*Full Length Research Paper*

# Data estimation of the irresistible illnesses outbreak on biotechnology

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**Statutory infectious diseases breakout not only affects people's health and lives, but also stagnates the economic growth. However, in order to prevent or strain infectious diseases, the prevalence of infectious diseases also provides the development opportunities of biotechnology corporations. The impact of substantial diseases to stock prices had been investigated in previous literature. The effect of the statutory infectious diseases outbreak on Taiwanese biotechnology stock price movements is examined in this paper by using an event study. After observing nearly 10 years of major statutory infectious diseases in Taiwan, sample events include ENTEROVIRUS 71 in 1998, DENGUE FEVER in 2002, SARS in 2003 and H1N1 in 2009. There are 39 observations and the event periods are 15 trading days following the first confirmed case respectively. The empirical results point out that there exists a significantly positive abnormal return of Taiwan's biotechnology industry because of the statutory infectious epidemic.**

**Key words:** Biotechnology industry, infectious diseases, event study, abnormal returns.

## INTRODUCTION

The current world population is over 6 billion. However, crowded residence and population density is getting higher, so that an increasing number of diseases transmitted easily between people (Sutherst, 2004; Pimentel et al., 2007). Moreover, the internationalization trends is unavoidable, the relations among nations become increasingly close. Population movements become very fast. A regional outbreak of disease may evolve into a global disaster. This may cause the world economic recession (Yang et al., 1999) . For example, Standardized Abnormal Returns (SARS) was estimated to reduce Taiwan's economic growth in 2003 by 0.5% (Waugh, 2003; Chen et al., 2007). There are significantly negative cumulative abnormal returns of Chemicals, Construction, Department Stores, Foods, Hotel, Textiles and Automobile sector (Chen et al., 2007).

As the disease spread, demand of medicines, vaccines and related medical products is increasing. Major related R and D activities on biotechnological research in Asia and it may be favorable to biotechnology industry (Shinwari, 2010; Wang et al., 2010). Avian Influenza and

SARS catastrophe affects the stock performance of the Biotechnology Industry in Taiwan. There are significantly positive cumulative abnormal returns of Biotech pharmaceutical industry, Medical product industry (Wang et al., 2005; Wang et al., 2007).

Since the electronics industry account for most of the market value in Taiwan stock market, fewer investors pay less attention to the biotechnology industry. Although, the government set a number of policies to reward biotechnology industry, Taiwan biotechnology industry is still in embryonic stage (Hsu et al., 2005; Efendioglu, 2006). According to the Taiwan Stock Exchange, there are only thirteen listed companies in the biotechnology industry in 2009. Relatively to the whole Taiwan stock market, the market value of biotechnology industry is low. However, the technology and products of the biotechnology companies in Taiwan continue developing. There is a great potential of sustainable growth (Dodgson et al., 2008).

In the past, there is little research or analysis of Taiwan biotechnology industry. Specifically, the purpose of this paper is to investigate the infectious diseases outbreak how it affect Taiwan's biotechnology stock performance. To test the biotechnology stocks investment performance caused by the prevalence of infectious diseases whether

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**Table 1.** Biotechnology company listed in Taiwan stock exchange.

| Company | Date of being listed |
|---------|---------------------|
| China chemical and pharmaceutical | 9 February,1962 |
| Grape king | 20 December,1982 |
| Yung shin pharma | 3 May, 1993 |
| Standard chemical and pharmaceutical | 12 December,1995 |
| Pihsiang machinery MFG | 21 March, 2001 |
| Maywufa | 17 September, 2001 |
| Apex biotechnology | 17 September, 2001 |
| Sinphar pharmaceutical | August 26, 2002 |
| Johnson Health Tech | 9 January, 2003 |
| Excelsior medical | 31 December, 2007 |
| Apex medical | 8 November, 2004 |
| Phytohealth | 16 July, 2008 |
| SCI pharmtech | 7 January,2004 |

