Alternative Settlement Methods and Australian Individual Share Futures Contracts

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Abstract

Individual share futures contracts have been introduced in Australia since 1994. Initially the contracts were settled in cash. In 1996, cash settlement was gradually replaced by physical delivery. This study investigates the effects of the settlement method change on Australian individual stock and its futures markets. Specifically, we examine whether the returns and volatility of each market, the correlation between the two markets, the basis behavior, and the hedging performance of futures markets differ across the cash settlement period and the physical delivery period. We use the error correction model to account for the cointegrated system of two markets in the mean equations and the bivariate GARCH model to estimate the conditional time-varying variance and covariance matrix of stock and futures returns. We find that, after the switch from cash settlement to physical delivery, the futures market, the spot market, and the basis all become more volatile. However, each individual share futures contract becomes a more effective hedging instrument. The improvement in hedging effectiveness is particularly impressive for the most recently established individual share futures contracts.

JEL classification: G13
Keywords: Bivariate GARCH model; Futures settlement methods; Hedging effectiveness of individual share futures; Basis behavior

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1. Introduction

There are two settlement methods associated with a futures contract, cash settlement and physical delivery. Before stock index futures contracts were introduced, all futures contracts were settled by delivery of the underlying asset. This settlement procedure promotes the convergence of cash and futures prices and thereby enhances the risk-transferring and price-discovery functions of futures markets. However, the high delivery costs and vulnerability to market manipulation of physical delivery have led to the adoption of cash settlement as an alternative (Garbade and Silber (1983), Jones (1983), Edwards and Ma (1996), and Manaster (1992)). For example, the stock index futures have been settled in cash since they were introduced because delivering a stock index portfolio would require high transaction costs if possible at all.

Commodities are by nature heterogeneous and perishable. The delivery process therefore incurs large transaction costs such as transportation, inspection, storage, and insurance. In addition, the physical delivery settlement must specify deliverable grades and locations. Restrictions on the deliverable grades and locations reduce the uncertainty of a successful delivery process but promote market manipulation (e.g., corners or squeezes). On the other hand, flexibility on the grades and locations increases the uncertainty of the good to be delivered, and hence reduces the hedging effectiveness of a futures contract. The necessity of constantly balancing restrictions and flexibility on the deliverable grades and locations for physical delivery specification renders cash settlement more desirable. Currently, feeder cattle and lean hog futures contracts both adopt cash settlement. In addition, proposals for cash-settled futures contracts on corn, soybean, and other livestock were considered.

Lien and Tse (2002) examine the effects of switching from physical delivery of feeder cattle futures contracts to cash settlement on the feeder cattle market performance. The result is consistent with the expectations of Chicago Mercantile Exchange when the change was initiated. Cash settlement reduced the futures market volatility and the basis variability. Further studies by Chan and Lien (2002, 2003) find the conclusions to be robust to different volatility estimation methods.

The challenge involved in cash settlement is to ensure that the settlement process be fair and orderly so that futures prices properly reflect underlying asset values during the final days of trading. If this does not occur, the hedging and price discovery functions of futures markets are compromised. Cornell (1997) summarizes three types of problems that can cause cash-settled futures prices to diverge from true equilibrium prices.

The underlying asset for an individual share futures (ISF) contract is a stock. There is no grade heterogeneity problem and the delivery cost is negligible. Physical delivery method is considered to be appropriate. Australian ISF contracts were settled in cash when they were first introduced in Sydney Futures Exchange (SFE). After two years, SFE decided to switch from cash settlement to physical delivery. Several rationales were provided by SFE. One of them is the improvement of hedging function. Consider an equity call writer who buys the ISF to reduce risk exposure in the options market. Under physical delivery method he obtains the stock at the maturity of the ISF. With the stock in hands, he can make delivery of the stock at the settlement of the options contract and perfectly achieve his hedging objective. Cash settlement method of the ISF concludes with cash transferring. To settle the options contract, the call writer has to enter into the spot market to purchase the stock. If the cash-settled futures prices are not equal to the stock price, the price risk in the futures market is incurred. The effect of hedging risk exposure in the options market with the ISF could be affected adversely.

This paper presents the first attempt to measure the impact of settlement method change on Australian individual stock and its futures markets. Specifically, we investigate the effect on the returns and volatility of each market, the correlation between the two markets, the basis behavior, and the hedging performance of the futures contracts. An error correction-bivariate GARCH model (EC-BGARCH) is proposed. Error correction terms are included in the conditional mean equations to preserve the long-term equilibrium relationship between spot and futures markets. The time-varying variance and covariance structure of the two markets is described by a bivariate GARCH model. Daily data is used to estimate the EC-BGARCH model. Dynamic optimal hedge ratios and hedging effectiveness are obtained from the estimation of the time-varying variance-covariance matrix and then are evaluated before and after the contracts were switched from cash settlement to physical delivery. In addition, the effect of the settlement method on the basis behavior is analyzed. We find that the switch from cash settlement to physical delivery improves hedging performance of the futures market, strengthens the comovement between futures and spot markets while promoting market volatility in both futures and spot markets. The variability of basis also becomes higher during the physical delivery period.

The remainder of the paper is organized as follows. In the next section we discuss the data and provide a preliminary statistical analysis. The EC-BGARCH model is described in Section 3 along with the estimation results. Optimal hedge ratios and hedging effectiveness are analyzed in Section 4. Section 5 devotes to the statistical analysis of the basis. Finally, Section 6 concludes the paper.

2. Data and Preliminary Analysis

Australian ISF contracts were introduced in 1994 on SFE. Each ISF contract is priced on the basis of 1,000 shares of the underlying stock. Prior to March 1996, the ISF contracts were settled in cash. On March 29, 1996, SFE modified rules to switch ISF contracts of Broken Hill Proprietary, Ltd. (BHP), Western Mining (WMC), and Rio Tinto (RIO) from cash settlement to physical delivery of shares. Seven additional ISF contacts were switched at later dates when their respective cash-settled contracts expire. Telstra Corporation is the sole exception. The futures contract of Telstra Corporation has been settled in cash since it was first introduced in November 1997. Table 1 reports names of the stocks, codes of the stocks, listing dates of their corresponding futures contracts, and the switching dates from cash settlement to physical delivery for each pair of stock and its futures prices being analyzed, respectively.

Daily closing prices of individual stocks and their corresponding futures contracts are used in this study. The price series are collected from Datastream. The sample period covers from the first day of each ISF contract being listed (see Table 1) to May 2001. A single futures price series for each ISF contract is constructed using closing prices from the nearby contract with rolling over at the beginning of the delivery month to the next nearby contract. The data point is removed if a missing value occurs in either stock or futures price at that day. Table 2 reports the summary statistics of mean, standard deviation, skewness, and kurtosis on each pair of return series during the cash settlement period, the physical delivery period, and the complete sample, respectively. The most evident change is that, after the ISF contracts were switched from cash settlement to physical delivery, the standard deviations across each of spot and futures markets except the FBG futures market increased rapidly, ranging from 3% up to more than

70%. Thus it appears that both spot and futures markets were more volatile during the physical delivery period.

