RESEARCH REPORT FOR 2019 TAIWAN FELLOWSHIP

Hedging Effectiveness of Taiwanese Stock Index Futures: Asymmetric Hedging Performance of Bull and Bear Markets

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Abstract

This study examines the asymmetric performance of hedging strategies between bull and bear markets. The study is driven by the presence of asymmetric covariance of spot-futures as a result of market trends. Using the Taiwanese stock index futures data, our results reveal that (1) hedging effectiveness of Taiwanese index futures is better in the bull market than in the bear market, and (2) highest hedging effectiveness is of OLS which place it in most-effective hedging model in terms of risk reduction. This study provides evidence for investors to adjust their hedging strategies using different hedging models in response to different market conditions.

1. Introduction

This study is driven by the presence of systemic price risk in Taiwan, especially in the aftermath of the 2008 global financial crisis which has caused financial turmoil in world economic outlook. The impact of stock market crash is widespread, particularly on the Taiwanese economy that is driven by the exports of electronics and information technology products. As a consequence of dropping exports, company revenue shrinks to a large extent that dampens the current state of financial performance. The underperformance of stock market will be propagated if the stock prices of electronic companies continue to fall, and this carryover effect will result in currency depreciation and eventually weaken the performance of the entire export industry. This over-dependency on electronic exports as a source of national income poses a cyclical risk to Taiwanese economy. The crisis is likely lead to high degree of variation of prices in both the cash and futures markets, which would subsequently negatively influence the export of Taiwanese products.

Taiwanese equity market is one of the key financial markets in Asia for investors. A number of domestic and international portfolio managers rely on the Taiwanese equity market as an investment vehicle for portfolio diversification. Thus, the amount of systemic risks associated to Taiwanese equity portfolios and its hedging effectiveness becomes an important issue in asset management. Moreover, the propagating and declining pattern of stock market performance may further vary the hedging behaviour of those risk-averse investors during bullish and bearish markets. It is therefore imperative to examine how effective the Taiwanese stock index futures are in eliminating the systemic price risk across

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different market periods. Findings from the current study are particularly useful to fund management dealing with Taiwanese stock index futures.

The Taiwan Futures Exchange (TAIFEX) is the sole derivatives exchange in Taiwan which offers and functions futures and options on major Taiwanese stock indices. The derivatives markets in Taiwan offer the asset managers with numerous choices for hedging by combining positions in the cash and futures markets. The key in making the right hedging decision is relying on an optimal hedge ratio. The hedge ratio determines the amount of risk in the cash position that is being hedged by the futures position. Although there are various econometric techniques that can be used to estimate the hedge ratio, there is no consensus as to which technique provides an efficient and consistent estimator of an optimal hedge ratio. The types of estimation techniques can be broadly divided into two forms; static and time-varying hedge ratios. The static models include the ordinary least square (Ederington, 1979; Figlewski, 1984), the Vector autoregressive method (Ghosh, 1993; Chou et al., 1996), the Vector Error Correction Model (Ghosh, 1993; Chou et al., 1996), and a class of Multivariate Generalised Autoregressive Conditional Heteroscedasticity models (Myers, 1991; Park and Switzer, 1995). It is therefore important to determine an appropriate econometric model for the performance evaluation of optimal hedge ratio.

A successful hedging will depend on its capability to capture the dynamic relationships between cash and futures prices. The current study is also driven by the fact that asset prices behave differently with respect to different market conditions. Meneu and Torro (2003) find that the conditional covariance matrix of spot-futures is more sensitive to negative than positive shocks. This asymmetric volatility of stock market returns refers to the empirical studies that stock returns response differently to bear and bull markets. In other words, are hedge ratios sensitive to different market conditions?

This study examines the hedging effectiveness in Taiwanese stock index futures market across two different market conditions of bear and bull markets. First, we will employ both constant and time-varying estimation procedures to estimate the optimal hedge ratios. Based on the estimated optimal hedge ratios, it would be very useful to know how systemic risks are hedged in futures on its underlying asset. Second, the study examines the importance of asymmetries in bull and bear markets on hedging performance. We seek to understand how hedging ratios behave in response to different market conditions. Based on various market conditions of bulls and bears, the effectiveness of hedging is evaluated using four different econometric models: (i) the ordinary least square (OLS) method, (ii) the vector autoregressive (VAR) method, (iii) the vector error correction model (VECM), and multivariate generalised autoregressive conditional heteroscedasticity (MGARCH) models.