**Table 2.** The infectious diseases, the event date and number of sample.

| The event (The infectious diseases) | The event date | Number of company listed in TSE |
|-------------------------------------|----------------|----------------------------------|
| ENTEROVIRUS 71 | 27 May, 1998 | 5 |
| DENGUE FEVER | 14 July, 2002 | 10 |
| SARS | 27 April, 2003 | 11 |
| H1N1 | 30 July,2009 | 13 |
| Total | | 39 |

significant cumulative abnormal return is different from zero. Event study analysis is applied to examine the relationship between the infectious disease outbreak and the Taiwan biotechnology stock performance.

## METHODOLOGY

### Data

The related data in the paper were obtained from the prospectuses of Taiwanese listed companies on TSEC, the TEJ database and the undated. There are four specific events of infectious diseases breakout in Taiwan. It includes ENTEROVIRUS 71 in 1998, DENGUE FEVER in 2002, SARS in 2003 and H1N1 in 2009. The estimated period is 90 trading days before event period and contains 39 observations presented in Table 1.

The event period is 30 trading days. The event period of ENTEROVIRUS 71 is from 7 May, 1998 to 16 June, 1998, the announcement date is on 27 May, 1998. The event period of DENGUE FEVER is from 24 June, 2002 to 5 August, 2002, the announcement date is on 14 July, 2002. The event period of SARS is from 7 April, 2003 to 20 May, 2003, the announcement date is on 27 April, 2003. The event period of H1N1 is from 9 July, 2009 to 21 August, 2009, the announcement date is on 30 July, 2009. Table 2 exhibit the announcement date of each that is the day of the confirmed death case in Taiwan respectively.

### Event study

In the past, related studies used event study to measure the effect

of specific event (Lin et al., 2008; Wang and Chuang, 2010; Wang et al., 2010), such as air crashes affect stock performance of airline industry and Chernobyl Nuclear Accident effect the stock performance prices of utility industry in U.S. There are significantly negative abnormal returns (Davidson et al., 1987; Rajiv et al., 1993). Natural disasters also affect stock performance of a company. California earthquake on 17 October, 1989 affect the stocks performance of real estate industry, there are significantly negative abnormal returns on day zero (Shelor et al., 1991).To sum up, the specific events maybe affect the certain market or a particular industry, there are significant abnormal returns of the each industry.

In order to examine the impact of the infectious diseases outbreak on biotechnology stock performance in Taiwan, the Event-Study Methodology (ESM) is applied, which has been widely used to measure the effect of specific event on the value of a company. The expected return was derived from using the market model and Ordinary Least Square (OLS) which establish the regression model

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$$

with . Average abnormal returns (AR) of t

$$\overline{AR_t} = \sum_{i=1}^{t} AR_{i,t} / N$$

days can be calculated as , t is day -15, -14, …, 0, …, 14, 15. Cumulative Abnormal Return (CAR) can be calculated abnormal return through t days from b accumulated to e, (-15 b e 15), can be calculated as

$$CAR(b, e) = \frac{1}{N} \sum_{t=1}^{N} \sum_{t=b}^{e} (AR_{t,t}^e)$$

. CAR (b, e) is the average

**Table 3.** The standardized average abnormal returns of biotechnology industry during the period of infectious diseases.

