

*Full Length Research Paper*

# Research on co-movement effects of conglomerate stock prices and derived investment strategies

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This study investigated the co-movement in stock indices between Taiwan business group members to find investment arbitrage portfolios. Two investment strategies, called co-integration model and quasi-arbitrage model to arbitrage, were developed and thus allowed excess return in Taiwan capital market to be obtained. Finally, the proposed quasi-arbitrage strategy was compared with the co-integration model to identify which had the higher annual return. The empirical results showed that the co-movement in stock indices between Taiwan business group members did exist. The predicted investment annual return of the quasi-arbitrage model was higher than that of the co-integration model. Therefore, the quasi-arbitrage model was the better investment strategy.

**Key words:** Conglomerate, business group, co-movement, quasi-arbitrage model, co-integration model.

## INTRODUCTION

How a financial market investor establishes a low-risk high return arbitrage portfolio and then invests in capital market for profit has become an issue of concern in financial academic research and in the practical sector (Markowitz, 1952; Rosenberg et al., 1985; Jegadeesh and Titman, 1993; Chordia and Swaminathan, 2000). Recently, factors causing co-movement in the financial market stock prices, such as industry and company factors, in addition to the overall environment market factor, must be considered at the same time. Nieh et al. (2005) point out that due to the semiconductor industry's designing, manufacturing, packaging and testing businesses, a complete set of supply chain system was formed. Therefore, within the industrial system, company stock prices have partial co-movement relationships. Shen (1999) investigates that in considering transaction costs, an arbitrage relationship exists between the Taiwan Stock Market and the Global Depository Receipts (GDR); moreover, studies show that the domestic stock market has an equal lead with the GDR market. From the above

results, the stock prices from each company in similar industries or identical companies but listed and issued in different markets have more co-movement quality due to higher feasibility of homogeneity.

However, some studies indicate that compared to each company within the industry, the movement in stock returns of companies within the conglomerate has more effect on each other (Mok et al., 1992). Moreover, the fact that intra-group diversification companies might span to different industries may reduce industrial system risk factors. Because related domestic and international literature has not yet mentioned the co-movement phenomenon within conglomerate stock prices, this study is the first domestically and internationally to probe the co-movement phenomenon in each member of the conglomerate, to make use of this phenomenon to form arbitrage opportunities, and to use the most likely phenomenon to establish two arbitrage management methods.

As most listed firms in Taiwan are small and medium family businesses are in transition (La Porta et al., 1999; Tan and Fock, 2001; Claessens et al., 2002), to strengthen the structure of company equity shares or for control of economic resources, these firms frequently go through a pyramid structure or form a cross-holdings style (Prowse, 1990; Windolf and Jurgen, 1996;

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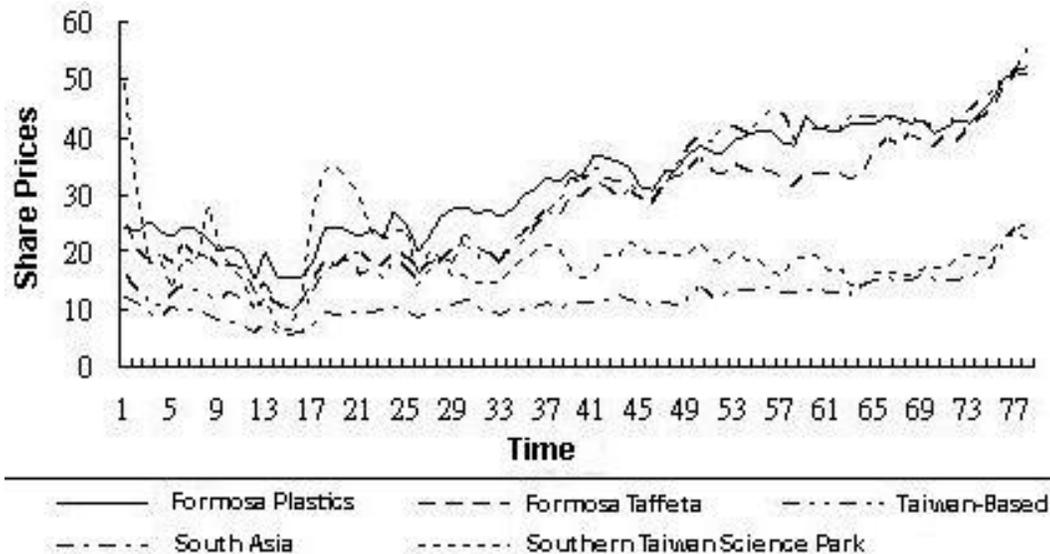


Figure 1. Formosa plastics group.

Claessens et al., 2000), a parent company conglomerate. But the equity share structure among the conglomerate's parent-subsidary companies are complicated and mutually acts as board member, resulting to inter-company profit correlation, as well as mutually sharing resources and risk responsibility, so investors will view these companies as a homogenous group. Therefore, under one business group, individual performances of stock prices also affect each other's potential profits and losses of reinvestment earnings in financial reports. Hence, the company's stock returns have a very high correlation (Khanna and Yafeh, 2005). Yeh (1998) finds that the degree of influence of the conglomerate factor on stock return co-variation is stronger than that of the industry factor; moreover, the stock returns controlled by the same conglomerate have homogeneity and the firms are combined to form one clan.

As mentioned earlier, due to the high homogeneity between each company in a conglomerate, there is a high relevance in the share prices, linking and influencing between each other. In addition, this study shows the stock price trend of the Formosa Plastics Group as an example in Figure 1. It is not difficult to find the "co-movement effect" of stock prices of subsidiaries in the group.

In summary, the stock prices of the intra-group subsidiary companies of the same group slavishly move together, and they may have the same stochastic trend, which may have a co-integration relationship. This study will first test whether the stock prices of intra-group companies have a non-stationary sequence. If they do, the stock prices of every two companies are distinguished as a new linear sequence combination. Then the study will test whether or not the residual error sequence of the new linear sequence combination is stationary; if it is, this

means the stock prices of these two companies have co-integration phenomenon. That is, the stock prices of the two companies have co-movement effect causing the residual error sequence to show stationary volatility. This study therefore forms an arbitrage portfolio of the two companies, and makes use of this stationary residual error sequence as arbitrage criterion. The study checks if there is a deviation from the normal volatility interval; if there is, it indicates that there is an arbitrage space, and this method is called a co-integration model.

In addition, this study proposes another arbitrage method that uses the intra-group's non-stationary stock price sequence of two companies and then divides their stock prices to form one ratio sequence. Then the study tests whether this ratio is a stationary series. If so, it shows that these two companies have co-movement, and the two companies with co-movement relationship form one arbitrage portfolio. If the arbitrage portfolio of both companies simultaneously rises and falls, then the ratio of the arbitrage portfolio in one interval will have stationary volatility. But if the rise and fall of the two companies have a backward link, then the volatility range of the arbitrage portfolio ratio deviates from the interval; therefore, it has an arbitrage space. The arbitrage method is called a "semi-arbitrage model".

This study proposes that these two arbitrage strategy models use the residual error sequence of the arbitrage portfolio or the ratio deviating from the volatile interval to form an arbitrage condition to carry out the deal. This study tries to examine which arbitrage strategy gets a high-yield return rate for the arbitrage portfolio when arbitrage space exists. Investors may also use the better arbitrage strategy to invest in the Taiwan securities market. Up to this time, this article serves as the first study domestically and internationally to make use of the

co-integration concept to extend towards arbitrage methods.

This article has the following contributions to the literature. First, this study is the first article that probes the co-movement of each company stocks within a business conglomerate. At the same time, it identifies the better investment portfolio strategy to serve as an investment basis for the general investors or institutional investors. Second, this study sets out to use two business group companies with random walk stock prices to find the stock price ratio of the two companies demonstrating the characteristics of a stationary state. Then we find the long-term relationship between stock prices. This basically can be viewed as an extension of the co-integration concept, and co-integration is based on whether the regression residuals of two random events are defined to be stationary. Since this study also looks into whether the ratio of the two random events is stationary, there is still a difference between the practice and traditional total integration analysis.

## LITERATURE REVIEW

### Co-movement correlation literature

In the past, there has been a considerable study on the stock market co-movement, and the focal point of the discussion is on the international stock market co-movement and the co-movement between financial derivatives and their underlying securities.

