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# Stock index hedging using a trend and volatility regime-switching model involving hedging cost

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## ABSTRACT

In this study, the risk hedge between the Morgan Stanley Taiwan stock index (MSTI) and its underlying futures is analyzed regarding hedging cost under various hedge states using the trend and volatility involved regime-switching models compared with OLS and the naive method. The correlation between MSTI spot and futures is very high and the cointegration test between them is very significantly. The hedging result is evaluated using out-of-sample data and the realized variances and covariances, and is really satisfying in the subprime period or when both spot and future stay in a down state. In this stock index context, the risk aversion is determined to be 1. The optimal hedge ratio on average is around 0.878. The White test favors the regime-switching models in prediction. The trend and volatility-switching model performs particularly well in wealth increase.

## 1. Introduction

Stock indices fluctuate frequently because of information shocks caused by sudden events resulting from economic, political, or natural disasters. The major market crises, such as the Asian financial crisis in 1997, the U.S. subprime mortgage crisis in 2008, the 2011 earthquake in Japan, and the Greek debt crisis in 2012, have all caused chaotic aftermaths in global stock markets. Therefore, hedging a stock portfolio is necessary.

The removal of investment quotas for foreign investors in July 2003 enabled the qualified foreign investors to invest in the Taiwan Stock Exchange (TWSE) openly and feely. At the end of 2013, the total market capitalization of the Taiwan stock exchange, involving 797 listed companies, had increased up to 20 percent compared with that in 2008, amounting to around US$ 666 billion, with the daily trading value and market turnover rate reaching approximately US$ 3 billion and 119.87 percent, respectively. In this paper, the MSCI Taiwan stock index (MSTI) is regarded as a spot position owned by domestic and qualified foreign investors that is susceptible to shocks of either favorable or unfavorable news in the Taiwanese stock market. MSTI is comprised of around 70 percent Taiwanese stock market capitalization covering 100 component stocks. To hedge the MSTI, the hedge tools used are the futures of the MSTI, the STW. STW is coded and traded on the Singapore Exchange (SGX) that was formed in 1999 thanks to the merger between the Stock Exchange of Singapore (SES) and the Singapore International Monetary Exchange (SIMEX).

At present, STW is traded globally, even online, at any time. Its open interest is gradually increasing and is admired by many foreign traders, who occupy over 28 percent of the trading volume. As of the end of 2013, the averaged STW open interest and the number of trading contracts were 185,372 and 45,838, respectively, gradually increasing from 12,977 and 31,884 at the beginning of 2001. This episode indicates that STW is useful and advantageous for foreign investors. In fact, the Taiwan stock market is more

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efficient and healthy than other Asian stock markets due to its robust economic strength and vitality, and it has survived several large financial disasters. For foreign investors, comprehending how to hedge the portfolio risk is crucial to benefit from the investment and hedge of MSTI.

The optimal hedge ratios (i.e., the best number of futures required to hedge the spot position) are calculated usually by the hedging model and the mean-variance method. However, the stock markets are nonstationary, in that anomalies, various trends, and different volatility states often occur.B, Besides, speculators who take advantage of trading signals are active in finding the momentum of price changes, while hedgers who want to insulate the risk of price changes are passive and, among them, the trading information is even asymmetrical. The aftermath can drive some hedgers to evade the futures market, as studied by Carter (1999). Besides, if bad news arrives, traders are subject to overreact more than to than news, as studied by Brooks, Henry, and Persand (2002). In consequence, the stochastic trend of returns often shifts up and down swiftly, as studied in time series momentum, and the volatility state is persistently high or low (i.e. long memory) for a period: as Hamilton (1990, 1991) has evidenced, the stock returns exhibit high and low volatility states. Hence, the conventional regression method that considers only one state equation is insufficient to describe the dynamic behavior of stock markets involving various states of trends and volatility. Since volatility is persistent in a high or low state for a while, the Markov switch becomes an appropriate way to model the phenomenon of volatility state switch. It is a nonlinear dynamic model and permits switching between two or more regimes to capture the specific dynamic patterns. Its state variables follow a first order Markov chain—i.e., the current value of the state variable depends only on its immediate past value. Hamilton (1991) and Engel (1994) have first started to apply the Markov chain to describe and predict nominal US dollar exchange rate changes based on the Bayes' theorem. Later, Hamilton and Susmel (1994) and Cai (1994) began to incorporate mixture normal likelihood function into autoregressive conditional heteroscedasticity (ARCH) model to investigate the time-varying volatility changes. McLachlan and Peel (2000) supported that the use of mixture distributions is appropriate due to their suitability and flexibility.