| Event window | SAR | t-test | | Event window | SAR | t-test | |
|---|---|---|---|---|---|---|---|
| -15 | 0.4711 | 2.8949 | *** | 1 | 0.2974 | 2.3384 | ** |
| -14 | -0.3316 | -2.6626 | *** | 2 | -0.2368 | -1.3849 | |
| -13 | -0.6917 | -4.7291 | *** | 3 | -0.4104 | -1.7212 | * |
| -12 | 0.5003 | 4.3983 | *** | 4 | 0.3899 | 1.4502 | |
| -11 | 0.1934 | 1.7056 | * | 5 | -0.1346 | -0.8160 | |
| -10 | 0.0400 | 0.4969 | | 6 | -0.2887 | -2.4979 | ** |
| -9 | 0.3632 | 2.5443 | ** | 7 | 0.0967 | 1.0086 | |
| -8 | 0.1909 | 1.1957 | | 8 | 0.1660 | 1.1859 | |
| -7 | -0.3151 | -2.0579 | ** | 9 | 0.1331 | 0.8929 | |
| -6 | -0.0550 | -0.4133 | | 10 | -0.0744 | -0.7612 | |
| -5 | 0.3752 | 1.8681 | * | 11 | -0.4673 | -5.0300 | *** |
| -4 | -0.2274 | -1.5447 | | 12 | -0.0524 | -0.3829 | |
| -3 | 0.6404 | 3.4854 | *** | 13 | -0.0058 | -0.0562 | |
| -2 | 0.5913 | 2.7713 | *** | 14 | -0.0889 | -0.9179 | |
| -1 | -0.6116 | -3.6113 | *** | 15 | -0.1755 | -0.9253 | |
| 0 | -0.3498 | -1.6644 | * | | | | |

* Significant at the 0.1 level, ** significant at the 0.05 level, *** significant at the 0.01 level.

abnormal return from event b day cumulative to e day, (b, e) is the event window, b is the beginning day, e is the last day.

Standardized cross-sectional test solve the cross-sectional test method for the shortage of test power (Boehmer et al., 1991). This paper uses the standardized cross-sectional for its t-test. The resulting t-statistic for $SAR_{jt}$ is calculated as

$$t = \frac{\frac{1}{N}\sum_{j=1}^{N} SAR_{jt}}{\sqrt{\hat{\sigma}^2_{SAR_t}}} \sim N(0,1)$$

,where

$$\sigma_{SAR_t}^2 = \frac{1}{N(N-1)}\sum_{i=1}^{N}\left(SAR_{it} - \frac{1}{N}\sum_{j=1}^{N}SAR_{jt}\right)^2$$

and

$$SCAR_{jt} = \sum_{k=1}^{} SAR_{jt}$$

.The t-test statistic for the $SCAR_t$ for standardized cross-sectional is calculated as

$$t = \frac{SCAR_{jt}}{\sqrt{\hat{\sigma}^2_{SCAR_t}}} \sim N(0,1)$$

,

where

$$\hat{\sigma}_{SCAR_t}^2 = \frac{1}{N(N-1)}\sum_{i=1}^{N}\left(SCAR_{it} - \frac{1}{N}\sum_{j=1}^{N}SCAR_{jt}\right)^2$$

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## THE EMPIRICAL RESULTS

Table 3 presents SAR of the biotechnology stocks. Empirical results show that there are significantly positive abnormal returns in days -15, -12, -11, -9, -5, -3, -2 and 1.

It is statistically significant at 0.01 levels in days - 15, -12, -3 and -2. It is statistically significant at 0.05 level in days -9 and 1. It is statistically significant at 0.1 levels in days - 11 and - 5.There are significantly negative abnormal returns in days -14, -13, -7, -1, 0, 3, 6 and 11. It is statistically significant at 0.01 level in days -14,-13,-1 and 11. It is statistically significant at 0.05 level in days -7 and 6. It is statistically significant at 0.1 level in days 0 and 3.

Causes of this phenomenon, the opinions of investors for biotechnology stocks affected by the epidemic views are not consistent. Some think that stock price of biotechnology will rise, others do not. The different AR indicated the different investment behavior. Relatively to the whole Taiwan stock market, the market value of biotechnology industry is low. There are not too many listed companies of biotechnology industry. Investors often ignored the biotechnology stocks. Moreover, foreign corporations hold most medicines or vaccines of disease. In other words, Taiwan's biotechnology companies often do not have the enough power to defense the disease of medicines or vaccines. Investors are unable to affirm that spread of the epidemic is favorable to biotechnology stocks. Hence, investors consider that risk of holding stocks is too high and begin to sell shares. That resulted in stock price fall as a whole.