Before discussing the model used in this study, we perform unit root and cointegration tests on the price and return series. According to the cost-of-carry theory, futures and spot prices should move up and down together in the long run whereas short-run deviations from the long-run equilibrium may take place due to mispricing of futures or spot price. This lays out the foundation for a cointegrated system of futures and spot prices. Therefore, we first perform augmented Dickey-Fuller (1981) test on each spot and futures price series and their first differences to investigate the stationarity of the price and price change series. If the price series of spot and futures are not stationary but the changes of prices are stationary, the cointegration concept becomes relevant. We then use the Engle and Granger (1987) method to test whether spot and futures prices are cointegrated.

Let p_{st} and p_{ft} denote the natural logarithm of the stock and its futures prices at time t, respectively. The changes of spot and its futures prices at time t are calculated as $\Delta p_{st} = p_{st} - p_{s,t-1}$ and $\Delta p_{ft} = p_{ft} - p_{f,t-1}$, respectively. For each price series, we consider the following equations.

(1) $$\Delta p_t = \gamma p_{t-1} + \sum_{i=1}^{k-1} \psi_i \Delta p_{t-i} + \mu_t \, .$$

(2) $$\Delta p_t = \alpha + \gamma p_{t-1} + \sum_{i=1}^{k-1} \psi_i \Delta p_{t-i} + \mu_t$$

(3) $$\Delta p_t = \alpha + \beta t + \gamma p_{t-1} + \sum_{i=1}^{k-1} \psi_i \Delta p_{t-i} + \mu_t$$

The null hypothesis in all three cases is that $\gamma = 0$; if the null cannot be rejected, the price series contains a unit root, and hence it is non-stationary. We use the Schwarz Bayesian criterion

(Schwarz, 1978) to determine *k*, the number of lags in equations (1)-(3). We then estimate the above equations for each pair of price series and test the null hypothesis. To save the space, the test statistics from equation (3) are reported in the first two columns of Table 3. The null hypotheses of a unit root for these series are not rejected at the 5% level (except two series at the 1% level) indicating that all the pairs of spot and futures price series are non-stationary[1]. The augmented Dickey-Fuller test is also applied to the changes of spot and futures price series as well as the basis series, B_t, calculated as $B_t = p_{st} - p_{ft}$. The results from equation (3) are reported in columns 3-5 of Table 3, respectively. The null hypotheses of a unit root for the change in price and the basis series are rejected at the 1% level, which concludes that the price change and basis series are stationary.

We now use the Engle-Granger (1987) cointegration test to examine the system of futures and stock prices. The test is based on assessing whether single-equation estimates of the equilibrium errors appear to be stationary. As reported in the last column of Table 3, the null hypothesis of no cointegration between futures and spot prices is rejected for each pair of price series at the 1% level. This suggests that each pair of stock and its futures prices are cointegrated. This finding is consistent with the prediction of the cost-of-carry theory.

3. EC-BGARCH Model

Our main objective is to examine market volatility and the hedging performance of a futures market under different settlement schemes. Estimation of the variance-covariance matrix of futures and spot returns becomes crucial to achieve the objective because the variance of the asset return measures market volatility. Moreover, hedge ratio and hedging effectiveness are two

[1] The critical values of the t-statistics depend on the equation being estimated. The critical values of Enders (1995) are used.

important elements for constructing hedging strategies, carrying out the task of risk management, and evaluating the hedging performance. The calculations of hedge ratio and hedging effectiveness require estimates of the variance-covariance matrix of spot and futures returns.

It is now well recognized that correlation and volatility of asset returns are time-varying. To account for this statistical property, multivaraite GARCH (MGARCH) models are widely adopted; see, e.g., Baillie and Myers (1991), Kroner and Claessens (1991), Lien and Luo (1994), and Karolyi (1995). Different model specifications and restrictions on the conditional variance-covariance matrix in the MGRACH model have been introduced to overcome the computational difficulty, to ensure a positive definite variance-covariance matrix, and to provide better goodness of fits to the data. For instance, there are the VECH model of Bollerslev, Engle, and Wooldridge (1988), the CCORR model of Bollerslev (1990), the FARCH model of Engle, Ng, and Rothschild (1990), the BEKK model of Engle and Kroner (1995), the ADC model of Kroner and Ng (1998), and the DCC model of Engle (2000). Each of these models has advantages and shortcomings, and may fit into one set of data better than others[2].

In this study, we use the BEKK representation to estimate the conditional time-varying variance-covariance matrix of futures and spot returns. This model ensures a positive variance-covariance matrix and it fits our data very well. In additional, to accommodate the statistical properties identified in the previous section, we use the error correction model to characterize the cointegrated system of futures and spot prices. Thus, we propose an error correction-bivariate GARCH (EC-BGARCH) model.

The conditional mean equations are given by

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[2] For the comparison of these models, see Kroner and Ng (1998) and Engle (2000).

(4) $$R_{st} = \alpha_{s0} + \sum_{i=1}^{p} \alpha_{si} R_{s,t-i} + \sum_{j=1}^{q} \beta_{sj} R_{f,t-j} + \phi_s B_{t-1} + \gamma_s D_t + \varepsilon_{st},$$

(5) $$R_{ft} = \alpha_{f0} + \sum_{i=1}^{p} \alpha_{fi} R_{s,t-i} + \sum_{j=1}^{q} \beta_{fj} R_{f,t-j} + \phi_f B_{t-1} + \gamma_f D_t + \varepsilon_{ft},$$

where R_{st} and R_{ft} denote the returns of stock and futures, which equal to Δp_{st} and Δp_{ft}, respectively. p and q are the numbers of lags in the model. D_t is a dummy variable at time t that equals to zero for the cash settlement period and one for the physical delivery period. The dummy variable is included into the system to gauge the effects of the change in the settlement method. The coefficients, γ_s and γ_f, measure the impact of physical delivery on the spot and futures returns, respectively. The basis at time t-1, B_{t-1}, serves as the error correction term. When the spot return exceeds the futures return at time t-1 (i.e., $B_{t-1} > 0$), the spot price tends to be decreasing whereas the futures price tends to be increasing at time t in order to maintain the long-term relationship between futures and spot prices. Similarly, when the spot price falls below the futures price at time t-1 (i.e., $B_{t-1} < 0$), the spot price tends to be increasing and the futures price tends to be decreasing in the next period. This would lead one to predict that $\phi_s \leq 0$ and $\phi_f \geq 0$.

The conditional variance-covariance matrix of residual series, $E_t = (\varepsilon_{st,}\varepsilon_{ft})'$, is denoted by

$$Var(\varepsilon_{st}, \varepsilon_{ft} \mid I_{t-1}) \equiv H_t = \begin{bmatrix} h_{st} & h_{sft} \\ h_{sft} & h_{ft} \end{bmatrix},$$

where I_t is the information set at time t. The time-varying variance-covariance matrix is generated by

(6) $$H_t = \begin{pmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{pmatrix} \begin{pmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{pmatrix}' + \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} E_{t-1} E_{t-1}' \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}' +$$

$$\begin{pmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{pmatrix} H_{t-1} \begin{pmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{pmatrix}' + \begin{pmatrix} \omega_s & \omega_{sf} \\ \omega_{sf} & \omega_f \end{pmatrix} D_t$$

This representation is the bivariate case of the BEKK (1,1) model proposed by Engle and Kroner (1995). It captures the dynamic structure of variances as well as the covariance of asset returns. The dummy variable D_t is included in the variance equation to capture the effect of the change in the settlement method on the conditional variance of stock returns, the conditional variance of futures returns, and the conditional covariance between futures and spot returns. The values of ω_s, ω_f, and ω_{sf} measure the magnitude and significant levels of the effects, respectively.