Literature on the co-movement in international stock market, such as Meric et al. (1997), find that 12 major European stock markets and U.S. stock market are more or less positively correlated after the collapse of the international stock market in 1987. Afterwards, the profit of international diversification investment portfolios declined. Yet after the 1987 international stock market collapse, there is a remarkable variation in the international market co-movement (Lau and McInish, 1993; Lee and Kim, 1993), Wang and Chen (2003) find that around the 1997 Asian financial storm, there are remarkable transport phenomena of stock returns between U.S. and Taiwan stocks, and the degree of influence has clearly increased after the crisis. Although it is not a new conception that each country's stock market returns are correlated, due to the rapid progress in trade liberalization, high transnational stock market co-movement phenomena in the future will increase or get worse steadily. Li et al. (2003) point out that when the stock market experiences huge shocks (particularly when both U.S. and Japan experienced huge shocks), the stock market has the strongest co-movement. The volatility and return rate of the international stock market have a remarkable transport effect (Hsin, 2004; King and Wadhwanl, 1990; Johnson and Soenen, 2003). A study of the U.S. eight major stock market (Argentina, Brazil, Chile, Mexico, Canada, Colombia, Peru and Venezuela)

returns shows significant positive co-movement, and by means of this co-movement, investors can then engage in arbitrage for profits. Iwatsubo and Inagaki (2007) also find that the transport effect of the U.S. versus Asian stock market information during the Asian financial crisis period was even more serious than after the financial crisis.

Another point of view pertaining to literature on the co-movement between derivatives of financial products and index spot market: In theory, the price of index futures and options should have some degree of correlation with regard to the prices of underlying securities, as Chan (1992) suggests that futures market has advantages of low transaction cost, high level of liquidity, full disclosure of information, more rapid response to market information, and price discovery function that leads the spot market. But Johansen (1991), Wahab and Lashgari (1993), Chou et al. (2002), and Hsieh (2002) find that spot market has information transmission effect upon futures market. Studies of Manaster and Rendleman (1982) and Cherian and Weng (1999) point out that options market leads the spot market, whereas Stephan et al. (1990) find the opposite result that the spot markets of stocks lead the options market inversely. But studies such as Abhyankar (1995), Bhattacharya (1987), and Chan et al. (1993) shows that there is no particular one-way relationship between the options market and the spot market. The above results explain that there is no identical final conclusion on the lead-lag relationship of futures or options.

### Related literature on conglomerates

Literature discussions related to conglomerates, such as the research result of Mok et al. (1992) with regard to the Hong Kong stock market, state that group factors have more effects on the change in stock returns than Industrial factors do. Conglomerates can share resources with each other, develop group synergy effect, and reduce the possibility of insufficient funds and other business risks. Schoar (2002) indicates that at a given point in time, diversification group companies as opposed to specialized independent companies have more productivity; Chang and Hong (2000) suggest that from a resource perspective, conglomerates can share heterogeneous resources with intra-group members through related and non-related diversification and, therefore, produce additional value. However, Yiu et al. (2005) find that the 224 conglomerates in the emerging Chinese market are incapable of sharing resources to create a competitive edge. Maksimovic and Philips (2002) propose a theoretical model and examine how each department in a diversification group of companies allocates its resources and how it reacts to industry attacks. Perhaps, there is somewhat a difference from the specialized independent companies, which do not have agency problems. The study found that the growth of diversification group of

**Table 1.** Sample selection and distribution of conglomerate members.

<b>Panel A: Sample selection</b>			
		<b>No. of conglomerates</b>	<b>Members</b>
No. of Taiwan's listed conglomerate members		337	1,229
Less: No. of conglomerate members that withdrew		(14)	(155)
Less: No. of members who joined conglomerates after 2001/10		(9)	(182)
Less: Incomplete stock prices within the sampling period			(138)
Less: Stationary state stock prices without stochastic trend		(22)	(78)
Less: Only 1 left in the conglomerate after deducting the above conditions		(234)	(532)
Total		58	(144)

<b>Panel B: Distribution of samples</b>			
<b>No. of conglomerate members</b>	<b>Conglomerate</b>	<b>Sample size</b>	<b>No. of investment portfolio</b>
2	43	86	43
3	8	24	24
4	4	16	24
5	1	5	10
6	1	6	15
7	1	7	21
Total	58	144	137

of companies together with specialized independent companies is related to investment and the productivity level of individual departments. Most diversification group of companies shows that the growth is through the most suitable component behavior of industrial departments. Hence, for a similar firm size, diversification companies with regard to specialized independent companies have lower productivity (Joao and Livdan, 2004), and they are also confronted with the loss of productivity after diversification.

In summary, with regard to the studies of conglomerates domestically and internationally, many are concentrated on the relationship between the morphology and performance of diversification strategies (Heaton, 2002; Khanna and Yafehm, 2005), but the literature is lacking on the co-movement of stock prices of companies in a conglomerate and in related investment strategies.

## METHODOLOGY

### The research period and sample handling

The research period of this study was from October 2001 - September 2005. The data pertaining to Taiwan's conglomerate profile and ex-dividend adjustment of monthly stock prices is derived from the database of Taiwan Economic Journal.

Table 1 shows the sample selection process and the sample distribution of Taiwan's group members. Panel A shows the sample selection process.

There is a total of 337 Taiwan conglomerates with 1,299 listed

companies. However, during the sample period, 14 conglomerates were dissolved within the sample period and 155 withdrew. If intra-group companies have co-movement, then there is arbitrage space. Therefore, in order to validate the accuracy of an arbitrage model, each group conglomerate member needed to participate in the conglomerate before October 2001; a total of 182 companies joined the conglomerate after October 2001. Among the newly established conglomerates, 9 cancelled, and 138 lacked complete stock price information. Moreover, this study obtained 22 conglomerates and 78 companies after deleting the data of the intra-group companies which had a stationary stock price sequence.

In this study, every 2 intra-group companies acted as an arbitrage portfolio. As a result of removing company profiles that conformed to the above conditions, the study was left with one company member in a conglomerate and thus was unable to form an investment portfolio. The 234 conglomerates of such cases were thus deducted.

Through the abovementioned sampling criteria, the study obtained a total of 58 conglomerates and 144 companies. Panel B shows the distribution of conglomerates and companies, and the stock prices of every 2 companies in the same conglomerate were combined to form an arbitrage portfolio. Most conglomerates had 2 listed companies and thus 1 arbitrage portfolio. The numbers of the conglomerates' listed companies were all lower than 7, the maximum arbitrage portfolio in a conglomerate was 21, and every 2 companies in the same conglomerate combined to form 1 portfolio, totaling 137.

Table 1 shows the sample selection process and the sample distribution of Taiwan's group members. Following Engle and Granger (1987), this study adopts two sequences  $\{y_t: t=0,1,\dots\}$  and  $\{x_t: t=0,1,\dots\}$  as I (1) process. After these two sequences make a linear combination, it will change into a new sequence as follows:

$$y_t = \beta_0 + \beta_1 x_t + e_t \quad (1)$$

where  $e_t$  must be I (0) sequence; that is,  $e_t$  is in a stationary state, indicating that  $y_t$  and  $x_t$  have co-integration relationship. This study extends the concept of this co-integration to obtain a ratio of two I (1) sequences as follows:

$$Z_t = \frac{\beta_1 a Y_t}{\beta_2 b X_t} \quad (2)$$

Taking Ln from both sides of the Equation (2) obtains the following equation:

$$\ln(Z_t) = \ln \left( \frac{a}{b} + \beta_1 \ln(Y_t) - \beta_2 \ln(X_t) \right) \quad (3)$$

Suppose that  $z_t = \ln(Z_t)$ ,  $y_t = \ln(Y_t)$ ,  $x_t = \ln(X_t)$ , taking the transpose of (3) obtains a new sequence as follows:

$$y_t = - \frac{\ln(a/b)}{\beta_1} + \frac{\beta_2}{\beta_1} x_t + \frac{z_t}{\beta_1} \quad (4)$$

If  $y_t$  and  $x_t$  have a co-integration relationship, then  $z_{t-1}$  (0) is a stationary sequence (stationary component).

This study, therefore, employs the concept of co-integration to look for "non-stationary" stock prices of specific companies in a conglomerate, and combinations of any two companies can obtain multiple portfolios for operations. First, the proposed management method is to use the stock price sequence of any two companies in a single conglomerate to form a linear combination, then take the residual error sequence in the linear combination and carry out a stationarity test to check if it is of stationary state; if it is, then the stock prices of the two companies have a co-integration phenomenon. In other words, if the arbitrage portfolio's residual error is in a stationary state, in the long term, this arbitrage portfolio's residual error sequence will be in a stable range of volatility loop. However, when this arbitrage portfolio's residual error sequence separates itself from the stable interval, after the price over-reaction, the price will return to the market value in the long term. This phenomenon is the so-called mean reversion. Therefore, one can use this price volatility relationship to carry out arbitrage management. If the stock price volatilities of the two companies in the arbitrage portfolio have a co-integration phenomenon, purchase stocks with co-integration in one of the two companies, simultaneously short selling the other company's stocks, wait until the residual error change to another point, and then reverse the operation. This study will call this management method a co-integration model.