Although, stock market value of the biotechnology is low in Taiwan, the biotechnology companies in Taiwan have world-class technology and products. Some investors believe that Taiwan's companies are good

**Table 4.** The standardized cumulative abnormal return of biotechnology industry during the period of infectious diseases.

| Event window | SCAR | t-test | | Event window | SCAR | t-test | |
|---|---|---|---|---|---|---|---|
| -15 | 0.4711 | 2.8949 | *** | 1 | 1.0809 | 2.3550 | ** |
| -14 | 0.1395 | 0.6933 | | 2 | 0.8440 | 1.9631 | ** |
| -13 | -0.5521 | -2.3071 | ** | 3 | 0.4336 | 1.0310 | |
| -12 | -0.0518 | -0.1672 | | 4 | 0.8235 | 1.5329 | |
| -11 | 0.1415 | 0.4972 | | 5 | 0.6890 | 1.3597 | |
| -10 | 0.1815 | 0.5857 | | 6 | 0.4003 | 0.7265 | |
| -9 | 0.5447 | 1.6497 | * | 7 | 0.4970 | 0.8836 | |
| -8 | 0.7356 | 2.1949 | ** | 8 | 0.6630 | 1.2438 | |
| -7 | 0.4205 | 1.2030 | | 9 | 0.7961 | 1.4989 | |
| -6 | 0.3655 | 0.9868 | | 10 | 0.7217 | 1.3924 | |
| -5 | 0.7406 | 2.0610 | ** | 11 | 0.2544 | 0.4698 | |
| -4 | 0.5132 | 1.4955 | | 12 | 0.2020 | 0.3498 | |
| -3 | 1.1536 | 2.6577 | *** | 13 | 0.1961 | 0.3402 | |
| -2 | 1.7449 | 3.5395 | *** | 14 | 0.1073 | 0.1789 | |
| -1 | 1.1333 | 2.7068 | *** | 15 | -0.0682 | -0.1162 | |
| 0 | 0.7834 | 1.8235 | ** | | | | |

* Significant at the 0.1 level. ** Significant at the 0.05 level. *** Significant at the 0.01 level.

enough to produce relative medicines and vaccines. Therefore, some investors consider spreading of the epidemic that is favorable to biotechnology stocks .It resulted in increasing of share price. Everyone had a different view to spread of the epidemic in future. The market atmosphere was chaos. Even a little incident will result in tremendous volatility in stock prices. Moreover, Taiwan is located in East Asia's transport hub, and the surrounding areas are quite close, such as China, Hong Kong, South Korea, Japan and Southeast Asia. The epidemic trend of neighboring regions also affects Taiwan's weighted stock price index. This makes the stock market atmosphere even more uncertain. In addition, political policy of Taiwan is chaos. The attitude of Taiwan government for the handling of the infectious diseases is often indefinite. Sometimes, it is being an ostrich. Sometimes there is a positive response. Therefore, the volatility of the stock is very dramatic.

Table 4 and Figure 1 present the trend of Standardized Cumulative Abnormal Return (SCAR). The empirical evidence found that there are significantly positive cumulative abnormal returns in days -15, -9, - 8, -5, -3, -2, -1, 0, 1 and 2; it is significantly positive cumulative abnormal return at 0.01 level in days-15, -3, - 2 and -1; it is statistically significant at 0.05 level in days -8, -5, 0, 1 and 2; it is statistically significant at 0.1 level in day -9.There are rise on the trend between the days -12 to -2. It reached highest point and began gradually to fall the trend. As the whole, rising period of share prices is more than falling period, resulting in a significantly positive

cumulative abnormal return. Investors consider that the epidemic is favorable to biotechnology stocks before in day -1. As the disease spread, demand of medicines, vaccines and related medical products was increasing. That made cumulative abnormal return rises on the trend. There was a fall in the trend of cumulative abnormal return after days -2. Investors consider that the effect is not arriving at the original expectations and cumulative abnormal return falls in the trend.