A two-step estimation method is used[3]. We first estimate the mean equations to obtain the residuals ε_{st} and ε_{ft} using the ordinary least squares (OLS) method[4]. We then treat ε_{st} and ε_{ft} as observed data to estimate the parameters in the conditional variance-covariance matrix using the maximum likelihood method. Before estimating the mean equations, we use the Schwarz Bayesian criterion (Schwarz, 1978) to determine p and q, the number of lags in the mean equations. Estimation results are reported in Tables 4 and 5, respectively. A number of observations can be made across the mean equations in Table 4. First, the effects of the lagged stock returns on the current stock returns are significantly positive for 8 out of 11 stocks, whereas the effects of the lagged futures returns on the current stock returns are significant for 5 out of 11 stocks, two with positive effects and three with negative effects. The effects of lagged

[3] For the two-step estimation procedure, see, for example, Pagan and Schwert (1990) and Engle and Ng (1993).
[4] It is well known in the literature on cointegration between conventional I(1) processes that the OLS estimator of the cointegrating vector is super-consistent (see, for instance, Stock (1987)). For the heteroskedastic cointegration system, e.g., cointegrated regression model with errors displaying nonstationary variances, as our model specification, Hansen (1992) developed an asymptotic theory of estimation and inference and demonstrated that the OLS estimation would also yield consistent estimates of the stochastically cointegrating vector.

stock and futures returns on the current futures returns are more consistent across each pair of markets. With the exception of WMC, lagged stock returns have significantly positive effects while lagged futures returns have significantly negative effects on the current futures return. The above observations suggest that both stock and futures returns follow a mean-reversing process. In addition, the information in the spot market is more relevant in predicting the price movement in the futures market when compared with the prediction of spot price movement using the information in the futures market.

Secondly, as predicted by the basis convergence, the lagged basis has a significant positive effect on the current futures returns for 8 of 11 futures markets, suggesting that the futures price tends to move closer to the spot price. In contrast, the effects of the lagged basis on the current stock returns are not significant across each stock market. This implies that the futures market tends to follow the movement of the spot market in order to maintain the long-term relationship. Finally, the results in Table 4 show that the switch from cash settlement to physical delivery has no effect on the stock returns and a negative effect on two futures returns of MIM and RIO[5].

In summary, the above results suggest that individual stock market tends to lead the corresponding futures market. This lead-lag pattern differs from what we have observed in other markets. For example, Chan (1992) documented that stock index futures market leads the cash market. Garbade and Silber (1983) found that the commodity futures markets dominate cash markets. Different findings of the informational role and price discovery function of a futures market may arise from different intensities of trading activity in spot and futures markets. Chan (1992) argued that lower trading activity means that the security is less frequently traded and

[5] The TEL futures contract has been settled in cash since it was introduced. Therefore, the switch effect analysis does not apply on it.

therefore observed prices lag "true" values more. In Australia, the individual stock futures contracts are traded far less frequently than their corresponding stocks. Daily average trading volume ratio of the individual stock to its futures during the sample period varies from 150 to 2,000 across each market being analyzed. This could cause the lead-lag relation between spot and futures markets to favor individual stocks[6]. Admati and Pfleiderer (1988) showed that both liquidity and informed traders prefer to cluster their trades with each group when the market is thick. The clustering of trades causes more information to be released. Therefore, the spot market can play the leading role in disseminating the information when trading of the stock is intensity.

Table 5 presents the estimation results of the variance and covariance matrix. The values of a_{11}, a_{22}, g_{11}, and g_{22} across each pair of the spot and futures markets are positive and statistically significant different from zero. The value of g_{21} is also positive and statistically significantly different from zero for 8 of 11 pairs whereas the value of a_{21} is negative and statistically significantly different from zero for all the pairs. The value of a_{12} is insignificant except for BHP and NCP. The value of g_{12} is insignificant except for BHP and PDP. These results suggest that the GARCH effect dominates the ARCH effect in both spot and futures markets[7]. Thus, the volatilities in both markets are more persistent, i.e., a high volatility tends to remain for a longer period. The covariance between spot and futures markets is also persistent.

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[6] We use an AR process to reduce the effects of infrequent trading in the individual share futures markets suggested by Chan (1992), then use the return innovations derived from the AR model to proxy for true returns. The results are similar to those observed above.

[7] The effect s of the error term E_{t-1} on H_t and H_{t-1} on H_t are denoted as the ARCH and GARCH effects, respectively. If the value of the combination of elements in the E_{t-1} and their corresponding coefficients is greater than that of the combination of elements in the H_{t-1} and their corresponding coefficients, then we conclude the ARCH effect is dominate the GARCH effect, otherwise, the GARCH effect dominates the ARCH effect.

The current covariance of spot and futures returns is highly correlated with the past covariance of two markets.

Of particular interest, we now discuss the estimated coefficients ω_s, ω_f, and ω_{sf} in equation (6), which capture the effect of the switch from cash settlement to physical delivery on the variances of spot and futures returns, and the covariance between the two returns. To ensure the nonnegative definiteness of H_t during the estimation, we transform the coefficient matrix of the dummy variable to the product of two identical vectors, $Z = \begin{pmatrix} z_1 & z_2 \end{pmatrix}$, i.e.,

$$\begin{pmatrix} \omega_s & \omega_{sf} \\ \omega_{sf} & \omega_f \end{pmatrix} = Z'Z .$$

Due to the transformation, the values of ω_s and ω_f are always positive even when the values of z_1 and z_2 are negative. Thus, a positive value of ω_s or ω_f does not always imply a positive effect on the variance of each market. To avoid overstating the positive effect, we base on the estimated values of z_1 and z_2 and their corresponding *t* statistics to draw our conclusion. The estimated values of z_1 and z_2 along with their corresponding *t* statistics are reported in Table 5. The values of ω_s, ω_f, and ω_{sf} are calculated based on the transformation and also reported in Table 5[8]. For 7 of 10 cases, the values of z_1 are positive and significantly different from zero. For the rest of 3 cases, the values of z_1 are negative and significantly different from zero. Thus, the switch from cash settlement to physical delivery has significantly positive effects on the stock variances in at least 7 of 10 stocks. Significantly positive effects on the futures variances prevail for at least 5 of 10 cases. The covariance between futures and stock returns also increases significantly in 7 of 10 cases. In sum, both futures and spot markets become more

[8] The t statistics for z_1 and z_2 cannot be transformed into those for ω_s ω_f and ω_{sf}.

volatile and the covariance between two markets becomes larger after physical delivery method is adopted.