The second management method is to divide the non-stationary stock price sequence of any two companies in a single conglomerate to form a sequence ratio, and then mix them to become an arbitrage portfolio, which will distinguish the ratio sequence in the portfolio to conduct stationarity tests on whether the ratio sequence in each portfolio is stationary. In other words, if the arbitrage portfolio's sequence ratio is stationary, this arbitrage portfolio's long term ratio while in a stable range volatility loop will show a co-movement effect. However, if the ratio of this arbitrage portfolio breaks away from this stable range, using the concept of mean reversion, after price over-reaction, prices will return to market value in the long term. Therefore, one can use this price volatility relationship to carry out an arbitrage management. If the stock price volatility of the companies in the arbitrage portfolio has a lag co-movement phenomenon, purchase stocks with co-movement relationship in one of the two companies, simultaneously short

selling the other company's stocks, wait until the ratio changes to another specific point in time, and then reverse the operation. This study will call this management method a semi-arbitrage model. Finally, this study compares the two arbitrage methods as to which has the higher average rate of return, to act as the arbitrage management model of the general investors or institutional legal persons.

### Mean reversion application model

The co-integration model defines the co-integration portfolio as two companies with non-stationary state stock prices in a conglomerate forming a new linear combination, as follows:

$$P_{i,t} = \beta_0 + \beta_1 P_{j,t} + e_t \quad ; i=1,2,3,\dots,n$$

$$j=1,2,3,\dots,n; i \neq j$$

where  $P_{i,t}$  is the price of  $i$  company conglomerate in  $t$  period;  $P_{j,t}$  is the price of  $j$  company stock price within the conglomerate in  $t$  period;  $e_t$  is the error term sequence;  $n$  is the number of family members within the conglomerate.

In the semi-arbitrage model, a semi-arbitrage portfolio is the ratio derived from the stock prices of two companies within the conglomerate, as follows:

$$P_{i,t} = \frac{P_{j,t}}{X_t} \quad ; i=1,2,3,\dots,n$$

$$j=1,2,3,\dots,n; i \neq j$$

where  $P_{i,t}$  is the price of  $i$  company conglomerate in  $t$  period;  $P_{j,t}$  is the price of  $j$  company stock price within the conglomerate in  $t$  period;  $n$  is the number of family members within the conglomerate:

$$e_{t+1} - e_t = a + \lambda (e_t^* - e_t) + \varepsilon_{t+1} \quad (7)$$

This study applies the mean reversion stochastic process model of Balvers et al. (2000) to examine if the residual error sequence of the arbitrage portfolio has a mean reversion phenomenon and its equation is defined as follows:

$e_t$  : Current residual error sequence of the arbitrage portfolio

$e_t^*$  : Equilibrium value; to use the "mean" of an arbitrage portfolio's residual error to replace the equilibrium value

$(e_t^* - e_t)$  : Equilibrium value (mean) to reduce current arbitrage portfolio's residual error sequence

$a$  : is a positive constant

$\varepsilon_{t+1}$  : Stationary state interference terms (stationary shock term) with an unconditional mean of zero

$\lambda$  : measures the speed of mean reversion (speed of reversion)

Suppose that  $0 < \lambda < 1$ , it indicates arbitrage portfolio's residual error sequence and the difference of the equilibrium value  $(P_{t+1} - P_t)$  will

be reversed over time (reversion). If  $\lambda=0$ , the arbitrage portfolio's residual sequence follows an integrated process, that is the so-called

random walk. This indicates that the behaviors of residual error sequence have no correlation between each other. If  $\lambda = 1$ , the ratio of arbitrage portfolio will complete correction of adjustment in the next period. Therefore, empirically, the range of  $\lambda$  shall be  $0 < \lambda < 1$  and of significance to show that the arbitrage portfolio has a mean reversion phenomenon.

“Half-life” is the time needed during which the stock price index returns to its long term mean value. Through the above analysis of mean reversion, the acquired  $\lambda$  value is used to measure the speed of mean reversion demonstrated by the stock price. The significance it represents explains half-life more. In many studies, because the time required to completely return to the original value is very long, the way to calculate the above is to assess the time required to restore to the mean value. The equation to calculate “half-life” is as follows:

$$\text{half - life} = \frac{\text{LN}(1 / 2)}{\text{LN}(1 - \lambda)} \quad (8)$$

For the same reason, the model of the mean reversion stochastic process of a semi-arbitrage model is identical with the abovementioned co-integration model.

### Establishing a co-integration model

The important feature of a co-integration model is the method of constructing a portfolio in which the two companies’ stock prices have a co-integration phenomenon. Based on historical data, this study adopts the stock price sequences of the two companies of an arbitrage portfolio to form a new linear combination of stationary state residual error sequence. Then, the study checks whether it will succeed to develop in a stable range of volatility loop and then acquire the arbitrage space through its buying and selling relationship.

This study assumes that the trading floor investor can short sell any company stock with no restrictions. If the stocks of the two companies have a co-integration relationship, then the stock prices of these two companies have a co-movement phenomenon, and the residual error sequence of the two companies’ stock price linear combination presents back and forth movements in a range. The stock price combination of the two companies developed from this is called co-integration arbitrage portfolio. The co-integration model of the arbitrage portfolio is as follows: According to the arbitrage portfolio’s residual error sequence volatility range, the study sets  $e_{min}$  and  $e_{max}$  to distinguish the minimum and maximum limit of the residual error sequence volatility range. Then this study carries out the quasi-arbitrage of the arbitrage portfolio:  $e_{min}$  type (minimum volatility range) means when  $e$  is below  $e_{min}$ , the stock prices of the intra-group’s  $i$  company is lower than the forecast value, indicating  $j$  company’s high stock price. One can reasonably explain that the stock prices of the two companies deviated from the stable range; maybe the stock prices of  $i$  company have indications of lagging, and the stock prices of  $j$  company have indications of advancing; thus simultaneously purchase  $i$  company’s stocks and sell  $j$  company’s stocks, wait when  $e$  returns to  $e_{max}$  and above, and reversely sell  $i$  company’s stocks and buy  $j$  company’s stocks at the same time to earn profits from the arbitrage spread.  $e_{max}$  type (maximum volatility range) means that when  $e$  is above  $e_{max}$ , the intra-group  $i$  company stock price is higher than the forecast value, indicating that  $j$  company’s stock price is low. One can reasonably explain that the stock prices of the two companies deviated from the stable range; maybe the stock price of  $j$  company has indications of lagging, and the stock price of  $i$  company has indications of advancing; thus, simultaneously purchase  $j$  company’s stocks and

sell  $i$  company’s stocks, wait when  $e$  returns to below  $e_{min}$ , and reversely sell  $j$  company stocks and buy  $i$  company stocks at the same time to earn profits from the arbitrage spread.

### Establishing a semi-arbitrage model

The important feature of a semi-arbitrage model is the method of constructing a portfolio in which the two companies’ stock prices have a co-movement phenomenon. Based on historical data, the study adopts the stock price sequence of any two companies of an arbitrage portfolio to form a ratio sequence and examines whether the ratio sequence would succeed to develop in a stable range of volatility loop. Accordingly, one can also earn profits from the buying and selling relationship of arbitrage space.

This study assumes that the market investors can sell any company stock with no restrictions. If the two companies have similar trends in stock price movement, and the ratio sequences of the two stock prices present back and forth movements in a range, the stock prices of these two companies have a co-movement relationship. The stock portfolio of the two companies developed from this is called quasi-arbitrage portfolio. The semi-arbitrage model of an arbitrage portfolio is shown in Figure 2. Depending on the arbitrage portfolio value’s ratio sequence volatility range, set  $X_{min}$  and  $X_{max}$  to distinguish the minimum and maximum limit of the value ratio sequence volatility range. Then this study uses the quasi-arbitrage management to carry out the arbitrage portfolio:  $X_{min}$

$X_{max}$  type (maximum volatility range) means that when  $X$  is above  $X_{max}$ , the intra-group  $i$  company stock price is higher than the forecast value, indicating that  $j$  company’s stock price is low. One can reasonably explain that the stock prices of the two companies deviated from the stable range; maybe the stock price of  $j$  company has indications of lagging, and the stock price of  $i$  company has advanced indications; thus, simultaneously purchase  $j$  company’s stocks and sell  $i$  company’s stocks, wait when  $e$  returns to below  $X_{min}$ , and reversely sell  $j$  company stocks and buy  $i$  company stocks at the same time to earn profit from the arbitrage spread.