Table 5 presents standardized cumulative abnormal returns separately over the periods, the SCAR over the event windows (-15, -1), ( -10, -1), (- 1, 0), (0, 3), (0, 12) and (0, 15) are calculated. There are significantly positive cumulative abnormal returns of the period (-15, -1) and (-10, -1). There are significantly negative cumulative abnormal returns of the period (-1, 0), (0, 3), (0, 6), (0, 12) and (0, 15).

Obviously, the volatility of the stock is very dramatic. The SCAR is from positive into negative. According to reasoning as the disease spread, demand of medicines, vaccines and related medical products is increasing; it should be favor to biotechnology stock performance. But it does not come true when the first death was outbreak. It exhibits negative cumulative abnormal returns in event windows (-1, 0) and between the days 0 to 15. The overreaction of investors caused this phenomenon, in that investors are too optimistic about stock performance so that stock price overreacted. However, it began to amend stock price after day -1. Out of control of the epidemic may also be one of the reasons causing price
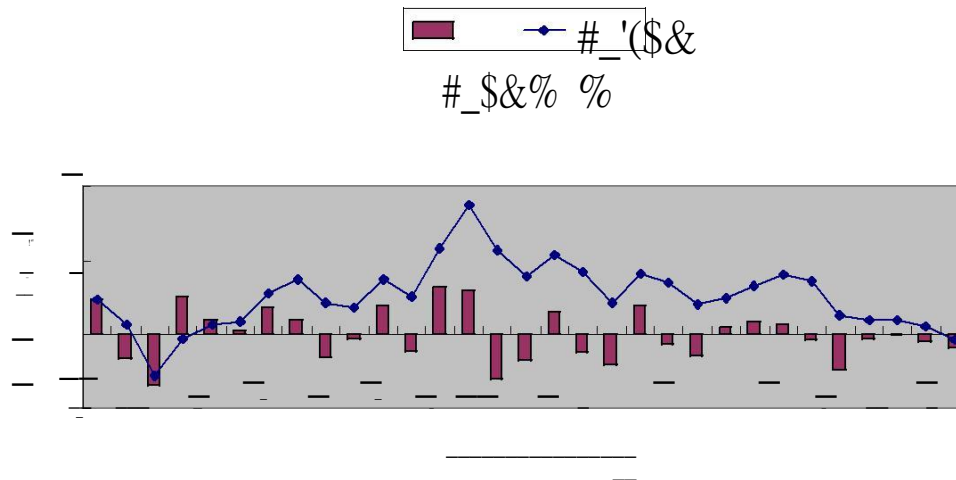
**Figure 1.** The trend of SCAR.

**Table 5.** Windows analysis of standardized cumulative abnormal returns.

| Interval | SCAR | t-test | |
|----------|------|--------|---|
| -15 to -1 | 2.235908 | 2.181853 | ** |
| -10 to -1 | 2.101354 | 2.019093 | ** |
| -1 to 0 | -1.75849 | -2.53031 | ** |
| 0 to 3 | -1.63500 | -2.19385 | ** |
| 0 to 12 | -2.22035 | -1.89452 | * |
| 0 to 15 | -3.10679 | -2.83682 | *** |

* Significant at the 0.1 level, ** significant at the 0.05 level, *** significant at the 0.01 level.

revision. Investors judge that the information of first death was that the epidemics may be out of control. They consider that spread of the epidemic will result in economic recession and may cause the biotechnology stock to drop.