To recast, the spot return does not respond to settlement method change whereas only two futures returns display negative effects. Meanwhile, most futures and stock markets become more volatile and the covariances between futures and stock returns become larger during the physical delivery period.

4. Optimal Hedge Ratio and Hedging Effectiveness

In this section, we directly test the Sydney Futures Exchange claim of improving hedging effectiveness by switching to the physical delivery method. Assume that a hedger uses the futures market to hedge the risk of the spot market. The time-varying optimal hedge ratio[9] under the minimum-variance framework at time $t - 1$ is calculated as the conditional covariance divided by the conditional variance of the futures return[10]:

(7) $$HR_{t-1} = Cov(R_{st}, R_{ft} | I_{t-1}) / Var(R_{ft} | I_{t-1}) .$$

Estimates of $\{HR_t\}$ series can be generated from the estimation results of equation (6). The nonparametric test of Wilcoxon sum rank is applied to test the differences of the mean and variance of the optimal hedge ratio series between the physical delivery period and the cash settlement period. The null hypothesis is that the mean and variance of the optimal hedge ratio series during the cash settlement period is the same as those during the physical delivery period. The alternative hypothesis is that the mean and variance of the optimal hedge ratio series during

[9] The hedge ratio is the ratio of the position taken in the futures contracts that offset the size of the exposure in the spot market.

[10] If futures prices follow a martingale process, then the minimum-variance optimal hedge ratio is also the expected-utility-maximizing hedge ratio for a hedger with a quadratic utility function. See, for example, Anderson and Danthine (1980), Ederington (1979), and Malliars and Urrutia (1991), among others.

cash settlement period is less than those during the physical delivery period. The results of test statistics and their *P*-values are reported in Table 6 along with the mean and variance for the complete sample period, the cash settlement period, and the physical delivery period. The results show that the average optimal hedge ratio becomes higher after the switch from cash settlement to physical delivery in every case. With physical delivery, the hedger receives the underlying stock directly and applies it to offset the spot position. Cash settlement, on the other hand, requires the hedger to enter the spot market for another round of trading if the stock is desirable. In addition, with cash settlement there is likely a mismatch in timing between the liquidation of spot and futures positions. Thus, hedging becomes more effective when physical delivery replaces cash settlement and the optimal hedge ratio increases accordingly. Figures 1-3 show the daily hedge ratios of ANZ, PDP, and WMC. The largest increase of the average optimal hedge ratio is PDP (from 0.536 to 0.812) while WMC presents the smallest increase after physical delivery is adopted. ANZ represents an intermediate case.

Note also that the variability of the optimal hedge ratio has no significant changes. The variation of hedge ratio becomes larger after the settlement method changes from cash settlement to physical delivery for 3 of 10 futures contracts but none of them is statistically significant.

Following Ederington (1979), the hedging effectiveness is measured by the squared covariance divided by the product of spot and futures return variances:

$$HE_t = Cov^2(R_{st}, R_{ft} \mid I_{t-1}) / Var(R_{st} \mid I_{t-1}) Var(R_{ft} \mid I_{t-1}) . \tag{8}$$

Estimates of $\{HE_t\}$ series can also be derived from the estimation results of equations (6). Again, the nonparametric test of Wilcoxcon sum rank is applied to test for the difference of mean and variability of hedging effectiveness between cash settlement and physical delivery periods. Summary statistics of the series are provided in Table 7. With the exception of BHP, MIM, and

NCP, the hedging effectiveness improves significantly after the cash settlement is replaced by physical delivery. For BHP, MIM, and NCP, they decrease minimally on average from 0.846 to 0.825, from 0.768 to 0.750, and from 0.852 to 0.834, respectively. The largest improvement appears in the most recently established individual share futures contracts, FBG, PDP, RIO, and WBC. For example, the average hedging effectiveness of PDP increases from 0.45 in the cash settlement period to 0.72 in the physical delivery period – a more than 100% increase. The variability of hedging effectiveness is very small relative to the mean in both periods and some of them are indistinguishable.

The comparisons of hedging effectiveness confirm the claim made by the Sydney Futures Exchange. After switching from cash settlement to physical delivery, the individual share futures contract becomes a more effective hedging instrument. The largest improvement is made in the most recently established contracts.

5. Effect on Basis

In this section, we adopt an AR(k)-GARCH model to examine the impact of the switch from cash settlement to physical delivery on the basis behavior. The basis is expected to converge to zero at the maturity. Before the maturity, the variation of the basis determines the hedging performance of a futures contract. To model the time-varying basis, the conditional mean and variance equations are given as follows:

(9) $$B_t = \beta_0 + \sum_{i=1}^{k} \beta_i B_{t-i} + \psi D_t + \eta_t ,$$

(10) $$\sigma_t^2 = \delta_0 + \delta_1 \sigma_{t-1}^2 + \delta_2 \eta_{t-1}^2 + \phi D_t ,$$

where B_t and D_t are defined as before. $\sigma_t^2 = \text{var}(\eta_t \mid \Omega_{t-1})$. We use the Schwarz Bayesian criterion (Schwarz, 1978) to choose the number of lags, *k*. The quasi-maximum likelihood method is used to estimate the parameters of the conditional mean and variance equations (9) and (10) jointly. The coefficient estimates and their *t*-values for each basis series are reported in Table 8.

The results from the mean equation show that the lagged basis has a significantly positive effect on the current basis. Thus, a large basis tends to be followed by another large basis, displaying a strong persistence. From the estimates of ψ, it indicates that the switch from cash settlement to physical delivery has no effect on the basis, which is consistent with Lien and Tse (2002). For the variance equation, the GARCH effect dominates the ARCH effect for the first seven basis series. The most recent two basis series, RIO and PDP, display a much stronger ARCH effect and a much weaker GARCH effect. The switch from physical delivery to cash settlement has a statistically significant impact on the basis variance for five (BHP, NCP, FGB, RIO, and PDP) out of ten series. With the exception of FGB, the basis becomes more volatile after the settlement method changes, which is consistent with Lien and Tse (2002). That is, cash settlement provides a cheaper alternative for arbitrages and hence promotes the convergence between spot and futures markets.

6. Conclusions

We adopt a bivariate GARCH model with error correction to investigate the effects of the switch from cash settlement of the Australian individual share futures contracts to physical delivery on individual stock and its corresponding futures markets. We find that the change has no significant effect on the level of the stock returns and has some minimal effect on the level of the futures returns. Both stock and its futures markets become more volatile, the covariance between two markets increases, and the variability of basis becomes higher after physical delivery is adopted.

When examining the effect of settlement methods on the dynamic optimal hedge ratios, we find that the level of the optimal hedge ratio series has been increased. The average optimal hedge ratio increases in all the futures markets being analyzed. The examination of the hedging effectiveness shows that all individual share futures contracts (except BHP, MIM, and NCP) have become more effective hedging instruments after the settlement method change. The improvement in hedging effectiveness is particularly impressive for the most recently established individual share futures contracts.

