, 5% and 1% significance levels, respectively.

3. Jarque-Bera was the statistic of the normal test.

4. L-B Q was the statistics of Ljung-Box Q.

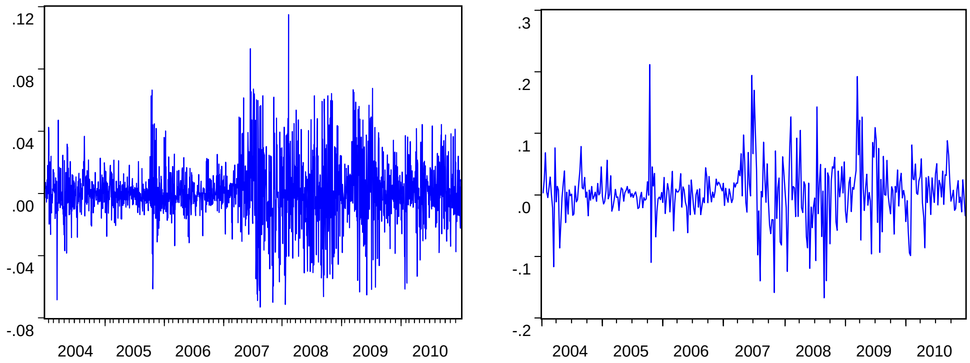

Figure 1. Daily and Weekly Returns of the Total Market Capitalization of the Nine Pharmaceutical Companies