## RESULTS AND ANALYSES

The sample span of this study is from October 2001 – September 2005, with a total of 48 months. Due to the ex-right and ex-dividend investment restrictions of Taiwan’s stock market, if investors employ margin facilities style to carry out arbitrage, they will be subject to a major stockholders’ meeting called together by the company, which forces the investors to buy back the shares. For ex-right three days and for ex-dividend five days prior to the meeting, investors must stop trading. Even those investors who are not subject to the ex-right or ex-dividend investment restrictions must also carry out mandatory semi-annual cash covering, which may affect the quasi-arbitrage investors. This is the limitation of this

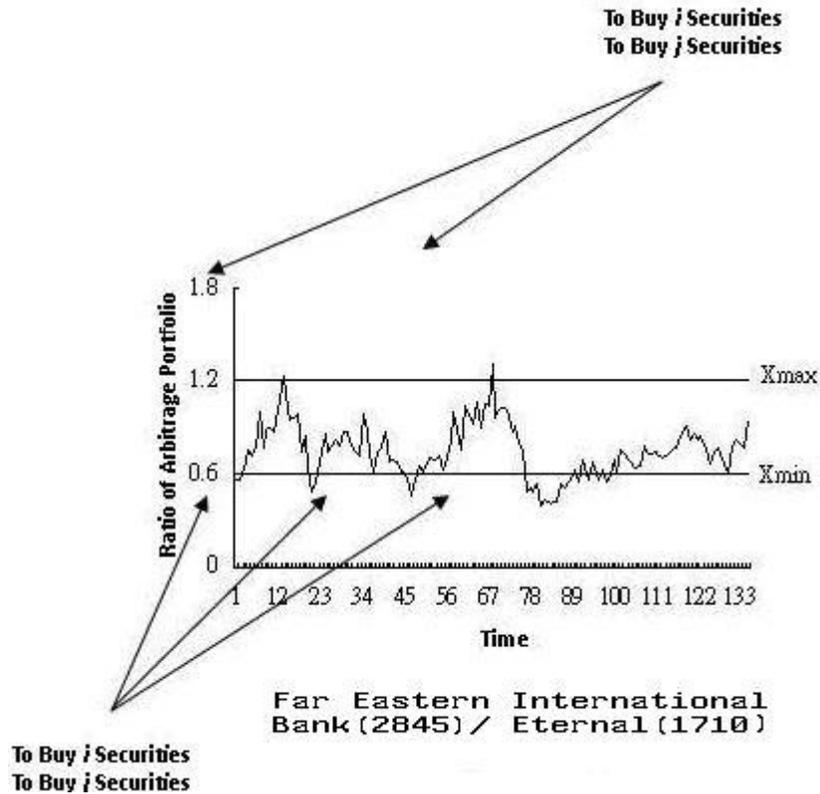


Figure 2. Arbitrage portfolio's Quasi-Arbitrage Model.

study.

## Co-integration model analysis

### Arbitrage portfolio stationarity test

In the data sample, there are 58 conglomerates, 144 companies, and intra-group companies with stock prices of non-stationary sequence. The study distinguishes the stock prices of the two companies forming a new linear sequence by pairing to form a portfolio, and then tests the new linear sequence residual error if it is stationary; if it is, it shows that the stock price sequence of the two companies has a co-integration phenomenon. After the ADF test (Augmented Dickey-Fuller test) is undertaken, the descriptive statistics and ADF statistics are shown in Table 2; a total of 19 conglomerates and 36 portfolios rejected the single root of their time series data. It shows that the residual error of the portfolios are stationary and do not conform to the random walk process, which means that the stock prices of the two companies in the portfolios have a long term relationship and a co-integration phenomenon. In other words, in the long term, the stock prices of the two companies in the portfolios while in a stable range of volatility loop will show the existence of a co-integration effect; therefore, the portfolio

with co-movement effect is called an arbitrage portfolio. Adopting the mean revision stochastic process model of Balvers et al. (2000), the mean reversion speed of 36 groups of arbitrage portfolios as in Table 2, are between  $0 < \lambda' < 1$  and of significance, meaning that there is a discrepancy between the residual error sequence and equilibrium value (mean statistics) of the arbitrage portfolio, which will be reversed over time.

“Half-life” is the time required for the residual error sequence to return to half of its equilibrium value. Through the above mean reversion analysis, the obtained significant estimate of  $\lambda$  value is a measure of residual error sequence presented by the mean reversion speed. The significance of it can explain “half-life” further. Table 2 shows that the half-life periods of all 36 arbitrage portfolios are within one year, during which their residual error sequences will be restored to half of its original value.

### Analysis of co-integration arbitrage returns

The co-integration model was formed through the co-integration relationship of the two companies of each arbitrage portfolio in a conglomerate. Based on historical data, we used the non-stationary stock price sequence of the two companies in an arbitrage portfolio to form a new

**Table 2.** Descriptive Statistics of Arbitrage Portfolio and the Half-Life ADF Test.

<b>Conglomerate name</b>	<b>Arbitrage portfolio</b>	<b>Std. Dev</b>	<b>ADF</b>	<b><math>\Lambda</math></b>	<b>Half-life</b>
Rexon	Li Wu/ Rexon	1.08	-3.74**	0.43***	2.83
Pleasure Diecast	Yong Jie/Shang Yao	1.55	-3.23*	0.25**	5.50
China Steel	Vanda Information / Zhonghong	2.42	-3.31*	0.41***	3.03
	Zhong Yu/In Hong	2.47	-3.39*	0.43***	2.87
	Zhong Yu/ China United Information	1.23	-3.42*	0.44***	2.75
ASE	ASE Test / USI	1.92	-4.25***	0.34***	3.86
	Wang Jing / ASE	2.42	-3.66**	0.46***	2.62
Tainan Bang	Southern Textile / USC	0.58	-3.20*	0.38***	3.40
Formosa Plastics	Formosa Chemicals / Formosa Taffeta	0.78	-4.08**	0.44***	2.80
	South Asia / Formosa Chemicals	2.57	-3.18*	0.29***	4.70
Cheng Loong	Shan Loong/Cheng Loong	0.86	-3.63**	0.47***	2.56
Yongxin Pharmaceuticals	Ever/Yung Shin	1.51	-4.54***	0.39**	3.21
Tongyang Group	Kai Yi/Tong Yang	4.34	-4.43***	0.35***	3.80
VIA	VIA/Vate	4.17	-4.31***	0.58***	1.87
Yageo	Chilisin/Yageo	1.85	-5.95***	0.80***	1.00
Yulon	Myson Century/Yulon	5.08	-4.11**	0.36***	3.57
	Jiang Shen/Yulon	2.51	-3.36*	0.41***	3.02
	Taiwan Mask/Yulon	7.01	-3.65**	0.27***	5.03
	Taiwan Mask/Jia Yu	1.74	-5.54***	0.17**	8.83
	Myson Century/Jia Yu	1.99	-5.84***	0.16*	9.04
	Yu Rong/Taiwan Mask	1.47	-3.88**	0.35***	3.67
	Myson Century/Taiwan Mask	1.12	-4.77***	0.40***	3.20
	Jiang Shen/Taiwan Mask	1.77	-4.32***	0.37***	3.52
	Taiwan Mask/Chunghua	4.08	-3.53**	0.44***	2.77
	Yu Rong/Myson Century	13.75	-3.23*	0.21**	6.83
UMC	Jiang Shen/Myson Century	12.00	-4.79***	0.41***	3.02
	Faraday/Unimicron	1.92	-3.66**	0.44***	2.75
	Faraday/Ali	8.05	-4.74***	0.34***	3.88
Powerchip	Novatek/Faraday	3.38	-5.41***	0.80***	1.00
	PSC/Force Wide	6.93	-4.61***	0.65***	1.51
SPIL	Unimicron/SPIL	1.96	-3.42*	0.46***	2.65

Table 2. Contd.

Veterans	Natural Gas/Shin Shin	2.04	-3.52**	0.37***	3.47
	Xin Gao You Qi/Shin Shin	2.08	-3.62**	0.38***	3.41
Huaxin	HannStar Bo/Chinese New Division	3.57	-3.34*	0.38***	3.34
Wanhwa	The First Store/Wanhwa	1.00	-3.89**	0.49***	2.42
Mitac-Synnex	Mitac/Union	1.84	-3.69**	0.39***	3.21

Note: The significance level of ADF and  $\lambda$  at 1%, 5%, 10% are indicated by \*\*\*, \*\*, and \* respectively.

sequence of linear combination, and to take the ADF test of its residual error sequence. If the sequence is in a stationary state, then it shows that the stock prices of the two companies have a co-movement phenomenon. Therefore, the residual error sequence is generally within a stable range of volatility loop, and the residual error sequence will have arbitrage space when deviated from the stable range. Arbitrage returns can accordingly be acquired through a buying and selling pair; as a result, an arbitrage management model can be set up.