2. Data and Methodology

The sample data consist of daily time series of the spot prices and futures settlement prices of Taiwan Stock Exchange Capitalization Weighted Stock Index (TAIEX). The data cover the period from January 17, 2000 to December 31, 2019. The data are sourced from Datastream Eikon. According to Figlewski (1984), the selection of a daily hedging horizon has tremendous value to money managers as it is helpful in adjusting their portfolio as frequently as daily.

2.1 Estimation model

The optimal hedge ratio is the slope of the regression line when change in spot price, ΔS is regressed against the change in futures price, ΔF

$$\Delta S_t = c + h^* \Delta F_t + \varepsilon_t$$

The optimal hedge ratio h^* estimated using the OLS is static. This means that once it is estimated using OLS, this ratio will be used to hedge the spot position for the entire hedging period. However, the estimates obtained using ordinary least square (OLS) regression may suffer from serial correlation and heteroscedasticity. Bivariate vector autoregressive (VAR) model is used to eliminate serial correlation.

$$\Delta S_t = c_s + \sum_{i=1}^{k} \beta_{si} \Delta S_{t-i} + \sum_{i=1}^{k} \theta_{si} \Delta F_{t-i} + \varepsilon_{st}$$
$$\Delta F_t = c_f + \sum_{i=1}^{k} \beta_{fi} \Delta S_{t-i} + \sum_{i=1}^{k} \theta_{fi} \Delta F_{t-i} + \varepsilon_{ft}$$

Vector error correction model (VECM) is employed if the two series are cointegrated, the VAR model is augmented with the error correction term (ECT) that accounts for long-run equilibrium between spot and futures price movements.

$$\Delta S_t = c_s + \sum_{i=1}^{k} \beta_{si} \Delta S_{t-i} + \sum_{i=1}^{k} \theta_{si} \Delta F_{t-i} + \gamma_s ECT_{t-1} + \varepsilon_{st}$$
$$\Delta F_t = c_f + \sum_{i=1}^{k} \beta_{fi} \Delta S_{t-i} + \sum_{i=1}^{k} \theta_{fi} \Delta F_{t-i} + \gamma_f ECT_{t-1} + \varepsilon_{ft}$$

$$ECT_{t-1} = S_{t-1} - \alpha - \beta F_{t-1}$$

Using the bivariate VAR and VECM, the optimal hedge ratio h^* will be

$$h^* = \frac{Cov(\varepsilon_{st}, \varepsilon_{ft})}{Var(\varepsilon_{ft})}$$

Multivariate GARCH (MGARCH) model is used to account for the autoregressive conditional heteroscedasticity effects in the residual series obtained from VECM.

The constant conditional constant (CCC) MGARCH model allows for time-varying conditional covariances. In the CCC MGARCH model,

$$h_{sf,t} = \rho_{sf}\sqrt{h_{ss,t}h_{ff,t}}$$

where $h_{sf,t}$ is the conditional covariance of spot and futures, the diagonal elements $h_{ss,t}$ conditional spot variance, and $h_{ff,t}$ conditional futures variance follow univariate GARCH processes and ρ_{sf} is a timeinvariate weight interpreted as a conditional correlation. Thus, the time-varying hedge ratios will be

$$h_t^* = \frac{\hat{h}_{sf,t}}{\hat{h}_{ff,t}}$$

2.2 Hedging performance

The returns on the unhedged and the hedged portfolios are calculated as follows:

$$r_u = S_t - S_{t-1}$$
$$r_h = (S_t - S_{t-1}) - h^*(F_t - F_{t-1})$$

where r_u and r_h are the return on the unhedged portfolio and the hedge portfolio, respectively. The variance of the unhedged and the hedged portfolios are calculated as

$$Var(U) = \sigma_s^2$$
$$Var(H) = \sigma_s^2 + h^{*2}\sigma_f^2 - 2h^*\sigma_{s,f}$$

where $Var(U)$ and $Var(H)$ represent variance of unhedged and hedged portfolios. The effectiveness of hedging is measured by the reduction in variance of the hedged portfolio relative to the unhedged portfolio. The variance reduction can be calculated as

$$\frac{Var(U) - Var(H)}{Var(U)}$$

The closer the variance reduction is to 1, the higher the degree of hedging effectiveness.

2.3 Determination of bull and bear markets

We use the algorithms of Lunde and Timmermann (2004) and Bry and Boschan (1971) to split the TAIEX time series into bull and bear markets. A bullish market is defined as the period between the previous immediate trough and the next peak. The period between an immediate peak and the next minimum of the time series is known as a bearish market.