Table 1: Australian Individual Share Futures Contracts: Names and Codes of Underlying Stocks, Listing Dates, and Switching Dates of Settlement Method

Company Name	Code	Listing Date	Switching Date
Australia and New Zealand Banking Group	ANZ	March 13, 1995	April 26, 1996
Broken Hill Proprietary, Ltd.	BHP	May 16, 1994	March 29, 1996
Fosters Brewing Group	FBG	March 13, 1995	April 26, 1996
Mount Isa Mines Holdings	MIM	Sept. 26, 1994	April 26, 1996
National Australia Bank	NAB	May 16, 1994	April 26, 1996
News Corporation	NCP	May 16, 1994	May 31, 1996
Pacific Dunlop	PDP	Oct. 18, 1995	May 31, 1996
Rio Tinto	RIO	March 13, 1995	March 29, 1996
Western Banking Corporation	WBC	Sept. 26, 1994	April 29, 1996
Western Mining Corporation	WMC	Sept. 26, 1994	March 29, 1996
Telstra	TLS	Nov. 28, 1997	

Table 2. Summary of Statistics on Cash and Futures Markets

		All Sample		Cash Settlement		Physical Delivery	
	Returns	Spot	Futures	Spot	Futures	Spot	Futures
ANZ	Mean	0.00073	0.00074	0.00085	0.00080	0.00071	0.00073
	STD	0.01532	0.01551	0.01269	0.01428	0.01584	0.01578
	Skewness	-0.07572	-0.0467	-0.44480	-0.17380	-0.03259	-0.02664
	Kurtosis	1.75903	1.75411	1.33650	1.02770	1.69267	1.83495
BHP							
	Mean	0.00022	0.00014	0.00023	-0.00002	0.00021	0.00018
	STD	0.01553	0.01645	0.01098	0.01239	0.01690	0.01772
	Skewness	0.22725	-0.19343	-0.01530	-1.4808	0.24397	-0.03074
	Kurtosis	1.24742	3.79212	0.80690	17.0670	0.89539	2.16716
FBG							
	Mean	0.00065	0.00095	0.00069	0.00244	0.00064	0.00063
	STD	0.01443	0.02096	0.01253	0.03368	0.01482	0.01698
	Skewness	0.11567	8.59732	0.07470	11.6307	0.11889	-0.10782
	Kurtosis	1.41767	206.3315	1.52800	171.259	1.34482	5.64061
MIM							
	Mean	-0.0004	-0.0004	-0.00099	-0.00097	-0.00022	-0.00021
	STD	0.02493	0.02794	0.01862	0.02125	0.02661	0.02971
	Skewness	0.2177	0.15962	0.41471	0.42490	0.18088	0.11703
	Kurtosis	2.8691	5.42461	1.57800	1.49550	2.6003	5.26135
NAB							
	Mean	0.00056	0.00055	-0.00012	-0.00014	0.00081	0.00081
	STD	0.01333	0.01647	0.01067	0.01103	0.01419	0.01831
	Skewness	-0.31693	-1.0699	-0.90707	-0.3064	-0.23671	-1.11163
	Kurtosis	1.97900	44.5661	2.85080	0.54210	1.60712	41.7554
NCP							
	Mean	0.00061	0.00059	0.00023	0.00018	0.00079	0.00078
	STD	0.02312	0.02773	0.01632	0.01732	0.02539	0.03103
	Skewness	0.72526	0.82806	0.3779	0.20432	0.72097	0.80835
	Kurtosis	10.04437	42.6439	1.8677	2.25673	9.32299	37.9491
PDP							
	Mean	-0.00071	-0.00073	-0.00116	-0.00129	-0.00065	-0.00065
	STD	0.01902	0.02903	0.01251	0.02181	0.01968	0.02982
	Skewness	-0.18282	-1.16900	-1.11754	-0.07995	-0.15619	-1.21159
	Kurtosis	4.16938	157.164	4.6882	0.55452	3.87475	158.6553
RIO							
	Mean	0.00056	0.00051	0.00056	0.00034	0.00056	0.00054
	STD	0.01651	0.02295	0.01124	0.01151	0.01741	0.02465
	Skewness	0.09076	-0.40571	0.33121	0.43105	0.07573	-0.40643
	Kurtosis	3.02305	126.643	0.91762	0.61193	2.74532	114.3562
WBC							
	Mean	0.00070	0.00069	0.00104	0.00102	0.00059	0.00059
	STD	0.01399	0.01482	0.01196	0.01298	0.01458	0.01536
	Skewness	-0.17081	-0.43828	-0.11548	0.02319	-0.17133	-0.51578
	Kurtosis	1.39645	4.751928	1.52742	0.41132	1.26548	5.27859
WMC							
	Mean	0.00012	0.00012	0.00019	0.00022	0.00010	0.00009
	STD	0.01998	0.16316	0.01541	0.01634	0.02115	0.18544
	Skewness	0.54002	0.18734	-0.01159	0.00851	0.59191	0.16569
	Kurtosis	3.98236	77.9477	0.41445	0.52435	3.92455	43.6420
TLS							
	Mean	0.00010	0.00102	0.00010	0.00102		
	STD	0.02008	0.04058	0.02008	0.04058		
	Skewness	4.21067	1.04095	4.21067	1.04095		
	Kurtosis	64.0754	38.3921	64.0754	38.3921		

Table 3. Unit Root and Cointegration Test Results

	Spot Price	Futures Price	Spot Return	Futures Return	Cointegration
			Cash Settlement		
ANZ	-2.096	-1.837	-8.081	-8.217	-7.487
BHP	-2.762	-3.313	-9.224	-9.271	-8.85
FBG	-3.153	-1.996	-7.774	-8.045	-8.666
MIM	-1.837	-1.924	-8.262	-8.377	-10.16
NAB	-3.247	-2.79	-9.914	-9.764	-9.927
NCP	-1.676	-1.747	-10.13	-10.42	-13.02
PDP	-2.888	-3.03	-5.422	-5.461	-5.409
RIO	-2.276	-2.014	-6.847	-6.328	-7.256
WBC	-3.237	-3.149	-9.649	-9.473	-9.787
WMC	-2.279	-2.29	-7.884	-7.797	-10.81
TLS	-1.520	-2.770	-20.911	-24.382	-18.723
			Physical Delivery		
ANZ	-2.643	-2.668	-16.03	-15.8	-18.61
BHP	-1.526	-1.728	-15.46	-16	-17.69
FBG	-2.49	-2.547	-17.34	-17.92	-18.42
MIM	-1.316	-1.323	-15.27	-15.8	-18.31
NAB	-2.542	-2.685	-15.17	-15.38	-17.72
NCP	-2.699	-2.62	-15.13	-15.21	-18.98
PDP	-2.751	-2.835	-16.46	-16.46	-18.97
RIO	-1.739	-1.768	-15.55	-15.99	-18.4
WBC	-3.046	-2.974	-15.57	-15.57	-17.18
WMC	-1.135	-14.41	-15.67	-15.93	-17.17
			All Sample		
ANZ	-2.876	-2.892	-17.95	-17.863	-20.248
BHP	-1.475	-1.646	-18.059	-18.63	-19.892
FBG	-2.670	-2.835	-19.122	-17.785	-18.972
MIM	-1.972	-1.988	-17.421	-17.995	-20.983
NAB	-2.981	-3.085	-17.986	-18.646	-19.399
NCP	-2.661	-2.585	-18.784	-18.891	-20.378
PDP	-2.111	-2.214	-17.392	-18.147	-17.917
RIO	-1.526	-1.44	-17.154	-18.385	-17.555
WBC	-3.524	-3.457	-18.269	-18.177	-19.799
WMC	-1.248	-1.637	-17.543	-26.735	-16.592
TLS	-1.520	-2.770	-20.911	-24.382	-18.723

