Available online at www.sciencedirect.com
ScienceDirect
Journal of Banking & Finance 32 (2008) 187–198
Journal of BANKING & FINANCE
www.elsevier.com/locate/jbf

Asymmetric effect of basis on dynamic futures hedging: Empirical evidence from commodity markets

Donald Lien [a], Li Yang [b,*]

[a] College of Business, University of Texas at San Antonio, San Antonio, TX 78249, USA
[b] School of Banking and Finance, University of New South Wales, Sydney 2052, Australia

Received 16 November 2004; accepted 22 January 2007
Available online 6 July 2007

Abstract

The dynamic minimum variance hedge ratios (MVHRs) have been commonly estimated using the Bivariate GARCH model that overlooks the basis effect on the time-varying variance–covariance of spot and futures returns. This paper proposes an alternative specification of the BGARCH model in which the effect is incorporated for estimating MVHRs. Empirical investigation in commodity markets suggests that the basis effect is asymmetric, i.e., the positive basis has greater impact than the negative basis on the variance and covariance structure. Both in-sample and out-of-sample comparisons of the MVHR performance reveal that the model with the asymmetric effect provides greater risk reduction than the conventional models, illustrating importance of the asymmetric effect when modeling the joint dynamics of spot and futures returns and hence estimating hedging strategies.

JEL classification: G13; C32

Keywords: Dynamic hedging strategy; Asymmetric basis effect; Time-varying volatility and correlation of spot and futures returns

1. Introduction

Minimum variance hedge ratio (MVHR), i.e., the ratio of futures contracts to a specific spot position that minimizes variance of the hedged portfolio returns, has been broadly used as a futures hedging strategy. Following Johnson (1960) and Stein (1961), the MVHR is calculated as the ratio of covariance between spot and futures returns to variance of futures returns. Early research utilizes regression models to estimate time-invariant MVHRs. More recently, Bivariate GARCH (BGARCH) models have been commonly adopted to estimate time-varying variance and covariance and subsequently generate dynamic MVHRs. It is often found that the dynamic MVHRs outperform those estimated from the regression models (Castelino (1990), Baillie and Myers (1991), Kroner and Sultan (1993), Park and Switzer (1995), Brooks et al. (2002), Lien et al. (2002), among many others). However, much of this research overlooks the effect of basis (difference between spot and futures prices) on the variance-covariance structure when estimating the dynamic MVHRs.

Importance of incorporating the changes in the basis into hedging decision dates back to Working (1953a,b, 1961)). Most research focuses on the effect of basis on the level of spot and futures price movements in the models where MVHRs are estimated (Kroner and Sultan (1993), Lien, 1996), Lien and Tse (1999), and Lien et al. (2002)). The effect of basis on the variance-covariance structure is however mostly overlooked.[1] Ng and Pirrong (1994), Lee (1994), and Zhong et al. (2004) find that spot and futures prices become more volatile and less correlated as basis gets larger, suggesting that the MVHR should be altered as the

* Corresponding author. Tel.: +610293853837.
E-mail address: l.yang@unsw.edu.au (L. Yang).

[1] See Lien and Tse (2002) for comprehensive survey on this topic.

0378-4266/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.jbankfin.2007.01.026

basis changes. The models that ignore this effect of basis prescribe that the MVHR remain the same regardless of the changes in the basis. This "constant" MVHR may create over-hedged positions when the basis decreases and under-hedged positions when the basis increases, raising serious concerns regarding risk reduction ability of the conventional hedging models.

In this paper, we propose an alternative specification of BGARCH model in which the basis effect is incorporated. We decompose basis into positive and negative bases and introduce them into the conditional variance and covariance equations of BGARCH model to investigate a potential asymmetric basis effect on the conditional variances and covariance of spot and futures returns and its consequences in dynamic hedging strategies. Examining commodity markets, the conditional variances are positively (negatively) related to the positive (negative) lagged basis, suggesting a V-shape relationship between the variance and the basis.[2] In addition, the marginal effects when the basis is positive are greater than those when the basis is negative, indicating that the V-shape relationship is asymmetric.[3] The asymmetric effect on the time-varying correlation between the two markets is also observed. Larger basis in the absolute term tends to reduce market co-movements more.