## Conclusions

This paper investigates the infectious diseases outbreak, how it affects Taiwanese biotechnology stock performance. Observations are stock performance of Taiwanese thirteen listed companies in the biotechnology industry. Observed events are major infectious diseases, including ENTEROVIRUS 71, DENGUE FEVER, SARS and H1N1 nearly 10 years. We observed that biotechnology stock price exist significantly positive cumulative abnormal returns before the announcement date and significantly negative cumulative abnormal returns after the announcement date. We found that the outbreak will cause the overreacted stock prices.

### REFERENCES

Boehmer E, Musumeci J, Poulsen AB (1991). Event-Study Methodology under Conditions of Event-Induced Variance, J. Fin. Econ., 30: 253-272.

Chang SC, Chen SS, Lai JH (2008). The wealth effect of Japanese-US strategic alliances, Fin. Manage., 37(2): 271-301.

Chen MH, Jang SC, Kim WG (2007). The Impact of the SARS Outbreak on Taiwanese Hotel Stock Performance: An Event-study Approach, Hospitality. Manage., 26(1): 200-212.

Davidson III WN, Chandy PR, Cross M (1987). Large Losses, Risk Management and Stock Returns in the Airline Industry, J. Risk. Insurance., 54(1): 162-172.

Dodgson M, Mathews J, Kastelle T, Hu MC (2008). The evolving nature of Taiwan's national innovation system: The case of biotechnology innovation networks, Res. Policy., 37(3): 430-445.

Efendioglu AM (2006). Bay Area (California, USA) and Hsinchu (Taiwan) Biotech Clusters: A Comparative Analysis , J. Asia-Pacific. Bus., 6(4): 45-60.

Hsu YG, Shyu JZ, Tzeng GH (2005). Policy tools on the formation of new biotechnology firms in Taiwan, Technovation ,25(3): 281-292.

Lin CT, Wang YH, Lin WR (2008). Informational Effect of Top Executive Turnover: Testing Hybrid Grey-Market Model, J. Grey. Syst., 20(1): 53-64.

Pimentel D, Cooperstein S, Randell H, Filiberto D, Sorrentino S, Kaye B, Nicklin C, Yagi J, Brian J, O'Hern J, Habas A, Weinstein C (2007). Ecology of Increasing Diseases: Population Growth and Environmental Degradation, Hum. Ecol., 35(6): 653-668.

Rajiv K, Henderson GV, Raines GA (1993). Effects of the Chernobyl Nuclear Accident on Utility Share Prices, Quarterly. J. Bus. Econ., 32(2): 52-77.

Shelor RM, Anderson DC, Cross ML (1991). The Impact of The California Earthquake on Real Estate Firm's Stock Value, J. Real. Estate. Res., 5(3): 335-340.

Shinwari ZK (2010). Medicinal plants research in Pakistan, J. Med. Plants. Res., 4(3): 161-176.

Sutherst RW (2004). Global Change and Human Vulnerability to Vector-Borne Diseases, Clinical. Microbiol. Rev., 17(1): 136-173.

Wang HL, Tam SC, Chang HF (2005). The Research of SARS Catastrophe Effect of Stock of the Biotechnology Industry in Taiwan, J. Health Manage., 3(2): 99 -119.

Wang HL, Tam SC, Chang HF (2007). A Study of the Effect of Avian Influenza on Stock Market in Taiwan's Biotechnology Industry, J. Health Manage., 5(2): 107 -116.

Wang YH, Shih KH, Chuang YH (2010). Market Behavior of Patent Infringement Litigations, Afr. J. Bus. Manage., 4(4): 390-395.

Wang YH, Chuang CC (2010). Electoral Information in Developed Stock Market: Testing Conditional Heteosecdasticity in the Market Model, Appl. Econ., 42(9): 1125-1131.

Waugh B (2003). Economic recovery in the wake of SARS. Taiwan. Rev., pp. 26-31.

Yang PC, Chu RM, Chung WB, Sung HT (1999). Epidemiological characteristics and financial costs of the 1997 foot-and-mouth disease epidemic in Taiwan, Vet. Record, 145(25): 731-734.