In this study, the period October 2001 - September 2005, a total of 48 months served as sample data to carry out stock price arbitrage management of each conglomerate's arbitrage portfolio. According to stable volatility range of the arbitrage portfolio's residual error sequence, set up the  $e_{min}$  and  $e_{max}$  values to distinguish the upper limit and lower limit of 36 arbitrage portfolios' residual error sequences to carry out arbitrage management. Therefore, this study distinguishes each arbitrage portfolio's residual error sequence depending on different volatility range by setting up  $e_{min}$  and  $e_{max}$  values, and the average annual return rate under different ranges are shown in Table 3. The results of the study showed that when the arbitrage portfolio's residual error sequence separates from the volatility range,

it possesses arbitrage space, and the long term volatility period of 36 arbitrage portfolios' residual error sequences has not separated from the stable range. Therefore, majority of the arbitrage holding period exceeds 30 months, and most of the arbitrage frequency is less than 10 times, so transaction costs are lower, and majority of the average annual return rates are positive values. Aside from the arbitrage portfolios of "Zhong Yu/In Hong", "Myson Century/Yulon", "Myson Century/Taiwan Mask", and "Mitac/Liancheng", the arbitrage portfolio of "Yurong/Taiwan Mask" has five arbitrage opportunities, but the total holding period extends up to 47 months, with an average annual return rate of 33.59%. The arbitrage portfolio of "Myson Century/Jiayu" has one arbitrage opportunity, but the total holding period is 7 months with an average annual return attaining 312.73%. The arbitrage portfolio of "Zhong Yu/In Hong" has the highest average annual return rate among the 36 arbitrage portfolios with an average annual return rate reaching 436.85%. And the arbitrage portfolio with the lowest average return rate is "Myson Century/Yulon" with 4 arbitrage opportunities, total holding period of 36 months, and average annual return rate of -83.97%. From this, the study shows that the length of arbitrage holding period and the number of arbitrage opportunities have no significant effect upon the

level of return rate.

#### Out-of-sample forecast analysis on the co-integration arbitrage returns

To examine whether the co-integration model has arbitrage profit phenomenon in the future, this study uses historical data (October 2001 - September 2005) of quasi arbitrage management with different volatility ranges to set up  $e_{min}$  and  $e_{max}$  values as upper and lower limits of volatility for out-of-sample forecasting. The period of out-of-sample forecasting is from October 2005 to January 2007. Within the period, the number of arbitrage portfolios that reached the upper and lower limits of volatility trading conditions is only 25. The reason is that most volatility of the residual error sequence is within the stable range; that is, the rise and fall extent of the arbitrage portfolio companies is similar, being not yet out of the stable relationship, and thus causing the decrease in arbitrage opportunities. Table 4 shows that from the 36 arbitrage portfolios, 25 arbitrage portfolio stock price ratios broke away from the volatility range; therefore, the lowest average annual return rate of the arbitrage portfolio that can accomplish the deal is "Myson Century/Yulon" with a range of (40%, 60%), average annual

**Table 3.** Co-integration model under different volatility ranges and average annual returns.

Conglomerate name	Arbitrage portfolio	[10%,90%]	[20%,80%]	[25%,75%]	[30%,70%]	[40%,60%]
Rexon	Li Wu/ Rexon	25.78 [19,1]	78.93 [26,5]	84.99 [38,10]	71.51 [37,10]	50.00 [47,11]
Pleasure Diecast	Yong Jie/Shang Yao	50.22 [36,1]	113.28 [32,3]	121.67 [30,3]	154.14 [31,5]	128.81 [31,5]
China Steel	Vanda Information / Zhonghong	60.49 [30,3]	355.37 [42,4]	355.37 [42,4]	430.72 [42,6]	421.08 [41,8]
	Zhong Yu/In Hong	436.85 [43,2]	-15.03 [43,4]	68.03 [42,6]	12.81 [42,6]	35.46[42,8]
	Zhong Yu/ China United Information	68.42 [38,2]	45.21 [38,4]	50.86 [38,4]	54.94 [38,4]	58.24[38,4]
ASE	ASE Test / USI	79.30 [45,5]	122.25 [35,5]	122.25 [35,5]	125.58 [35,7]	107.41 [34,7]
	Wang Jing / ASE	102.20 [31,4]	61.54 [45,5]	60.81 [44,5]	107.26 [44,9]	123.45 [40,7]
Tainan Bang	Southern Textile / USC	106.06 [17,3]	80.01 [46,6]	81.02 [46,6]	78.36 [46,6]	66.92 [41,8]
Formosa Plastics	Formosa Chemicals / Formosa Taffeta	39.68 [33,4]	41.73 [36,6]	34.45 [39,9]	33.69 [42,10]	20.05 [46,14]
	South Asia / Formosa Chemicals	42.98 [41,2]	44.31 [40,4]	46.92 [37,4]	51.89 [37,6]	39.15 [37,6]
Cheng Loong	Shan Loong/Cheng Loong	48.99 [46,4]	49.72 [43,6]	49.86 [42,6]	55.21 [42,8]	56.68 [42,10]
Yongxin Pharma	Ever/Yung Shin	19.80 [38,2]	19.80 [38,2]	27.78 [46,5]	26.59 [46,5]	23.92 [47,6]
Tongyang Group	Kai Yi/Tong Yang	109.95 [32,3]	56.97 [43,5]	54.17 [46,6]	65.48 [46,8]	75.05 [46,12]
VIA	VIA/Vate	273.98 [23,4]	222.32 [29,5]	155.93 [45,6]	147.48 [44,6]	115.52 [43,6]
Yageo	Chilisin/Yageo	80.19 [23,4]	42.54 [46,5]	42.95 [45,5]	42.95 [45,5]	35.53 [42,5]
Yulon	Myson Century/Yulon	61.95 [33,2]	61.95 [33,2]	29.39 [33,2]	26.36 [32,2]	-83.97 [32,4]
	Jiang Shen/Yulon	57.86 [33,4]	88.37 [41,8]	61.34 [45,8]	61.34 [45,8]	55.09 [42,8]
	Taiwan Mask/Yulon	96.75 [21,1]	157.03 [15,1]	103.55 [21,3]	67.68 [38,5]	19.30[45,7]
	Taiwan Mask/Jia Yu	302.73 [7,1]	98.59 [40,5]	90.83 [46,6]	78.55 [47,6]	45.58 [47,8]
	Myson Century/Jia Yu	312.73 [7,1]	73.09 [35,4]	123.55 [35,5]	135.91 [43,9]	89.12 [46,11]
	Yu Rong/Taiwan Mask	72.44 [17,2]	39.20 [47,5]	33.59 [47,5]	34.52 [47,7]	34.87 [47,9]
	Myson Century/Taiwan Mask	-47.69 [28,3]	-47.60 [42,4]	-52.73 [45,5]	-56.38 [45,5]	-44.22 [45,9]
	Jiang Shen/Taiwan Mask	96.86 [42,4]	25.00 [42,4]	19.58 [42,6]	16.17 [42,6]	29.88 [42,8]
	Taiwan Mask/Chunghua	54.90 [32,2]	46.59 [34,4]	43.44 [39,6]	34.74 [47,9]	30.97 [47,9]
	Yu Rong/Myson Century	205.34 [11,2]	35.24 [44,5]	22.88 [44,5]	21.86 [43,5]	25.82 [40,5]
	Jiang Shen/Myson Century	128.68 [37,2]	103.39 [35,4]	124.58 [32,4]	124.58 [32,4]	120.40 [31,4]
UMC	Faraday/Unimicron	46.35 [40,3]	41.80 [46,4]	50.38 [46,6]	62.51 [46,8]	46.21 [46,10]
	Faraday/Ali	49.00 [24,2]	55.36 [21,2]	71.99 [22,3]	71.99 [22,3]	65.51 [21,3]
	Novatek/Faraday	44.80 [39,5]	62.07 [41,8]	56.68 [41,8]	45.18 [45,12]	87.89 [45,16]

**Table 3. Contd.**

Powerchip	PSC/Force Wide	5.13 [21,3]	25.84 [21,3]	93.79 [37,7]	100.17 [44,11]	87.92 [46,11]
SPIL	Unimicron/SPIL	79.87 [32,4]	63.42 [45,7]	48.63 [45,7]	59.48 [45,9]	61.97 [46,12]
Veterans	Natural Gas/Shin Shin	79.66 [40,2]	41.38 [39,4]	93.75 [37,4]	112.43 [37,4]	114.39 [37,4]
	Xin Gao You Qi/Shin Shin	31.59 [40,2]	41.78 [37,4]	41.78 [37,4]	35.05 [37,4]	34.53 [37,4]
Huaxin	HannStar Bo/Chinese New Division	19.14 [24,3]	67.71 [42,4]	67.71 [42,4]	137.35 [41,8]	95.63 [47,9]
Wanhwa	The First Store/Wanhwa	0.57 [44,3]	11.83 [44,7]	12.58 [43,7]	1.45 [43,7]	1.45 [43,7]
Mitac-Synnex	Mitac/Union	105.55 [30,4]	98.62 [30,4]	98.62 [30,4]	98.62 [30,4]	-11.94 [47,7]

Parentheses (i; j): i stands for the total holding transaction period (month) number; j is the transaction frequency.

return of -142.48%, and total holding period of 12 months, with five times of transactions. The highest arbitrage portfolio is “South/Huanni” with a range of (10%, 90%), average annual return of 516.20%, and total holding period of 2 months, with one time of transaction. This shows that more than five times of annual returns can be gained in a short period of time, and because the number of transactions is few, costs are also low. Therefore, to achieve arbitrage portfolio trading conditions under different volatility ranges, the average annual return must be between the range of -142.48% and 516.20%, the number of transactions are less than five times, and the majority of the transaction holding period is within 1 year, but the main disadvantage is that some average annual returns of a co-integration model are negative. In other words, this arbitrage model can obtain a large return rate in a short period of time, but the investment model can also suffer losses.