3. Results and Discussion

3.1 Descriptive statistics

Table 1 shows the descriptive statistics of spot and futures daily price (S and F) and return series (ΔS and ΔF) of TAIEX. Mean price and return in futures and spot are very close between the two markets, approximately 0.0051% for the mean return. An examination of standard deviation suggests that the spot and futures market returns are volatile, but the futures market returns vary more dramatically than spot markets returns. Measure of skewness and kurtosis suggests that the spot and futures are negatively skewed for market prices and returns. Futures market is more skewed and peaked compared to spot market, which indicates that there is a high chance of small deviations from the mean return, and even a greater chance of extremely large deviations from mean return. In terms of market perception, such phenomenon is perceived as increasing risk (Gupta et al., 2017). Due high skewness and kurtosis, the normality assumption is rejected according to Shapiro-Wilk (z) statistics, which indicates the unconditional distributions of the spot and futures market returns are more leptokurtic than normal distributions.

Table 1: Descriptive Analysis of Spot and Futures Prices and Returns of TAIEX

Variable	Mean	Std Deviation	Skewness	Kurtosis	Shapiro-Wilk (z)
S	7696.451	1856.444	-.0317828	2.213293	10.014***
F	7681.381	1855.893	-.0362288	2.219650	9.9040***
ΔS	.000051	.0131810	-.2291170	6.384110	12.986***
ΔF	.0000513	.0152247	-.3363229	10.63001	14.368***

Notes: S = spot price, F = future price, ΔS = spot return, ΔF = futures return. Shapiro-Wilk test is based on the null hypothesis of normality. *** p<0.01

3.2 Unit root and cointegration tests

In order to verify the order of integration of the series, stationarity test is conducted on the spot and futures prices and their respective return series. The test results are presented in Table 2. The augmented Dicky-Fuller (ADF) and Phillips–Perron (PP) statistics indicate that spot and futures prices contain one unit root, i.e. integrated of order one $I(1)$, while their returns are stationary. After confirming the stationarity of the series, we proceed with the Engle-Granger cointegration test. The cointegration regression is estimated using the spot and futures prices, where the residuals from the cointegrating equation is assessed using the ADF and PP unit root tests. Both the unit root tests been applied on the error correction term (ECT) which confirms the presence of cointegration relationship between spot and futures prices.

Table 2: Unit Root and Cointegration Tests

	ADF		PP	
	With constant	Without constant	With constant	Without constant
S	-1.066	0.156	-1.120	0.136
F	-1.359	0.042	-1.249	0.088
ΔS	-67.317***	-67.322***	-67.271***	-67.276***
ΔF	-72.315***	-72.320***	-72.378***	-72.383***
ECT	-31.669***	-31.672***	-34.535***	-34.538***

Notes: S = spot price, F = future price, ΔS = spot return, ΔF = futures return, ECT = error correction term from the cointegrating equation. Significant at 1% level, *** p<0.01

3.3 Identification of bull and bear markets

Figure 1 plots the observed spot prices of TAIEX with increasing trends (bull) and decreasing trends (bear). We applied the algorithms of Lunde and Timmermann (2004) and Bry and Boschan (1971) to identify turnings points between the bull and bear markets of TAIEX. The identification is summarised in Table 3. The sample in this study identifies seven bullish markets and six bearish markets. Table 4 further indicates the descriptive statistics of each market phase in terms of duration and amplitude that occurred during phase.

Figure 1: Identification of Bull and Bear Markets

Notes: The sample of daily prices covers the period from January 17, 2000 to December 31, 2019. The number of observations is 4958.

Table 3: Identification of Bull and Bear Markets

	Dates	Duration	Bull markets Amplitude	Frame
Bull 1	2000-01-18 to 2000-02-17	19	10	2/20
Bull 2	2000-12-28 to 2001-02-15	30	27	258/287
Bull 3	2001-10-04 to 2002-04-22	132	85	443/574
Bull 4	2002-10-14 to 2007-10-29	1253	151	696/1948
Bull 5	2008-11-21 to 2011-01-28	551	119	2214/2764
Bull 6	2011-12-20 to 2015-04-27	825	50	2983/3807
Bull 7	2015-08-25 to 2019-12-31	1069	56	3890/4958

	Dates	Duration	Bear markets Amplitude	Frame
Bear 1	2000-02-18 to 2000-12-27	237	-54	21/257
Bear 2	2001-02-16 to 2001-10-03	155	-43	288/442
Bear 3	2002-04-23 to 2002-10-11	121	-40	575/695
Bear 4	2007-10-30 to 2008-11-20	265	-58	1949/2213
Bear 5	2011-02-08 to 2011-12-19	218	-27	2765/2982
Bear 6	2015-04-28 to 2015-08-24	82	-26	3808/3889

Notes: We follow the algorithms of Lunde and Timmermann (2004) and Bry and Boschan (1971) in identifying the market conditions.