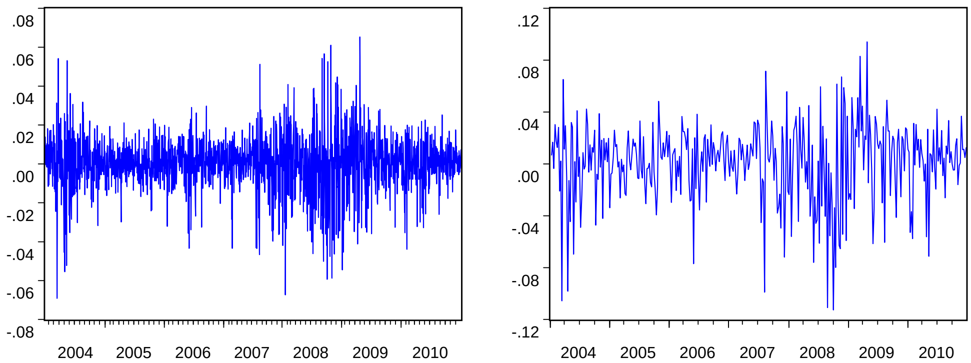

Figure 2. Daily and Weekly Returns of the TSEC Weighted Index

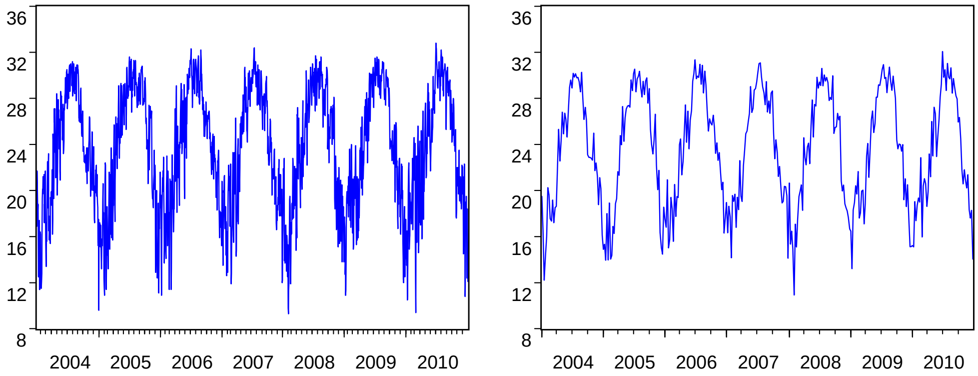

Figure 3. Daily and Weekly Average Temperatures in Taipei City

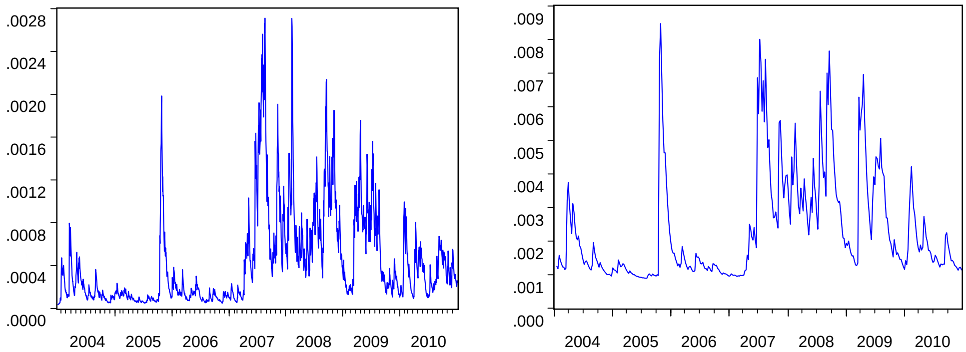

Figure 4. The Volatilities of Daily and Weekly Returns of the Total Market Capitalization of the Nine Pharmaceutical Companies

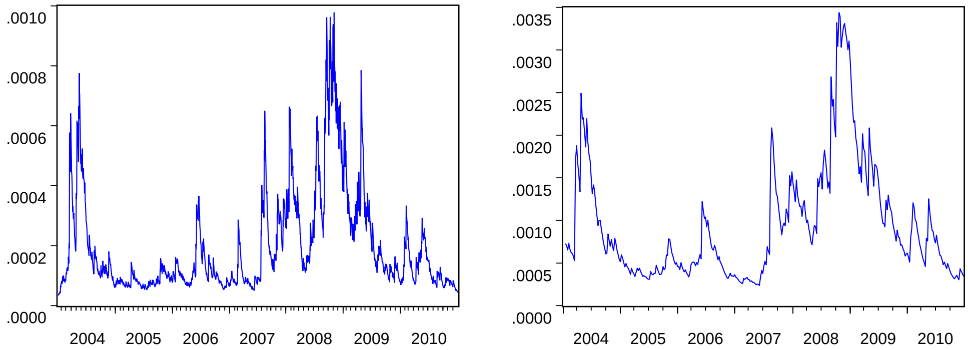

Figure 5. The Volatilities of Daily and Weekly Returns of the TSEC Weighted Index

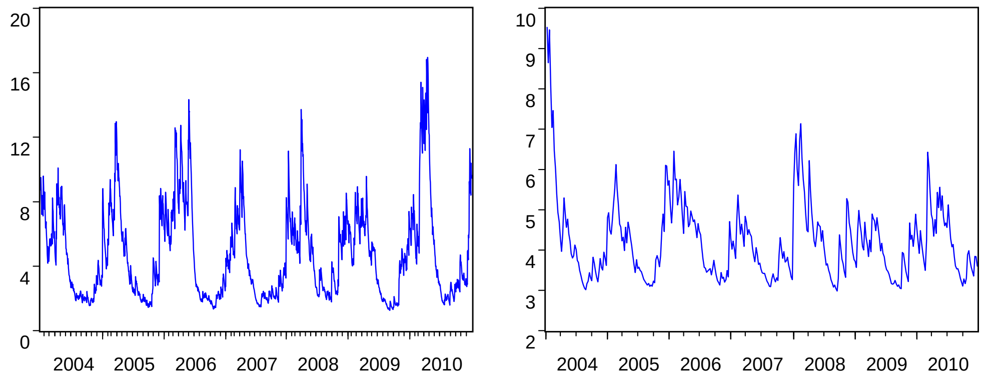

Figure 6. The Volatilities of Daily and Weekly Average Temperatures in Taipei City

Table 2. Results of Various Unit Root Tests

	ADF	PP	KPSS
T_t^{daily}	-17.2314 (5)***	-36.6190***	0.0793
T_t^{weekly}	-16.4603 (6)***	-34.5620***	0.0902
R_t^{daily}	-14.5142 (5)***	-29.8737***	0.1527
R_t^{weekly}	-14.9672 (7)***	-31.4268***	0.1099
$R_{M,t}^{daily}$	-13.8640 (5)***	-30.4380***	0.1839
$R_{M,t}^{weekly}$	-15.1311 (6)***	-30.3007***	0.1957

Notes: 1. *** denote significance at 1% significance level, the numbers in the parentheses were the appropriate lag-lengths selected by minimizing AIC.