We then calculate the MVHR based on the estimates of the conditional variance and covariance from our model and compare it with the MVHRs estimated from the BGARCH models where only symmetric effect is incorporated or the effect is totally ignored. Both in-sample and out-of-sample comparisons indicate that the model incorporating the asymmetric effect of basis into the hedging decision leads to a greater risk reduction than the conventional models.

To capture the economic significance of different hedging strategies, we evaluate how much a hedger's expected utility would increase if one strategy were used over others after taking into account transaction costs for rebalancing the hedging positions when there is benefit to do so, i.e., when the potential expected utility gains offset the transaction costs. We find that the expected utility increases significantly using the strategy from the asymmetric model over that from the symmetric model. Thus, we conclude that separating the effect of positive and negative bases on the market volatility and the correlation between the two markets not only provides better descriptions of the joint dynamic behavior of the commodity prices, but also plays an important role in determining the dynamic hedging strategies.

[2] Kogan et al. (2003) examine energy futures price data and empirically establish a "V-shape" relationship between the volatility of futures prices and the slope of the term structure of futures prices (i.e., the futures spread). In other words, futures markets become more volatile when the futures spread is either positive and large, or negative and small.

[3] To our knowledge, this evidence has not been documented previously either from any theoretical models or empirical investigations.

The remainder of the paper is organized as follows. Section 2 discusses the model specifications. Section 3 discusses the data and preliminary diagnostic tests on the data. The model estimation results are provided in Section 4. The asymmetric effects of basis on the dynamic hedging strategy as well as on the risk reduction are analyzed in Section 5. Section 6 provides the conclusions of the paper.

2. Model specifications

The theory of storage suggests that spot and futures prices move up and down together in a long run; however, the short-run deviations from the long run equilibrium could take place due to mispricing of either futures or spot price. The lagged basis helps determine the spot and futures price movement, therefore, facilitates adjustment of price deviation. This establishes a cointegrated system of futures and spot prices while the lagged basis serves as an error correction term (see, for example, Kroner and Sultan (1993), Ng and Pirrong (1994), Yang et al. (2001), and Lien and Yang (2006)). Hence, the conditional means of spot and futures returns are specified as:

$$R_{k,t} = \alpha_{k0} + \sum_{i=1}^{p} \alpha_{ki} R_{k,t-i} + \sum_{j=1}^{q} \beta_{kj} R_{k,t-j} + \gamma_k B_{t-1} + \varepsilon_{k,t}, \qquad (1)$$

where $R_{k,t} = \ln(p_{k,t}) - \ln(p_{k,t-1})$, for $k = s, f$; $p_{k,t}$ is either the spot or the futures price at time t; p and q are the numbers of lags; and $B_{t-1} = \ln(p_{s,t-1}) - \ln(p_{f,t-1})$ is the basis at time $t-1$. When the spot price exceeds the futures price 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 $t-1$ (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 $\gamma_s \leqslant 0$ and $\gamma_f \geqslant 0$.

It has been well known that the variance-covariance of asset returns is time-varying. To account for this statistical property, the GARCH specification is adopted. Specifically, the conditional variance-covariance matrix of residual series from Eq. (1), $E_t = (\varepsilon_{s,t}, \varepsilon_{f,t})'$, is denoted by

$$\mathrm{Var}(\varepsilon_{s,t}, \varepsilon_{f,t} | I_t) \equiv H_t = \begin{bmatrix} h_{s,t} & h_{sf,t} \\ h_{sf,t} & h_{f,t} \end{bmatrix},$$

where I_t is the information set at time t.

As predicted in Kogan et al. (2003), the relationship between the volatility of spot or futures returns and the basis is not monotonic and presents a V-shape. To investigate this V-shape effect empirically, we decompose basis into positive and negative terms and use them as separate explanatory variables in modeling the time-varying variances of spot and futures returns, i.e.,

$$h_{k,t} = \omega_k + \theta_k \varepsilon^2_{k,t-1} + \delta_k h_{k,t-1} + \xi_k \max(B_{t-1}, 0) + \varphi_k \min(B_{t-1}, 0), \text{ for } k = s, f. \qquad (2)$$