Table 4: Descriptive Statistics of Bull and Bear Markets

	Bull	Bear
Number of phases	7	6
Minimum duration	30	121
Average duration	558	190
Median duration	551	186
Maximum duration	1253	265
Minimum amplitude	32	-27
Average amplitude	90	-42
Median amplitude	88	-42
Maximum amplitude	155	-58

Notes: We follow the algorithms of Lunde and Timmermann (2004) and Bry and Boschan (1971) in identifying the market conditions.

3.4 Estimation of optimal hedge ratio

Table 5 presents a summary of estimation of optimal hedge ratio using four different estimation methods; (1) ordinary least square (OLS), (2) vector autogressive (VAR), (3) vector error correction (VECM), and (4) constant conditional correlation (CCC) in multivariate GARCH (MGARCH). Based on the results, the hedge ratios are consistently different between bullish and bearish markets across the four estimation models.

In bull markets, the model which leads to highest hedge ratio is consistent across models. On average, the VECM yields the highest hedge ratio relative to the other three models. Except for a bull period (bull 1), the estimated hedge ratios using VECM during the remaining six bull markets (bulls 2 to 7) are highest compared to other models. The VECM yields highest hedge ratio is possibly because spot and futures prices are cointegrated with an error correction term which would not allow these prices to drift apart in the long run. The model which consistently leads to lowest hedge ratio is MGARCH in all bull markets. The low hedge ratios of the time-varying model implying that price movements are not necessary best represented by changeable means and time-varying variances.

In bear markets, however, the level of hedge ratio is mixed across models. The OLS model for two bear markets and the MGARCH for the remaining four bear markets provide the lowest hedge ratio. The VECM estimates the highest hedge ratio during three bear markets. Consistent with the bull markets, the VECM yields the highest hedge ratio across models on average. This shows the importance of the error correction term in converging the spot and futures prices towards the long-run equilibrium.

Table 5: Estimation of Optimal Hedge Ratio

	OLS	VAR	VECM	MGARCH
Bull markets				
Bull 1	0.82377680	0.80646984	0.81764694	0.79408093
Bull 2	0.75861840	0.83345396	0.83807917	0.69453299
Bull 3	0.79662650	0.80168039	0.81446840	0.74047377
Bull 4	0.83813280	0.84915771	0.85535877	0.81368406
Bull 5	0.82508490	0.82693508	0.83495674	0.79165101
Bull 6	0.91308020	0.91280855	0.91837482	0.86624368
Bull 7	0.87408760	0.88229107	0.88619105	0.83361370
Average	0.83277246	0.84468523	0.85215370	0.79061145
Bear markets				
	OLS	VAR	VECM	MGARCH
Bear 1	0.66286360	0.75269127	0.77883227	0.81539243
Bear 2	0.47346300	0.55391270	0.59095393	0.69528770
Bear 3	0.81776990	0.83822792	0.85988940	0.77526565
Bear 4	0.81223290	0.81569276	0.82171837	0.79573402
Bear 5	0.89454290	0.88635406	0.89115496	0.83139053
Bear 6	0.90612190	0.91508997	0.92361656	0.87511317
Average	0.76116570	0.79366145	0.81102758	0.79803058

3.5 Comparison of hedging effectiveness

Table 6 presents a summary of hedging effectiveness, showing that hedging performances (in terms of variance reduction) are consistently different between bullish and bearish markets across models. On average, the hedging effectiveness in bull markets is approximately 10% higher than the bear markets across models. In the bull markets, variance reduction ranges from 88.3% to 88.6%. The optimal model with highest hedging effectiveness is OLS (88.6%) while MGARCH (88.3%) ranks last relative to other models. In details, the OLS has a negligibly better hedging performance measure while the MGARCH shows slightly lower outcomes in bullish markets. This shows that a complex model such as the time-varying hedge model does not always outperform a static model (the OLS).

The variance reduction in bear markets is smaller than that those of bull markets. In line with the bull markets, the OLS model provides the best performing strategy in terms of producing highest variance reduction. MGARCH have the lowest amount of variance reduction (74.4% average) followed by VECM and VAR. Across the markets and models, MGARCH provides the worst performing strategy in terms of producing lowest variance reduction. The low level of estimated hedge ratios and hedging performance indicates that equity futures is not effective for risk management in cash market.