2. The critical values for the 10%, 5% and 1% significance levels of ADF, PP and KPSS were (-2.567948, -2.863659, -3.435402), (-2.567944, -2.863651, -3.435385) and (0.3470, 0.4630, 0.7390), respectively. .

3. The null hypothesis of ADF and PP was non-stationary (unit root); the null hypothesis of KPSS was stationary (non unit root).

Table 3. Results of the Nonlinear Unit Root Test –the KSS Test

	t Statistics on $\hat{\delta}$
T_t^{daily}	-17.5471 (2)***
T_t^{weekly}	-15.7514 (2)***
R_t^{daily}	-19.5173 (2)***
R_t^{weekly}	-18.3522 (3)***
$R_{M,t}^{daily}$	-16.8273 (3)***
$R_{M,t}^{weekly}$	-17.2011 (2)***

Notes: 1. The numbers in the parentheses were the appropriate lag-lengths selected by minimize AIC.

2. The simulated critical values for different Ks were tabulated in Kapetanios *et al.* (2003).

3. *** denoted significance at the 1% significance level.

Table 4. Linear Models to test the General Relationship between the Market Capitalization Returns and Temperatures for the Daily Data

	period $t-1$	period $t-2$	period $t-3$	period $t-4$	period $t-5$	period $t-6$	period $t-7$
constant	-0.00116	-0.00215	-0.00048	-0.00089	-0.00157	-0.00086	-0.00157
	(0.5387)	(0.2543)	(0.7981)	(0.6389)	(0.4070)	(0.6503)	(0.4054)
R_{t-1}^{daily}	0.0632***	0.0630***	0.0633***	0.0636***	0.0633***	0.0632***	0.0632***
	(0.0088)	(0.0090)	(0.0088)	(0.0085)	(0.0088)	(0.0089)	(0.0089)
R_{t-2}^{daily}	0.03686	0.0365	0.0370	0.0367	0.0371	0.0371	0.0366
	(0.1259)	(0.1290)	(0.1241)	(0.1282)	(0.1241)	(0.1241)	(0.1288)
T_{t-j}^{daily}	0.000072	0.000114	0.000044	0.000061	0.000090	0.000060	0.000091
	(0.3521)	(0.1420)	(0.5738)	(0.4347)	(0.2495)	(0.4429)	(0.2473)
$R_{M,t}^{daily}$	0.7859***	0.7862***	0.7857***	0.7859***	0.7864***	0.7859***	0.7863***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$R_{M,t-1}^{daily}$	0.0345	0.0351	0.0342	0.0342	0.0348	0.0346	0.0348
	(0.3236)	(0.3145)	(0.3272)	(0.3270)	(0.3190)	(0.3223)	(0.3187)
$R_{M,t-2}^{daily}$	0.0184	0.0188	0.0179	0.0183	0.0185	0.0182	0.0190
	(0.5961)	(0.5878)	(0.6068)	(0.5983)	(0.5951)	(0.6009)	(0.5847)

Note: 1. *, ** and *** denoted significance at the 10%, 5% and 1% significance levels, respectively. Numbers in parentheses are the p-values.

2. The threshold model for the temperature:

$$R_t^{daily} = \alpha + \sum_{i=1}^{n} \delta_i R_{t-i}^{daily} + \rho_j T_{t-j}^{daily} + \sum_{k=0}^{m} \beta_k R_{M,t-k}^{daily} + \mu_t \qquad j = 1, 2, 3\ldots\ldots 7$$

Where R_t^{daily} represented the daily returns of the market capitalization of the nine Taiwanese medicinal and pharmaceutical industries, T_t^{daily} represents the daily average temperature factor variable, $j = 1, 2, 3\ldots\ldots 7$, represented the temperature factors on period $t-1$ (one trading day lag) until on period $t-7$ (seven trading days lag), and $R_{M,t}^{daily}$ represented the daily returns of the TSEC Weighted Index.

