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Journal of Empirical Finance 9 (2002) 589–603

Journal of EMPIRICAL FINANCE

www.elsevier.com/locate/econbase

Testing for constant hedge ratios in commodity markets: a multivariate GARCH approach

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Abstract

We develop a new multivariate generalized ARCH (GARCH) parameterization suitable for testing the hypothesis that the optimal futures hedge ratio is constant over time, given that the joint distribution of cash and futures prices is characterized by autoregressive conditional heteroskedasticity (ARCH). The advantage of the new parameterization is that it allows for a flexible form of time-varying volatility, even under the null of a constant hedge ratio. The model is estimated using weekly corn prices. Statistical tests reject the null hypothesis of a constant hedge ratio and also reject the null that time variation in optimal hedge ratios can be explained solely by deterministic seasonality and time to maturity effects.

JEL classification: C52; Q14
Keywords: Autoregressive conditional heteroskeclasticity; Futures; Hedging; Hypothesis testing

1. Introduction

Hedging with futures contracts is an important risk management strategy for firms dealing with commodities, the prices of which are notoriously volatile. Hedging reduces risk because cash and futures prices for the same commodity tend to move together, so that changes in the value of a cash position are offset by changes in the value of an opposite futures position. Because cash and futures price movements are typically not perfectly correlated (i.e., there is basis risk), risk management requires determination of the "optimal hedge ratio" (the optimal amount of futures bought or sold expressed as a

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PII: S0927-5398(02)00012-9

proportion of the cash position). When basis risk is the only source of uncertainty,[1] the optimal hedge ratio often can be reduced to a simple ratio of the conditional covariance between cash and futures prices to the conditional variance of futures prices (Benninga et al., 1983; Myers, 1991; Lence, 1995). To estimate such a ratio, early work simply used the slope of an ordinary least squares regression of cash on futures prices. An improved procedure is possible by computing the relevant moments of the price distribution relative to the proper conditional means (Myers and Thompson, 1989; Moschini and Lapan, 1995).[2] More generally, estimation of the optimal hedge ratio recognizes that commodity cash and futures prices often display time-varying volatility and relies on techniques consistent with such a hypothesis, such as Engle's (1982) autoregressive conditional heteroskedasticity (ARCH) framework or Bollerslev's (1986) generalized ARCH (GARCH) approach.

ARCH and GARCH models appear ideally useful for estimating time-varying optimal hedge ratios, and a number of applications have concluded that such ratios seem to display considerable variability over time (Cecchetti et al., 1988; Baillie and Myers, 1991; Myers, 1991; Kroner and Sultan, 1993). Yet, no existing study has provided compelling evidence that such time-varying hedge ratios are statistically different from a constant hedge ratio. A time-varying covariance matrix of cash and futures prices, per se, is not sufficient to establish that the optimal hedge ratio is time varying. Constancy of the hedge ratio restricts the ratio of the covariance between cash and futures prices to the variance of futures prices to be constant, but it need not restrict the moments of the joint distribution of cash and futures prices in any other way. Unfortunately, the particular parametric GARCH models that have been used to date admit a constant hedge ratio only under very restrictive conditions, so that the hypothesis of a constant optimal hedge ratio can be tested only jointly with other hypotheses. The main purpose of this article is to develop a more general GARCH parameterization that yields a constant hedge ratio as a special case, while still allowing for a flexible time-varying distribution of cash and futures prices. The model is illustrated with an application to the problem of storage hedging of corn using futures prices from the Chicago Board of Trade and Iowa cash prices for the period 1976–1997.

2. The optimal futures hedge and GARCH models

A typical hedging model in our setting involves a decision maker who allocates wealth between a risk-free asset and two risky assets: the physical commodity and the corresponding futures. Let y_t^* and z_t^* denote the optimal quantity of the physical commodity bought and futures sold, respectively, with both positions taken at time $t-1$ and held until time t. The optimal hedge ratio (OHR) is defined as $\mathrm{OHR}_t \equiv z_t^*/y_t^*$.

[1] This setting applies mostly to commodity handlers (country elevators, shippers, millers, storers, etc.) but not to producers because the latter are typically also exposed to quantity (production) uncertainty. For a review of more general hedging problems, see Moschini and Hennessy (2001).

[2] If cash and futures prices follow a martingale process, for instance, the slope of a regression of cash price changes on futures price changes (and not the slope of a regression in levels) estimates the relevant hedge ratio.