### Semi-arbitrage model analysis

#### *Arbitrage portfolio stationarity test*

The sample data consists of 58 conglomerates

and 144 companies. The study used any two company stock prices within the same conglomerate to form a ratio and arranged the two companies in a portfolio. A total of 137 groups passed through the ADF test of the ratio, and its descriptive characteristics and ADF statistics are shown in Table 5. The time series data of a total of 29 portfolios rejected the unit root, illustrating that its combined ratio is stationary and does not meet the random walk process. Besides, the stock prices of two companies have a long-term stable relationship with each other. In other words, in the long term, the portfolio ratios in a stable range of volatility loop will show the existence of co-movement effects. Therefore, the portfolio with co-movement effect is called an arbitrage portfolio.

Adopting the mean reversion stochastic process model of Balvers et al. (2000), the mean reversion speed of 29 arbitrage portfolios in Table 5 are significantly between  $0 < \lambda' < 1$ ; it shows that with the difference between the stock price ratio and equilibrium value (mean) of the arbitrage portfolio, this will reverse over time. “Half-life” is the time needed during which the stock price index returns to its long term mean value. Through the above analysis of mean reversion, the acquired significant  $\lambda$  value is used to measure the speed of

mean reversion demonstrated by the stock price. The significance it represents will explain half-life more. In many studies, because the time required to completely return to the original value is very long, the way to calculate the above is to assess the time required to restore to the mean value. Table 5 shows that the half-lives of the arbitrage portfolios are all within one year, during which the stock prices will restore to half of the original price.

#### *The return analysis of quasi-arbitrage management*

The semi-arbitrage model, formed by two companies' stable relationship of each arbitrage portfolio uses historical data to observe whether an arbitrage portfolio's stock price ratio can be successfully developed from a stable range of volatility loop. Furthermore, arbitrage space can be obtained in a buy and sell relationship.

This study used the period October 2001 – September 2005, a total of 48 months, as sample data, and carried out stock price arbitrage management on each conglomerate's arbitrage portfolio. According to the stable range of

**Table 4.** Co-Integration model under different volatility ranges and out-of-sample forecast of average annual returns.

<b>Conglomerate name</b>	<b>Arbitrage portfolio</b>	<b>[10%,90%]</b>	<b>[20%,80%]</b>	<b>[25%,75%]</b>	<b>[30%,70%]</b>	<b>[40%,60%]</b>
Rexon	Li Wu/ Rexon	88.94 [6,1]	88.94 [6,1]	46.30 [9,1]	46.30 [9,1]	22.24[12,2]
Pleasure Diecast	Yong Jie/Shang Yao	N	N	105.76 [14,1]	105.76 [14,1]	105.76 [14,1]
China Steel	Vanda Information / Zhonghong	N	N	N	N	N
	Zhong Yu/In Hong	25.15 [12,1]	25.15 [12,1]	25.15 [12,1]	25.15 [12,1]	25.15[12,1]
	Zhong Yu/ China United Information	82.62 [6,1]	66.48 [5,1]	66.48 [5,1]	40.05 [4,1]	8.96[4,1]
ASE	ASE Test / USI	N	N	N	75.68 [9,2]	47.13 [9,2]
	Wang Jing / ASE	239.52 [13,1]	225.83 [14,1]	225.83 [14,1]	225.83 [14,1]	225.83 [14,1]
Tainan Bang	Southern Textile / USC	516.20 [2,1]	98.81 [13,2]	98.81 [13,2]	110.64 [13,2]	110.64 [13,2]
Formosa Plastics	Formosa Chemicals / Formosa Taffeta	121.73 [2,1]	170.65 [1,1]	170.65 [1,1]	170.65 [1,1]	170.65 [1,1]
	South Asia / Formosa Chemicals	92.57 [3,1]	92.57 [3,1]	92.57 [3,1]	92.57 [3,1]	103.29 [2,1]
Cheng Loong	Shan Loong/Cheng Loong	109.24 [6,1]	109.24 [6,1]	109.24 [6,1]	109.24 [6,1]	102.38 [4,1]
Yongxin Pharma	Ever/Yung Xin	N	N	N	N	N
Tongyang Group	Kai Yi/Tong Yang	87.09 [8,1]	60.71 [9,1]	60.71 [9,1]	60.71 [9,1]	39.01[12,2]
VIA	VIA/Vate	N	N	N	N	479.46 [15,1]
Yageo	Chilisin/Yageo	N	N	N	N	N
Yulon	Myson Century/Yulon	N	101.04 [8,1]	211.11 [3,1]	-45.34 [12,3]	-142.48 [12,5]
	Jiang Shen/Yulon	96.24 [7,2]	96.24 [7,2]	96.24 [7,2]	89.17 [13,4]	89.17[13,4]
	Taiwan Mask/Yulon	N	N	N	N	N
	Taiwan Mask/Jia Yu	N	N	N	N	N
	Myson Century/Jia Yu	N	N	N	N	89.17[13,4]
	Yu Rong/Taiwan Mask	N	N	N	N	N
	Myson Century/Taiwan Mask	N	N	N	N	N
	Jiang Shen/Taiwan Mask	N	-28.51 [5,1]	50.44 [4,1]	50.44 [4,1]	50.44 [4,1]
	Taiwan Mask/Chunghua	N	N	N	N	60.32 [7,2]
	Yu Rong/Myson Century	N	N	400.40 [7,2]	400.40 [7,2]	145.11 [7,2]
	Jiang Shen/Myson Century	N	N	N	N	N
UMC	Faraday/Unimicron	N	N	N	N	N
	Faraday/Ali	N	N	57.41 [7,1]	85.25 [13,3]	81.83[12,3]
	Novatek/Faraday	18.27 [13,1]	18.27 [13,1]	18.27 [13,1]	18.27 [13,1]	18.27[13,1]

**Table 4.** Contd.

Powerchip	PSC/Force Wide	N	N	N	N	N
SPIL	Unimicron/SPIL	63.27 [12,1]	63.27 [12,1]	63.27 [12,1]	63.27 [12,1]	63.27 [12,1]
Veterans	Natural Gas/Shin Shin	75.53 [12,1]	97.61 [6,1]	97.61 [6,1]	97.61 [6,1]	97.61 [6,1]
	Xin Gao You Qi/Shin Shin	24.51 [6,1]	24.51 [6,1]	24.51 [6,1]	24.51 [6,1]	24.51 [6,1]
Huaxin	HannStar Bo/Chinese New Division	N	N	N	N	N
Wanhwa	The First Store/Wanhwa	N	N	15.72 [6,2]	15.72 [6,2]	15.72 [6,2]
Mitac-Synnex	Mitac/Union	57.42 [6,1]	46.30 [13,1]	46.30 [13,1]	46.30 [13,1]	61.67 [13,3]

Parentheses (i; j): i stands for the total holding transaction period (month) number; j is the transaction frequency.

arbitrage portfolio value ratio volatility trend, set  $X_{min}$  and  $X_{max}$  value to distinguish the price ratio of 29 arbitrage portfolio carrying out stock price quasi-arbitrage management. Therefore, this study used the stable trend of each arbitrage portfolio ratio, based on different volatility ranges, to set  $X_{min}$  and  $X_{max}$  values, respectively, and the average annual return rate of different ranges in Table 6. The result of the study shows that when the arbitrage portfolio ratio separates from the volatility loop, it has arbitrage space. The ratios of the 29 arbitrage portfolios did not break free from the stable range of the long term volatility; therefore, the majority of the arbitrage holding periods exceed 24 months and the arbitrage opportunities will be less than 10 times, so the transaction costs will be lower. But the average annual return rate is positive; for example, the arbitrage portfolio of “Epistar/Everlight” has four arbitrage opportunities and a total holding period extended to 47 months with an average annual return rate of 135.82%. The arbitrage portfolio of “Union Fund/In Hong” has one arbitrage opportunity and the total holding period is 15 months, with an annual return rate reaching up to 1210.65%, which is the highest average annual return rate of an arbitrage portfolio. The arbitrage portfolio with

portfolio with the lowest average return rate is “Ever/Yongxin” which has 1 arbitrage opportunity, a total holding period of 32 months, and an average annual return of 10.90%. From this, the study shows that the length of the arbitrage holding period and the number of arbitrage opportunities have no significant relationship with the level of return rate.