Table 5. Linear Model to test the General Relationship between the Market Capitalization Returns and Temperatures for the Weekly Data

	Coefficients and Statistics
constant	-0.0117
	(0.3511)
R_{t-1}^{weekly}	0.0444
	(0.3225)
R_{t-2}^{weekly}	0.0812*
	(0.0776)
T_t	0.00061
	(0.2292)
$R_{M,t}^{weekly}$	0.8284***
	(0.0000)
$R_{M,t-1}^{weekly}$	0.2455***
	(0.0035)
$R_{M,t-2}^{weekly}$	0.0131
	(0.8761)

Note: 1. *, ** and *** denoted significance at the 10%, 5%, and 1% significance levels, respectively. Numbers in parentheses were the p-values.

2. The threshold model for the temperature:

$$R_t^{weekly} = \alpha + \sum_{i=1}^{p} \delta_i R_{t-i}^{weekly} + \rho_1 T_t^{weekly} + \sum_{k=0}^{q} \beta_k R_{M,t-k}^{weekly} + \eta_t$$

Where R_t^{weekly} represented the weekly returns of the market capitalization of the nine Taiwanese medicinal and pharmaceutical industries, T_t^{weekly} represented the weekly average temperature factor variable, and $R_{M,t}^{weekly}$ represented the weekly returns of the TSEC Weighted Index.

Table 6. The Threshold Model of the Temperature for the Daily Data

	period $t-1$	period $t-2$	period $t-3$	period $t-4$	period $t-5$	period $t-6$	period $t-7$
constant	6.8739e-04	1.5678e-03	1.0164e-03	3.0263e-04	1.2003e-03	1.5179e-03	1.3845e-03
	(0.5824)	(0.2673)	(0.3883)	(0.8001)	(0.3077)	(0.2044)	(0.2354)
R_{t-1}^{daily}	0.0682***	0.0693***	0.0685***	0.0712***	0.0690***	0.0696***	0.0695***
	(0.0016)	(0.0021)	(0.0021)	(0.0013)	(0.0025)	(0.0023)	(0.0014)
R_{t-2}^{daily}	5.6327e-03	5.7025e-03	5.2297e-03	9.1634e-03	7.4525e-03	5.8699e-03	5.7006e-03
	(0.8269)	(0.8224)	(0.8326)	(0.7241)	(0.7735)	(0.8192)	(0.8262)
$T_{t-j}^{daily} I_t^{+}$	-2.1809e-05	-3.0813e-05	-3.3465e-05	-6.0412e-06	-3.4209e-06	-5.5567e-05	8.8642e-05
	(0.6675)	(0.5404)	(0.4852)	(0.9016)	(0.9864)	(0.2589)	(0.7521)
$T_{t-j}^{daily} I_t^{-}$	4.9791e-04*	-6.6528e-05	0.0108***	8.9227e-04***	-4.1625e-05	7.5145e-04	-6.9913e-05
	(0.0525)	(0.2902)	(0.0005)	(0.0051)	(0.3913)	(0.2800)	(0.2210)
$R_{M,t}^{daily}$	0.6050***	0.6035***	0.6064***	0.6059***	0.6033***	0.6035***	0.6045***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$R_{M,t-1}^{daily}$	0.0517*	0.0486*	0.0493**	0.0505**	0.0515*	0.0504*	0.0564**
	(0.0608)	(0.0778)	(0.0490)	(0.0439)	(0.0509)	(0.0710)	(0.0197)
$R_{M,t-2}^{daily}$	0.0581**	0.0550**	0.0528**	0.0563**	0.0549**	0.0561**	0.0573**
	(0.0271)	(0.0378)	(0.0428)	(0.0283)	(0.0360)	(0.0322)	(0.0288)
F_C	5.7637*	1.7447	12.7951***	9.0921***	0.7435	2.9628	1.8213
	(0.0560)	(0.4180)	(0.0017)	(0.0106)	(0.6895)	(0.2273)	(0.4023)
F_A	4.7245**	1.6371	12.3788***	8.6195***	0.0366	1.3733	0.3321
	(0.0297)	(0.2007)	(0.0004)	(0.0033)	(0.8484)	(0.2413)	(0.5644)
τ	9.80	28.60	9.30	11.40	32.20	17.80	32.30

Note: 1. F_C and F_A denoted that the F-statistics for the null hypothesis were $\rho_{1,j} = \rho_{2,j} = 0$ and symmetric adjustment ($\rho_{1,j} = \rho_{2,j}$). τ was the estimated threshold value of the average temperature.