Table 4: Estimation Results for Mean Equations

R_{st}	α_{s0}	α_{s1}	α_{s2}	α_{s3}	β_{s1}	β_{s2}	β_{s3}	ϕ_s	γ_s
ANZ	0.001	-0.072	-0.124		0.164	0.098	-0.059	0.010	-0.000
	(1.087)	(-1.196)	(-2.131)**		(2.70)+	(1.737)*	(-2.34)**	(0.294)	(-0.291)
BHP	0.000	0.062	-0.060	0.002	0.002	0.005	-0.032	0.000	0.000
	(0.507)	(1.128)	(-0.993)	(0.035)	(0.037)	(0.094)	(-0.611)	(0.453)	(-0.286)
FBG	0.001	-0.021			0.028	-0.045		0.000	0.000
	(0.790)	(-0.647)			(1.263)	(-2.50)+		(-0.248)	(-0.286)
MIM	-0.001	0.044	-0.180	-0.128	0.066	0.086	0.082	-0.024	0.001
	(-0.785)	(0.687)	(-2.97)+	(-2.47)+	(1.067)	(1.496)	(1.767)*	(-0.401)	(0.591)
NAB	0.000	0.046	-0.066		0.063	0.009		-0.004	0.001
	(-0.238)	(1.076)	(-1.691)		(1.615)	(0.272)		(-0.163)	(1.386)
NCP	0.000	0.063	0.009	0.023	0.004	-0.035	-0.047	0.007	0.000
	(0.247)	(1.224)	(0.174)	(0.537)	(0.075)	(-0.752)	(-1.279)	(0.210)	(0.380)
PDP	-0.001	-0.072	-0.090		0.016	0.039		-0.037	0.000
	(-0.546)	(-1.911)*	(-2.61)+		(0.514)	(1.583)		(-0.861)	(-0.256)
RIO	0.000	0.130	0.037	0.005	-0.030	-0.087	-0.051	-0.003	0.000
	(0.221)	(2.99)+	(0.803)	0.117	(-0.850)	(-2.31)**	(-1.599)	(-0.113)	(0.093)
WBC	0.001	0.148			-0.001	-0.061		-0.029	0.000
	(1.235)	(2.62)+			(-0.030)	(-1.138)		(-1.078)	(-0.111)
WMC	0.000	0.074	-0.087		0.003			0.006	0.000
	(0.231)	(3.01)+	(-3.58)+		(0.793)			(0.133)	(-0.148)
TLS	0.000	-0.035	-0.070		0.118	0.030		-0.001	
	(0.582)	(-0.864)	(-1.890)*		(5.74)**	(1.459)		(-1.190)	
R_{ft}	α_{f0}	α_{f1}	α_{f2}	α_{f3}	β_{f1}	β_{f2}	β_{f3}	ϕ_f	γ_f
ANZ	0.001	0.401	0.091		-0.298	-0.074	-0.064	0.120	0.000
	(1.535)	(6.69)+	(1.581)		(-4.9)+	(-1.330)	(-2.55)+	(3.41)+	(-0.398)
BHP	0.001	0.643	0.333	0.175	-0.552	-0.357	-0.189	0.001	0.000
	(0.961)	(11.4)+	(5.39)+	(3.03)+	(-10.0)+	(-6.0)+	(-3.48)+	(1.429)	(-0.664)
FBG	0.000	0.193			-0.169	-0.025		0.004	0.001
	(-0.418)	(4.18)+			(-5.26)+	(-0.981)		(2.60)+	(0.759)
MIM	0.007	0.393	0.030	-0.047	-0.253	-0.113	0.003	0.379	-0.004
	(3.78)+	(5.73)+	(0.461)	(-0.855)	(-3.84)+	(-1.86)*	(0.068)	(6.02)**	(-2.394)**
NAB	0.000	0.356	0.121		-0.238	-0.153		0.089	0.001
	(-0.298)	(8.28)+	(3.09)+		(-6.04)+	(-4.6)+		(3.89)+	(1.322)
NCP	0.000	0.543	0.332	0.193	-0.458	-0.328	-0.181	0.001	0.001
	(0.112)	(10.2)+	(6.41)+	(4.40)+	(-9.06)+	(-6.9)+	(-4.8)+	(0.037)	(0.615)
PDP	-0.001	0.241	0.056		-0.255	-0.092		0.133	0.001
	(-0.677)	(5.93)+	(1.503)		(-7.5)+	(-3.4)+		(2.86)+	(0.506)
RIO	0.007	0.743	0.423	0.163	-0.627	-0.436	-0.184	0.118	-0.006
	(3.15)+	(13.5)+	(7.36)+	(3.15)+	(-13.9)+	(-9.2)+	(-4.61)+	(4.02)+	(-2.80)+
WBC	0.001	0.492			0.039	-0.398		0.023	0.000
	(1.493)	(8.43)+			(1.533)	(-7.2)+		(0.842)	(-0.280)
WMC	0.004	0.099	-0.096		0.001			0.485	-0.001
	(3.59)+	(3.90)+	(-3.86)+		(0.287)			(9.86)+	(-1.097)
TLS	0.001	0.340	0.158		-0.376	-0.138		0.002	
	(1.557)	(4.33)+	(2.155)**		(-9.3)+	(-3.4)+		(1.906)*	

The number within the parenthesis is the corresponding t statistics. *, **, and + denote significant levels of 10%, 5%, and 1%, respectively.