#### **Out-of-sample forecast analysis on quasi-arbitrage returns**

To serve as a test regarding whether the arbitrage model has arbitrage profit phenomenon in the future, based on historical data (October 2001 - September 2005) on the quasi-arbitrage management, under different volatility ranges, the study set  $X_{min}$  and  $X_{max}$  values as the upper limit and lower limit of volatility for out-of-sample forecast.

During the out-of-sample forecasting period from October 2005 - January 2007, only 12 arbitrage portfolios' volatility reached the low and high limits of trading conditions. The main reason is that most ratios are within the stable range; that is, the fluctuation scope of the arbitrage portfolio

does not break away from the stable relationship, causing the decrease in arbitrage opportunities. Table 7 shows that in 29 arbitrage portfolios, there are 12 arbitrage portfolio stock price ratios that broke away from the volatility range. Therefore, the arbitrage portfolio with the lowest average annual return rate to reach a deal is “Li Wu/Rexon” in the (40%, 60%) range, the average annual return rate is 35.99%, and the total holding period is 11 months with 2 arbitrage opportunities. The highest arbitrage portfolio is “Central Electric/Wang Jing” in the (25%, 75%) range, with an average annual return rate of 340.63% and a total holding period of 2 months with 1 time of transaction; this means that in a short period more than three times the annual returns can be obtained, so there is lower cost due to the less number of transactions. Therefore, to attain the transaction requirements of arbitrage portfolio under different volatility ranges, the average annual returns must be from 35.99% - 340.63%, with less than 4 times of transactions and the majority holding period is within one year. In other words, this semi-arbitrage model shows that in a short period of time a high return rate and low transaction costs of an investment can be obtained.

**Table 5.** Descriptive Statistics of the ADF test and Half-Life of Arbitrage.

Conglomerate Name	Arbitrage portfolio	Mean	Std. Dev	ADF	$\lambda$	Half-Life
Rexon	Li Wu/ Rexon	1.09	0.16	-3.85**	0.35***	1.6
Tatung	Jean/Tatung	1.66	0.96	-3.42*	0.27***	2.23
China Steel	Union Fund/In Hong	1.70	2.13	-3.54**	0.31***	1.88
	Steel Chemical/In Hong	4.45	6.16	-3.54**	0.29***	2.02
	Zhong Yu/In Hong	1.93	3.5	-3.74**	0.32***	1.83
ASE	Central Electric/ASE	0.63	0.14	-3.53**	0.15**	4.41
	ASE Electronics/ASE	0.23	0.06	-3.87**	0.10**	6.85
	Central Electric/Wang Jing	1.78	0.65	-3.32*	0.19**	3.32
	ASE Electronics/Wang Jing	0.64	0.22	-3.83**	0.17**	3.64
	ASE Electronics/Central Electric	0.37	0.08	-3.63**	0.23***	2.61
Tainan Bang	Southern Textile/USC	1.03	0.15	-3.40*	0.22**	2.82
	Tai Zi/South Imperial	0.54	0.25	-3.28*	0.13**	5.18
Formosa Plastics	South Asia/ Formosa Chemicals	0.97	0.13	-3.32*	0.18**	3.59
Delta	Gan Shen/Delta	0.59	0.17	-3.28*	0.08*	8.45
Taiwan Rubber	Da Lu/Taiwan Rubber	1.29	0.35	-3.33*	0.16***	3.88
TSMC	World/TSMC	0.44	0.11	-3.38*	0.23***	2.65
Cheng Loong	Shan Loong/Chen Loong	1.38	0.25	-3.82**	0.26***	2.26
Yongxin Pharma	Ever/Yongxin	0.53	0.09	-3.66**	0.11*	5.95
YFY	First Feng/China Paper	1.30	0.99	-3.63**	0.13**	4.85
YAGEO	Tak Kee/YAGEO	0.55	0.19	-3.83**	0.13**	5.05
Yulon	Jiang Shen/Yulon	0.70	0.08	-4.09**	0.39***	1.39
	Jiang Shen/Chunghwa	0.56	0.12	-3.43*	0.10*	6.28
Far East	Tigers/East Union	0.45	0.29	-4.48***	0.16***	3.96
	Far East Bank/East Union	0.65	0.14	-4.25***	0.19***	3.31
Everlight	Epistar/Everlight	1.25	0.24	-3.62**	0.17**	3.62
UMC	Novatek/SiS	3.02	2.13	-3.62**	0.28***	2.11
	MediaTek/SiS	7.64	3.57	-4.15***	0.33***	1.75
	ALi/Yan Xing	1.74	0.56	-3.36*	0.34***	1.67
	MediaTek/Novatek	3.05	0.80	-3.33*	0.10**	6.38

The significance levels of ADF and  $\lambda$  at 1%, 5%, and 10% are indicated by \*\*\*, \*\*, and \*, respectively.

### Comparison analysis on the returns of a co-integration model and a semi-arbitrage model

Table 8 serves to compare the annual rate of returns of co-integration and quasi-arbitrage management strategies. Out-of-sample forecast of quasi-arbitrage management return rate is positive, with less than 2 times of transactions, and almost all trading occurs within one year. This means lower transaction cost and high annual return rate. But some parts of the co-integration model's investment return rate are negative with less than four

times of transactions, and almost all trading in a period within one year. This means lower transaction costs, but the annual return rate may be higher or may be negative bringing about losses. The two management methods have only 11 groups with similar company arbitrage portfolio; among the groups, because the volatility of ratios of quasi-arbitrage management is between the stable ranges, it is not easy to attain transaction requirements, and the greater the high and low limits of the volatility range, the more difficult it is to reach a deal.

This study is based on arbitrage portfolio's highest return

**Table 6.** Semi-arbitrage model under different volatility ranges and average annual returns.

<b>Conglomerate name</b>	<b>Arbitrage portfolio</b>	<b>[10%,90%]</b>	<b>[20%,80%]</b>	<b>[25%,75%]</b>	<b>[30%,70%]</b>	<b>[40%,60%]</b>
Rexon	Li Wu/ Rexon	60.51 [33,1]	105.72 [23,3]	129.68 [23,5]	110.50 [32,7]	69.68 [47,8]
Tatung	Jean/Tatung	42.15 [31,1]	54.44 [31,1]	54.44 [31,1]	53.16 [28,1]	53.16 [28,1]
China Steel	Union Fund/In Hong	1210.65 [15,1]	438.90 [46,2]	441.15 [45,2]	449.00 [44,2]	464.25 [42,2]
	Steel Chemical/In Hong	1205.22 [15,1]	1205.22 [15,1]	1205.22 [15,1]	411.97 [46,2]	456.32 [43,4]
	Zhong Yu/In Hong	675.72 [35,1]	810.32 [20,1]	810.32 [20,1]	363.98 [46,2]	442.29 [45,4]
ASE	Central Electric/ASE	28.02 [22,1]	29.08 [23,1]	29.08 [23,1]	18.94 [22,1]	32.02 [45,7]
	ASE Electronics/ASE	25.99 [37,1]	25.99 [37,1]	27.90 [34,1]	57.94 [34,3]	65.05 [30,5]
	Central Electric/Wang Jing	92.36 [25,1]	44.03 [25,1]	41.79 [22,1]	27.57 [41,2]	66.64 [42,5]
	ASE Electronics/Wang Jing	56.32 [28,1]	46.89 [29,1]	56.66 [27,1]	85.08 [27,3]	85.08 [27,3]
	ASE Electronics/Central Electric	128.09 [41,5]	115.31 [35,5]	115.31 [35,5]	115.46 [34,5]	76.75 [34,5]
Tainan Bang	Southern Textile/USC	43.66 [43,2]	70.27 [42,4]	84.03 [42,6]	64.92 [41,6]	53.68 [41,8]
	Tai Zi/South Imperial	156.72 [28,1]	151.86 [27,1]	151.86 [27,1]	130.99 [26,1]	104.82 [27,1]
Formosa Plastics	South Asia/Formosa Chemicals	44.97 [39,1]	35.60 [36,1]	29.92 [35,1]	44.14 [23,3]	37.32 [23,3]
Delta	Gan Shen/Delta	38.28 [36,1]	26.73 [33,1]	25.96 [32,1]	23.96 [31,1]	16.86 [26,1]
Taiwan Rubber	Da Lu/Taiwan Rubber	100.38 [26,1]	93.13 [24,1]	80.31 [40,3]	108.67 [37,5]	116.08 [32,7]
TSMC	World/TSMC	182.80 [35,4]	174.34 [35,4]	152.49 [44,5]	144.99 [44,5]	81.48 [44,7]
Cheng Loong	Shan Loong/Chen Loong	37.49 [47,2]	61.22 [46,6]	60.89 [46,6]	72.53 [43,8]	61.62 [42,8]
Yongxin Pharma	Ever/Yongxin	17.31 [37,1]	13.56 [36,1]	12.87 [35,1]	10.90 [32,1]	26.98 [32,4]
YFY	First Feng/China Paper	115.70 [22,1]	147.74 [15,1]	147.74 [15,1]	65.26 [43,2]	85.38 [42,4]
YAGEO	Tak Kee/YAGEO	135.70 [9,1]	96.56 [24,2]	54.45 [23,2]	45.52 [41,4]	37.99 [41,4]
Yulon	Jiang Shen/Yulon	50.97 [32,3]	55.50 [39,5]	63.73 [46,8]	58.51 [46,8]	51.10 [46,8]
	Jiang Shen/Chunghwa	49.27 [41,1]	69.04 [38,3]	76.14 [32,3]	76.14 [32,3]	61.29 [30,3]
Far East	Tigers/East Union	255.14 [21,1]	122.40 [18,1]	69.18 [46,3]	81.09 [45,3]	83.63 [40,3]
	Far East Bank/East Union	94.67 [46,2]	92.10 [36,2]	96.29 [30,2]	96.29 [30,2]	96.29 [30,2]
Everlight	Epistar/Everlight	135.82 [47,4]	122.63 [46,4]	124.28 [46,4]	91.97 [39,4]	74.74 [37,4]
UMC	Novatek/SiS	126.32 [38,1]	110.46 [37,1]	109.12 [35,1]	146.20 [31,1]	171.81 [29,1]
	MediaTek/SiS	56.62 [35,1]	56.62 [35,1]	56.62 [35,1]	55.36 [32,1]	72.88 [29,1]
	ALi/Yan Xing	16.50 [31,1]	14.77 [30,1]	35.53 [24,1]	35.53 [24,1]	35.53 [24,1]
	MediaTek/Novatek	100.46 [39,1]	77.71 [38,1]	98.93 [29,1]	98.93 [29,1]	76.62 [28,1]