2. *, ** and *** denoted significance at the 10%, 5% and 1% significance levels, respectively. Numbers in parentheses are the p-values.

3. The threshold model for the temperature:

$$R_t^{daily} = \alpha + \sum_{i=1}^{n} \delta_i R_{t-i}^{daily} + \rho_{1,j} T_{t-j}^{daily} I_t^{+} + \rho_{2,j} T_{t-j}^{daily} I_t^{-} + \sum_{k=0}^{m} \beta_k R_{M,t-k}^{daily} + \omega_t \qquad j = 1, 2, 3\ldots\ldots 7$$

Table 7. The Results from the GJR-GARCH Model of the Temperature for Daily Data

	period $t-1$	period $t-2$	period $t-3$	period $t-4$	period $t-5$	period $t-6$	period $t-7$
constant	3.1204e-06***	3.2037e-06***	3.1047e-06***	3.2469e-06***	3.2564e-06***	3.2834e-06***	3.1320e-06***
	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)
h_{t-1}	0.8688***	0.8662***	0.8707***	0.8619***	0.8626***	0.8609***	0.8605***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ω_{t-1}^2	0.1063***	0.1092***	0.1039***	0.1121***	0.1120***	0.1148***	0.1198***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\omega_{t-1}^2 I_{t-1}$	0.0368	0.0366	0.0358	0.0398*	0.0385	0.0369	0.0301
	(0.1122)	(0.1165)	(0.1091)	(0.0869)	(0.1137)	(0.1196)	(0.2219)

Note: 1. *, ** and *** denoted significance at the 10%, 5% and 1% significance levels, respectively. Numbers in parentheses were the p-values.

2. The GJR-GARCH model for the temperature:

$$h_t = \beta + \theta\, h_{t-1} + \lambda \omega_{t-1}^2 + \gamma \omega_{t-1}^2 I_{t-1}$$

Table 8. The Threshold Model of the Temperature for the Weekly Data

	Coefficients and Statistics
constant	0.0171***
	(0.0018)
R_{t-1}^{weekly}	0.0561
	(0.2423)
R_{t-2}^{weekly}	0.03654
	(0.4393)
$T_t I^+$	-0.00077***
	(0.0004)
$T_t I^-$	0.0054***
	(0.0081)
$R_{M,t}^{weekly}$	0.7405***
	(0.0000)
$R_{M,t-1}^{weekly}$	0.1317**
	(0.0277)
$R_{M,t-2}^{weekly}$	-0.0156
	(0.7453)
F_C	22.0177***
	(0.0000)
F_A	8.6945***
	(0.0032)
τ	12.214

Note: 1. F_C and F_A denoted that the F-statistics for the null hypothesis were $\rho_1 = \rho_2 = 0$ and symmetric adjustment ($\rho_1 = \rho_2$). τ was the estimated threshold value.

2. *, ** and *** denoted significance at the 10%, 5% and 1% significance levels, respectively. Numbers in parentheses were the p-values.

3. The threshold model for the temperature:

$$R_t^{weekly} = \alpha + \sum_{i=1}^{p} \delta_i R_{t-i}^{weekly} + \rho_1 T_t^{weekly} I_t^+ + \rho_2 T_t^{weekly} I_t^- + \sum_{k=0}^{q} \beta_k R_{M,t-k}^{weekly} + \varsigma_t$$

Table 9. The Results from the GJR-GARCH Model of the Temperature for the Weekly Data

	Coefficients and Statistics
constant	0.000055
	(0.1347)
h_{t-1}	0.4315***
	(0.0000)
ς_{t-1}^{2}	0.6767***
	(0.0006)
$\varsigma_{t-1}^{2} I_{t-1}$	0.7639**
	(0.0279)

Note: 1. *, ** and *** denoted significance at the 10%, 5% and 1% significance levels, respectively. Numbers in parentheses were the p-values.

2. The GJR-GARCH model for the temperature:

$$h_t = \beta + \theta\, h_{t-1} + \lambda \varsigma_{t-1}^{2} + \gamma \varsigma_{t-1}^{2} I_{t-1}$$

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