Table 5: Estimation Results for Variance Equations

	c_{11}	c_{21}	c_{22}	a_{11}	a_{21}	a_{12}	a_{22}	g_{11}	g_{21}	g_{12}	g_{22}	z_1	z_2	ω_s	ω_f	ω_{sf}
ANZ	0.003	0.001	0.003	0.275	-0.151	-0.025	0.401	0.888	0.166	0.059	0.773	0.002	0.001	0.004	0.001	0.002
	(6.16)+	(1.86)*	(8.32)+	(4.88)+	(-2.69)+	(-0.46)	(6.88)+	(12.3)+	(2.19)**	(0.78)	(9.53)+	(3.87)+	(1.49)			
BHP	0.000	0.001	0.001	0.252	-0.154	-0.123	0.344	0.957	0.068	0.031	0.907	0.002	0.003	0.004	0.009	0.006
	(3.55)+	(2.71)+	(13.5)+	(7.16)+	(-4.66)+	(-2.80)+	(8.08)+	(61.5)+	(4.42)+	(1.72)*	(50.4)+	(3.97)+	(3.15)+			
FBG	0.002	0.001	0.001	0.207	-0.301	-0.017	0.443	0.960	0.116	0.012	0.872	-0.001	-0.001	0.001	0.001	0.001
	(3.28)+	(0.62)	(2.03)**	(2.52)+	(-3.85)+	(-0.23)	(6.30)+	(23.5)+	(3.03)+	(0.31)	(24.5)+	(-1.75)*	(-0.74)			
MIM	0.002	0.001	0.002	0.160	-0.213	-0.005	0.367	0.983	0.081	-0.003	0.909	0.002	-0.001	0.004	0.001	-0.002
	(6.38)+	(1.70)*	(4.71)+	(4.71)+	(-5.89)+	(-0.15)	(10.6)+	(62.0)+	(4.97)+	(-0.17)	(56.2)+	(4.02)+	(-1.63)			
NAB	0.003	0.000	0.004	0.212	-0.286	-0.042	0.493	0.899	0.251	0.073	0.680	0.001	0.003	0.001	0.009	0.003
	(6.76)+	(0.55)	(9.30)+	(5.16)+	(-5.71)+	(-0.91)	(8.78)+	(16.3)+	(4.22)+	(1.19)	(10.3)+	(3.34)+	(6.89)+			
NCP	0.004	0.004	0.001	0.234	-0.201	-0.115	0.251	0.958	0.058	-0.027	0.887	0.003	0.002	0.009	0.004	0.006
	(7.38)+	(6.89)+	(8.76)+	(4.23)+	(-3.02)+	(-2.95)+	(5.35)+	(44.3)+	(2.75)+	(-1.21)	(41.5)+	(5.30)+	(4.23)+			
PDP	0.005	0.005	0.001	0.189	-0.159	0.060	0.345	0.923	-0.002	-0.036	0.912	-0.004	-0.004	0.016	0.016	0.016
	(4.72)+	(4.05)+	(3.75)+	(4.77)+	(-4.34)+	(1.52)	(8.69)+	(29.0)+	(-0.07)	(-1.69)	(45.2)+	(-4.66)+	(-4.18)+			
RIO	0.001	0.002	0.002	0.219	-1.032	-0.046	1.219	0.968	0.377	0.014	0.594	-0.001	0.002	0.001	0.004	-0.002
	(3.07)+	(0.71)	(0.95)	(4.44)+	(-15.8)+	(-0.95)	(18.2)+	(56.8)+	(15.5)+	(0.82)	(22.7)+	(-4.95)+	(5.08)+			
WBC	0.004	0.003	0.003	0.276	-0.244	-0.039	0.465	0.923	0.211	-0.003	0.719	0.002	0.002	0.004	0.004	0.004
	(5.44)+	(3.21)+	(13.3)+	(5.54)+	(-3.77)+	(-0.89)	(7.51)+	(15.0)+	(3.26)+	(-0.05)	(10.8)+	(4.96)+	(3.09)+			
WMC	0.002	0.002	0.002	0.223	-0.168	-0.065	0.328	0.968	0.078	0.013	0.900	0.001	0.001	0.001	0.001	0.001
	(3.12)+	(1.59)	(15.4)+	(3.68)+	(-2.73)+	(-1.03)	(5.02)+	(35.5)+	(2.77)+	(0.44)	(29.2)+	(1.71)*	(0.75)			
TLS	0.005	0.003	0.001	0.369	-0.352	-0.059	0.690	0.722	-0.025	0.004	0.831					
	(7.96)+	(5.21)+	(1.62)	(5.38)+	(-5.14)+	(-0.91)	(11.2)+	(10.3)+	(-0.38)	(0.26)	(53.5)+					

The number within the parenthesis is the corresponding *t* statistics. The values of ω_s, ω_f, and ω_{sf} have been increased by 1000.

*, **, and + denote significant levels of 10%, 5%, and 1%, respectively.

Table 6: Optimal Hedge Ratios

	Mean					Variance				
	All Sample	Cash Settlement	Physical Delivery	Test Statistics	P-Value	All Sample	Cash Settlement	Physical Delivery	Test Statistics	P-Value
ANZ	0.898	0.828	0.912	-12.997	0.000	0.007	0.009	0.005	2.00	0.977
BHP	0.902	0.886	0.908	-6.804	0.000	0.012	0.013	0.012	2.00	0.977
FBG	0.773	0.561	0.818	-19.127	0.000	0.033	0.037	0.021	2.00	0.977
MIM	0.818	0.784	0.828	-11.565	0.000	0.017	0.010	0.019	0.000	0.500
NAB	0.854	0.826	0.865	-8.458	0.000	0.015	0.018	0.014	2.00	0.977
NCP	0.893	0.890	0.895	-3.841	0.001	0.008	0.008	0.009	0.000	0.500
PDP	0.784	0.536	0.812	-14.256	0.000	0.037	0.037	0.029	2.00	0.977
RIO	0.763	0.660	0.784	-10.073	0.000	0.054	0.054	0.052	2.00	0.977
WBC	0.873	0.827	0.886	-12.550	0.000	0.011	0.016	0.009	2.00	0.977
WMC	0.884	0.870	0.889	-5.884	0.000	0.009	0.007	0.009	0.000	0.500

Table 7: Hedging Effectiveness

	Mean					Variance				
	All Sample	Cash Settlement	Physical Delivery	Test Statistics	P-Value	All Sample	Cash Settlement	Physical Delivery	Test Statistics	P-Value
ANZ	0.790	0.749	0.803	-9.143	0.000	0.012	0.010	0.009	2.000	0.977
BHP	0.831	0.846	0.825	0.112	0.555	0.020	0.016	0.021	0.000	0.500
FBG	0.717	0.507	0.762	-19.497	0.000	0.037	0.031	0.027	2.000	0.977
MIM	0.754	0.768	0.750	1.625	0.948	0.020	0.014	0.021	0.000	0.500
NAB	0.731	0.676	0.753	-17.516	0.000	0.017	0.016	0.015	2.000	0.977
NCP	0.839	0.852	0.834	2.171	0.985	0.018	0.016	0.019	0.000	0.500
PDP	0.693	0.450	0.720	-13.236	0.000	0.044	0.041	0.038	2.000	0.977
RIO	0.718	0.636	0.735	-6.951	0.000	0.055	0.059	0.053	2.000	0.977
WBC	0.820	0.760	0.837	-16.142	0.000	0.016	0.019	0.014	2.000	0.977
WMC	0.801	0.792	0.804	-6.167	0.000	0.016	0.010	0.018	0.000	0.500