Parentheses (i; j): i stands for the total holding transaction period (month) number; j is the transaction frequency.

return range under different volatility ranges to forecast out-of-sample arbitrage portfolio. Therefore, the out-of-sample forecast on the co-integration model has seven arbitrage portfolios, and among the semi-arbitrage models, there are five arbitrage portfolios that passed through the transaction requirements. But only four portfolios achieved transaction requirements for the two management methods, and among the semi-arbitrage models, there are 2 arbitrage portfolios with greater average annual returns than those of the co-integration

model. Therefore, using the quasi-arbitrage management strategy can obtain a large amount of returns in a short period of time and the management strategy can ensure that the benefits obtained are positive.

### Conclusion

This study aims to examine if the stock prices of each intra-group company has a lag co-movement effect with

**Table 7.** Semi-arbitrage model under different volatility ranges and out-of-sample forecast of average annual returns.

Conglomerate name	Arbitrage portfolio	[10%,90%]	[20%,80%]	[25%,75%]	[30%,70%]	[40%,60%]
Rexon	Li Wu/Rexon	N	140.99 [5,1]	104.15 [10,2]	80.25 [10,2]	35.99 [11,2]
Tatung	Jean/Tatung	N	N	N	N	N
China Steel	Union Fund/In Hong	N	N	N	N	N
	Steel Chemical/In Hong	N	N	N	N	N
	Zhong Yu/In Hong	N	N	N	N	N
ASE	Central Electric/ASE	N	N	N	N	N
	ASE Electronics/ASE	N	N	N	N	N
	Central Electric/Wang Jing	N	N	340.63 [2,1]	340.63 [2,1]	92.99 [6,1]
	ASE Electronics/Wang Jing	N	N	251.99 [6,2]	251.99 [6,2]	196.37 [8,2]
Tainan Bang	ASE Electronics/Central Electric	N	N	N	N	65.94 [11,2]
	Southern Textile/USC	74.29 [14,1]	74.29 [14,1]	74.29 [14,1]	74.29 [14,1]	74.29 [14,1]
Formosa Plastics	Tai Zi/South Imperial	N	N	N	N	N
	South Asia/Formosa Chemicals	N	N	N	N	N
Delta	Gan Shen/Delta	N	N	N	N	N
Taiwan Rubber	Da Lu/Taiwan Rubber	N	N	N	N	N
TSMC	World/TSMC	N	N	N	N	N
Cheng Loong	Shan Loong/Chen Loong	109.24 [6,1]	109.24 [6,1]	109.24 [6,1]	109.24 [6,1]	102.38 [4,1]
Yongxin Pharma	Ever/Yongxin	N	N	N	N	96.40 [2,1]
YFY	First Feng/China Paper	N	N	N	N	91.09 [5,1]
YAGEO	Tak Kee/YAGEO	N	124.73 [11,1]	124.73 [11,1]	70.16 [12,1]	47.82 [9,1]
Yulon	Jiang Shen/Yulon	N	96.24 [7,2]	96.24 [7,2]	89.17 [13,4]	89.17 [13,4]
	Jiang Shen/Chunghwa	N	N	N	N	N
Far East	Tigers/East Union	N	N	N	N	N
	Far East Bank/East Union	N	N	N	N	61.92 [11,2]
Everlight	Epistar/Everlight	N	N	N	67.38 [12,2]	55.79 [12,2]
UMC	Novatek/SiS	N	N	N	N	N
	MediaTek/SiS	N	N	N	N	N
	ALi/Yan Xing	N	N	N	N	N
	MediaTek/Novatek	N	N	N	N	N

Parentheses (*i*; *j*): *i* stands for the total holding transaction period (month) number; *j* is the transaction frequency.

**Table 8.** Out-of-sample forecast on average annual return rate comparison.

Conglomerate name	Arbitrage portfolio	Co-integration model	Semi-arbitrage model
Rexon	Li Wu/Rexon	46.30 [9,1]	104.15 [10,2]
China Steel	Union Fund/In Hong	N	N
	Zhong Yu/In Hong	25.15 [12,1]	N
ASE	ASE Electronics /Central Electric	75.68 [9,2]	N
Tainan Bang	Southern Textile/USC	516.20 [2,1]	74.29 [14,1]
Formosa Plastics	South Asia /Formosa Chemicals	92.57 [3,1]	N
Cheng Loong	Shan Loong/Cheng Loong	102.38 [4,1]	109.24 [6,1]
Yongxin Pharma	Ever/Yongxin	N	96.40 [2,1]
YAGEO	Chilisin/YAGEO	N	N
Yulon	Jiang Shen/Yulon	96.24 [7,2]	96.24 [7,2]
	Jiang Shen/Chung Hwa	N	N

Parentheses (*i*; *j*): *i* stands for the total holding transaction period (month) number; *j* is the transaction frequency.

each other. If there is, then this relation can be used for arbitrage management to obtain profits. First, take the non-stationary stock price of any two companies in the conglomerate to form a new linear combination; if the residual error sequence is stationary, then it means that the stock prices of the two companies have a co-integration phenomenon. Therefore, this study forms portfolios to manage arbitrage by means of this phenomenon. The long term testing of residual error sequence will present a mean reversion phenomenon, which means that if the residual error sequence breaks away from the volatility range, it then possesses arbitrage space, and this method is called a co-integration model. Using the non-stationary stock prices of any two intragroup companies to fit an investment portfolio, test whether the stock price ratio of the two companies has a stationary state phenomenon; if there is, it means the portfolio has the same rise and fall co-movement. A portfolio that has co-movement is called an arbitrage portfolio. Then this study suggests that observing the semi-arbitrage model under different volatility ranges, when each ratio of arbitrage portfolio separates from the stable volatility range, arbitrage management is carried out to obtain returns. Finally, the study compares the two methods, namely, "co-integration model" and "semi-arbitrage model", to find out which method is the better arbitrage management method.

These empirical results show that in 58 conglomerates and 144 companies, the co-integration model searched out 36 arbitrage portfolios with residual error sequence in stationary state; this means that among the arbitrage portfolio, the stock prices of the two companies have co-integration phenomenon. The semi-arbitrage model searched out 29 arbitrage portfolios with price ratios demonstrating stationary state properties, which means that the arbitrage portfolio ratios of the stock prices of the two companies have a long-term steady relationship. Then, by the mean reversion test, this study shows that the price ratios of the arbitrage portfolios has a mean reversion phenomenon; that is, the company stock prices of the arbitrage portfolio mutually have co-movement and a phenomenon of reverting to the mean value in the long-term. Therefore, the study finds that only 6 groups have co-integration and semi-arbitrage models with similar arbitrage portfolio. Moreover, the two models which equally accomplished the transaction requirements have only 4 arbitrage portfolios. But there are two groups of the semi-arbitrage model with an average annual return rate greater than that of the co-integration model, and the semi-arbitrage model's average return rate is positive while there are parts of the co-integration model with a negative return rate. On investments, using quasi-arbitrage management strategy can obtain high returns in a short period of time, and the benefits are all positive. Therefore, this study can be used by the general investors to utilize a small amount of capital and follow the semi-arbitrage model to obtain arbitrage profits in

Taiwan securities.

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