Evidences also show that not only correlation in an asset itself but correlation between assets is crucial to track the price returns and thus the application of vector autoregression is very popularly for studying two or more assets. Based on the aforementioned researches, this paper uses the bivariate regime-switching generalized ARCH to study the stock index hedge. Besides, as Alizadeh, Nomikos, and Pouliasis (2008), Kroner and Sultan (1993), and Lien (1996), among others, pointed out, the spread between spot and futures prices is mean reverse and a long term equilibrium relationship exists and this phenomenon is termed 'cointegration'. Hence, in our paper, the vector autoregression combining the cointegration effect becomes the vector error correction model (VECM) is incorporated into the regime-switching generalized autoregressive conditional heteroscedasticity (RS-GARCH) model to accommodate the reverse changes in the trend of returns and the different state persistences in volatility.

In this study, using the regime switch, the trend of returns with cointegration is allowed to shift between two states and the volatility can persist at either a high or low state. Once the trend of returns in cointegration and volatility in GARCH are predicted using the regime-switching hedging model, the optimal hedge ratios are subsequently computed by maximizing the expected hedging utility function while considering the hedge cost. The optimal risk preference also determined when maximizing the expected hedging utility function actually implies the amount of risk premium in market. In other words, if one can capture the true market risk premium, it follows that the return should reach its maximum with risk restricted to a constant. Meanwhile, the hedging cost would definitively reduce the hedgers' wealth, and so the use of time-varying models should not ignore the hedging cost (Lence, 1995, 1996). In addition, the realized variances and covariances are compared to the predicted variances and covariances to evaluate the hedging performance.

The contribution of this paper is exclusive compared to Alizadeh and Nomikos (2004) and Lee and Yoder (2007), because it allows for the state change of stochastic return trend when hedging and it evaluates the hedge effectiveness of the out-of-sample period instead of the in-sample period using the realized variance and covariance. Most articles evaluating the in-sample variance reduction may not reflect the hedger's true benefit. In addition, to discover the optimal risk aversion, hedge effectiveness is assessed and compared using the different risk aversions of utility function.

The remainder of the paper is structured as follows. In Section 2, the methods for obtaining optimal hedge ratios and the regime-switching models are discussed based on related articles. In Section 3, the specification of future contract and transaction costs associated with hedger behavior are described in detail. In Section 4, the sample of data, estimations of regime-switching methods for calculating hedge ratios, and measurements of hedge effectiveness are addressed in detail. In Section 5, the hedge ratios obtained using a rolling window technique and the hedge results are compared among various hedging models, measurements, periods, and states. The final section presents the concluding remarks.

## 2. Literature review

Investors generally want to understand the methods for obtaining the optimal hedge ratio to achieve successful hedging of portfolio risk. According to Markowitz (1952), investors wish to minimize the risk of investment. Therefore, the minimum-variance optimization method has been applied by early authors such as Ederington (1979), Johnson (1960), and Stein (1961), and subsequent authors such as Alizadeh et al. (2008), Baillie and Myers (1991), Harris and Shen (2003), Koutmos and Pericli (1998), Lien and Yang (2008), Moschini and Myers (2002), and Poomimars, Cadle, and Theobald (2003). However, this method considers neither the wealth effect, nor the hedge cost.

Investors also want to minimize risk and obtain maximum profit (Working, 1962); therefore, the mean-variance utility (MVU) method is adopted by authors such as Gagnon, Lypny, and McCurdy (1998), Heifner (1972), Kroner and Sultan (1993), and Lence (1995). The MVU method incorporates the expectation of investment return and variance into a hedging utility function involving a