Table 8: Estimation Results for the Effect on Basis Behavior

	β_0	β_1	β_2	β_3	β_4	β_5	ψ	δ_0	δ_1	δ_2	ϕ
ANZ	0.004	0.458	0.238	0.118	0.110		0.003	0.219	0.308	0.205	0.027
	(0.076)	(9.035)+	(6.524)+	(3.276)+	(1.574)		(0.058)	(0.595)	(0.307)	(0.595)	(0.112)
BHP	0.024	0.479	0.240	0.134	0.139		-0.019	0.036	0.782	0.024	0.154
	(0.876)	(11.35)+	(6.126)+	(3.526)+	(4.337)+		(-0.698)	(1.184)	(8.508)+	(1.184)	(2.551)+
FBG	0.017	0.461	0.296	0.091	0.098		-0.025	0.203	0.382	0.567	-1.231
	(1.072)	(11.47)+	(7.473)+	(1.758)*	(2.092)**		(-1.361)	(2.689)+	(4.344)+	(2.689)+	(-3.184)+
MIM	0.348	0.358	0.235	0.159	0.069		-0.157	0.247	0.612	0.142	0.276
	(4.029)+	(8.023)+	(2.767)+	(3.189)+	(1.342)		(-1.769)*	(1.260)	(2.786)+	(1.260)	(0.879)
NAB	-0.011	0.492	0.197	0.164	0.078		0.034	0.617	0.242	0.051	0.044
	(-0.920)	(8.839)+	(4.740)+	(3.753)+	(1.691)		(1.172)	(1.386)	(0.719)	(1.386)	(1.055)
NCP	0.135	0.321	0.288	0.319	-0.066		-0.088	0.089	0.589	0.199	0.894
	(1.881)*	(3.469)+	(3.475)+	(4.518)+	(-1.220)		(-1.638)	(2.421)+	(6.720)+	(2.620)+	(2.620)+
RIO	0.063	0.771	0.255	-0.042			-0.199	0.194	0.020	0.487	4.138
	(0.509)	(7.954)+	(3.141)+	(-1.067)			(-1.810)*	(4.260)+	(0.534)	(2.743)+	(2.743)+
PDP	-0.194	0.675	-0.045	0.132			0.152	0.556	0.015	0.627	1.657
	(-1.428)	(8.008)+	(-0.503)	(2.137)**			(0.988)	(2.962)+	(0.674)	(1.805)*	(1.805)*
WBC	-0.064	0.350	0.275	0.172	0.098	0.101	0.012	0.090	0.491	0.320	0.269
	(-1.313)	(2.831)+	(5.109)+	(2.145)**	(1.648)	(1.800)*	(0.671)	(0.671)	(8.277)+	(2.091)**	(0.985)
WMC	0.097	0.422	0.210	0.109	0.118		-0.057	0.078	0.712	0.123	0.085
	(2.365)**	(11.44)+	(5.544)+	(2.896)+	(2.955)+		(-1.584)	(1.773)*	(7.671)+	(1.773)*	(1.480)

The number within the parenthesis is the corresponding t statistics. *, **, and + denote significant levels of 10%, 5%, and 1%, respectively.

Figure 1: ANZ Optimal Hedge Ratio

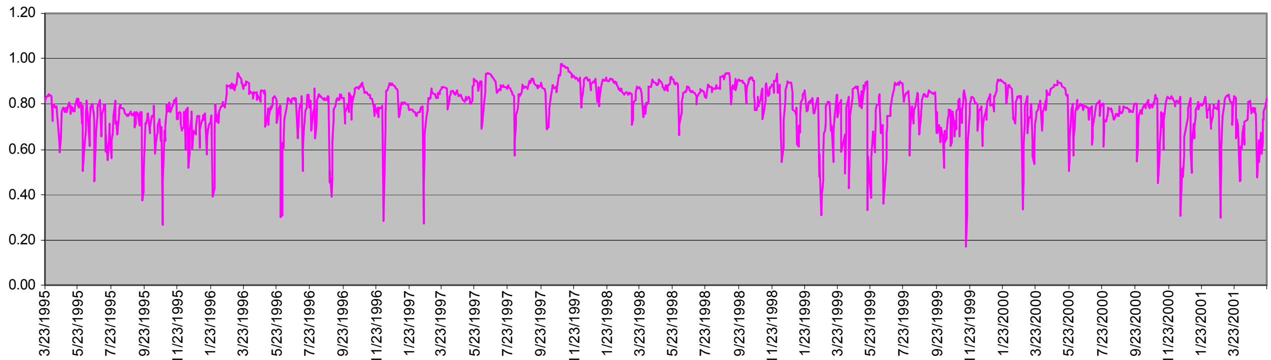


Figure 2: PDP Optimal Hedge Ratio

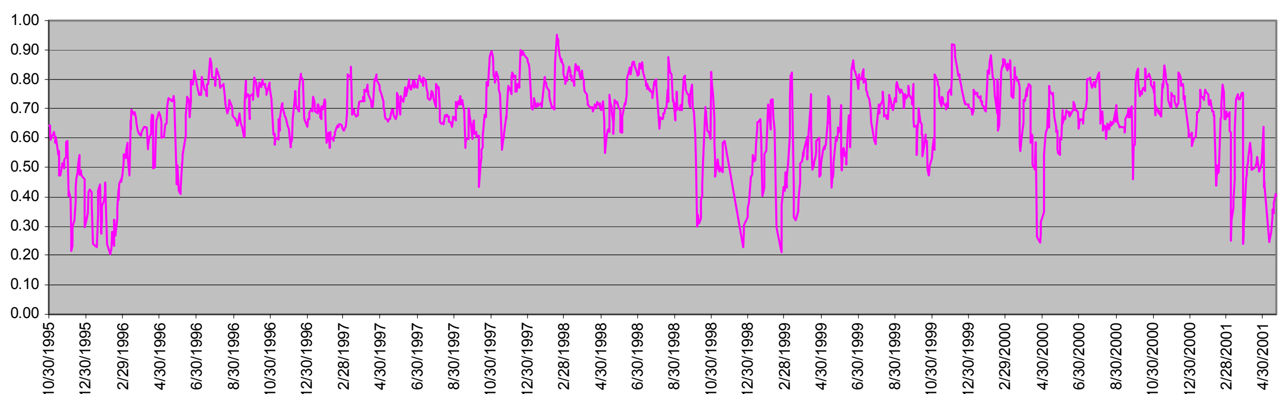
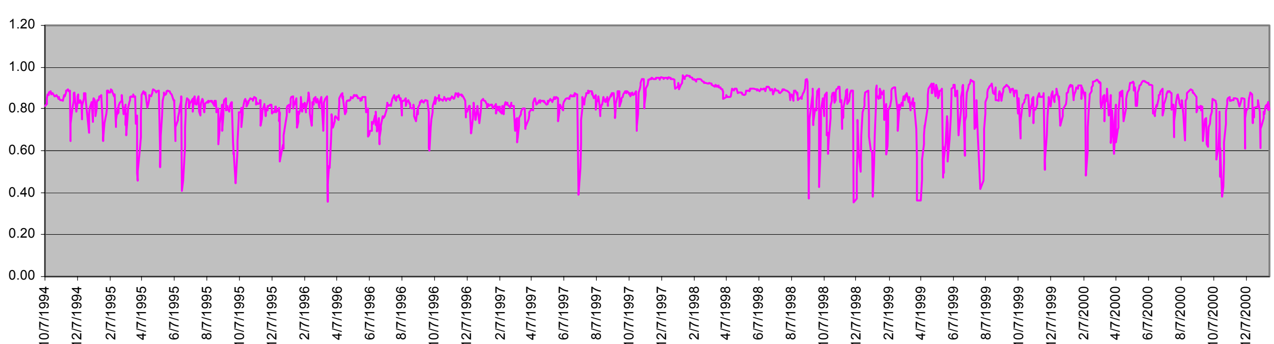


Figure 3: WMC Optimal Hedge Ratio



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