One important practical implication is that hedgers must rebalance their hedging strategies during bear and bull markets. For example, a hedger may consider adjusting futures positions according to the hedged ratio derived from the OLS model during the bull and bear markets. However, the hedger needs to be cautioned in bear markets as all hedging models provide lower risk reduction in bear markets. Our results suggest that investors may need to adjust their hedging strategies using different hedging models according to different market conditions. The real factor causing the differences is beyond the discussion of this study, though, one possible reason may come from differences in return volatility between different price trends. Bear markets have lower risk reduction, and this makes it more difficult to measure hedging performance by the given hedging models.

4. Conclusion

This study examines the asymmetric performance of hedging strategies between bull and bear markets. Few studies have shown various methods to measure the hedging effectiveness but due asymmetric fluctuations in stock market volatility, it becomes imperative to revisit the hedging effectiveness of the Taiwanese stock market. This paper highlights the fact that hedging effectiveness of Taiwanese index futures is different across bull and bear markets. In order to measure hedging performance, we present a comparison between the four most popular econometric techniques in literature. The results reveal that highest hedging effectiveness is of OLS which place it in most-effective hedging model in terms of risk reduction. It is evident that time-varying model does not perform better than static model. There is no improvement in hedging effectiveness with the time-varying model.

Our results show that identifying bull and bear phases of the Taiwanese stock index futures market is important. The main results indicate that hedging effectiveness is asymmetric between bearish and bullish markets. In terms of risk reduction, the hedging performance is better in the bull market than in the bear market. This form of asymmetric performance is consistent across the four hedging models. From the perspective of hedgers, it is important to adjust their hedging strategies using different hedging models in response to different market conditions.

Table 6: Variances of Hedged and Unhedged Portfolio Returns and Risk Reduction

	Bull Markets								
		OLS		VAR		VECM		MGARCH	
	Unhedged	Hedged	Reduction	Hedged	Reduction	Hedged	Reduction	Hedged	Reduction
Bull 1	0.00008151	0.00001476	0.81894790	0.00001459	0.82095537	0.00001469	0.81975323	0.00001469	0.81983107
Bull 2	0.00053492	0.00006186	0.88434813	0.00006647	0.87574232	0.00006705	0.87464569	0.00006548	0.87759259
Bull 3	0.00034152	0.00002788	0.91835676	0.00002790	0.91831979	0.00002804	0.91789609	0.00003072	0.91004059
Bull 4	0.00015137	0.00001543	0.89809189	0.00001545	0.89793648	0.00001548	0.89771251	0.00001595	0.89465173
Bull 5	0.00018477	0.00001794	0.90288487	0.00001795	0.90288033	0.00001797	0.90275562	0.00001805	0.90228621
Bull 6	0.00006683	0.00000818	0.87764430	0.00000818	0.87764423	0.00000818	0.87761479	0.00000852	0.87247560
Bull 7	0.00006499	0.00000600	0.90771930	0.00000600	0.90763935	0.00000601	0.90754525	0.00000621	0.90447321
Average			0.88685616		0.88587398		0.88541760		0.88305014

	Bear Markets								
		OLS		VAR		VECM		MGARCH	
	Unhedged	Hedged	Reduction	Hedged	Reduction	Hedged	Reduction	Hedged	Reduction
Bear 1	0.00048385	0.00019585	0.595218989	0.00020114	0.584288297	0.00020467	0.577000643	0.00021193	0.561980499
Bear 2	0.00029366	0.00015129	0.484808451	0.00015540	0.470811018	0.00016006	0.454954086	0.00020078	0.316295344
Bear 3	0.00033195	0.00003441	0.896331413	0.00003460	0.895770449	0.00003520	0.893953624	0.00003618	0.891001563
Bear 4	0.00041654	0.00003793	0.908941201	0.00003794	0.908924707	0.00003798	0.908817233	0.00003772	0.909443637
Bear 5	0.00019622	0.00001553	0.920879508	0.00001554	0.920802335	0.00001553	0.920866298	0.00001688	0.913972079
Bear 6	0.00010720	0.00001314	0.877408238	0.00001315	0.877322297	0.00001318	0.877081178	0.00001393	0.870013817
Average			0.780597967		0.776319850		0.772112177		0.743784490

Notes: The amount of risk reduction is calculated based on the difference between the hedged and unhedged return divided by the unhedged return. The higher value implies higher hedging performance. The sample of daily prices covers the period from January 17, 2000 to December 31, 2019. The number of observations is 4958.

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