The Hedging Performance of Treasury Futures

Jeong W. Lee
University of North Dakota

This study investigates the optimal timing for hedging in government securities spot markets utilizing treasury futures contracts. Since the effectiveness of minimum risk hedge ratios may differ under various market conditions, the optimum size of futures positions can be analyzed for periods of rising and falling interest rates. The results show generally hedging with the front month futures provides a better hedge than any other subset of time-to-delivery for treasury futures contracts.

INTRODUCTION

Implementations of tapering of the Federal Reserve's $85 billion-a-month bond buying program (known as QE) have wrecked a havoc in the credit markets last few quarters. Exposed investors big and small have suffered painful losses and licked wounds pining for their needed protections. In this study, we examine the effectiveness of treasury securities futures as a hedge vehicle against volatile interest rate markets. Because of its depth, treasury securities futures can be utilized as a hedging tool against any number of interest products. For example, even the new bonds ETFs known as "zero duration" or "negative duration" ETFs "short" treasury futures to counterbalance losses when rates rise. Usually, as uncertainties in the economies increase, the volatilities of debt instruments increase sometimes dramatically. Let's take an example of MF Global. Aside from the legality of using the customers' account balances for the margin money, the failure of this firm can also be attributed to imperfect or even no hedging in the volatile interest derivative markets when it loaded up Italian debts. However, MF Global collapse did not end merely with its own demise. The impact of its failure reverberated throughout the whole futures industry, albeit smaller than that of 2008 crisis, shaking the foundation of the faith in the market it is based on.

Reviewing financial statements that incorporate unfamiliar assets and leverage, whose characteristics include high volatility, may be too complex for routine traders where suggestions are made based primarily on the grounds of historic norms. In volatile markets, top decision makers should steer the course of companies based on "anything can happen" mentality rather than wishful thinking that the worst case scenario may not happen this particular time. If that is the right approach, they will know that they have to be protected all the time, not just some given times. The best vehicles to protect the investments on any types of interest products can be found in the Treasury bonds and Treasury notes futures.

As for the government securities, there are several types of products based on the maturities. Treasury bonds pay a fixed rate of interest every six months until they mature. They are issued in a term of 30 years. Treasury bills, or T-bills, are sold in terms ranging from a few days to 52 weeks. Treasury notes, or T-Notes, earn a fixed rate of interest every six months until maturity. Notes are issued in terms of 2, 3, 5, 7, and 10 years. Treasury Inflation-Protected Securities, or TIPS, provide protection against inflation. The principal of a TIPS increases with inflation and decreases with deflation, as measured by the Consumer Price Index. When a TIPS matures, investors are paid the adjusted principal or original principal, whichever is greater. TIPS pay interest twice a year, at a fixed rate. The rate is applied to the adjusted principal; so, like the principal, interest payments rise with inflation and fall with deflation. All above products can be bought through banks, brokers, or TreasuryDirect. In our study we utilize the Treasury bonds and Treasury notes with 10 year maturities.

This study investigates the optimal timing for hedging in government securities spot markets utilizing treasury futures contracts. Many of the previous studies took a slightly different approach to hedging problems. Some studies have shown that the optimal number of futures contracts to be sold is the number that minimizes the variance of net profit of the hedged positions (Johnson 1960; Stein 1961). Others have tried optimal hedging techniques to minimize the variance of earnings (McKinnon 1967; Overdahl 1987; Newberry 1988). Another studies on the stock market include those on the dynamic efficiency between spot and futures markets in the case where short-selling restrictions were lifted. (Jiang,Gung, and Cheng 2001)

Given the strong theoretical linkage between the U.S. Treasury cash and futures markets, some researchers compare how order flow contributes to price discovery and analyze how and when information flows from one market to the other (Brandt, et al., 2007). Their study considers how a number of environmental variables such as trader type, financing rates, and liquidity impact the information flows between these two markets. Their findings provide new evidence on the extent to which price discovery happens away from a primary market.

Another approach suggested recently tries to offer empirical evidence of the risk-reduction effectiveness of REIT futures (Lee, et al., 2012). They also compare other hedging instruments for the hedging effectiveness of real estate investment trust futures. They estimate optimal hedge ratios employing OLS and a bivariate GARCH model and find REIT futures outperform other hedging instruments in Japanese and Australian markets.

Since the effectiveness of minimum-risk hedge ratios may differ under various market conditions, the optimum size of futures positions can be analyzed for periods of rising and falling interest rates. Given potentially extreme nature of the price volatility of interest rate products, it is worthwhile studying the possibility of hedging treasury security markets with both T-Bond and T-Note futures. Recall historically long term interest rates have been declining even though some time periods there had been violent upside moves. A futures hedge is usually initiated by buying (selling) futures contracts and terminated by closing out the position when the spot market transaction occurs. The position is typically closed by selling (buying) the same contract in the futures market rather than taking delivery of the underlying asset. An investor can reduce part of their spot market exposure between the time of spot purchases and sales by selling futures contracts. This statement is especially true for holders of large volumes of spot treasury securities. Those exposed can offset short-term losses in their spot holdings by selling treasury securities futures. Price risk is reduced to the extent that the gain in the futures position offsets the losses in the value of the spot holdings and vice versa.

The paper first provides a review of prior studies and defines an appropriate measure of hedging effectiveness. The next section is the data analysis where hedging effectiveness and minimum-risk hedge ratios for the T-Bond and T-Note futures are determined using the daily T-Bond and T-Note spot prices. Additionally, the risk-reduction measures are examined across futures contracts with different numbers of day remaining. The final section is the conclusion of the paper.

HEDGING EFFECTIVENESS FOR TREASURY SECURITIES

The effectiveness of a hedged spot position is dependent on the size of the futures position and the degree of correlation between changes in the value of the spot position and changes in futures prices over the hedging period. During any particular hedging period, the co-movement between the treasury futures market and the treasury spot market may not be perfect since they are basically two different markets.

Their co-movements are not the same for the following reasons:

1. The differences between investors perceived present value of cash versus futures may fluctuate as economic and other conditions change.
2. The futures price is influenced by factors that do not necessarily affect the spot price.
3. Since spot and futures are different markets, their price changes can be random and independent over time.

Note: Futures prices reflect levels of, and changes in, financing costs of the underlying instrument, because futures are in effect an alternative to purchasing the instrument today and carrying it until the delivery date, thereby incurring the financing charges. Hence, it is safe to say that the supply-and-demand conditions in the spot and futures markets may not be exactly the same.

Several earlier studies (Ederington 1979; Johnson 1960) concluded that significant portions of the risk of price changes accompanying cash positions could be eliminated using futures contracts in various financial products over specific time periods. Based on these studies, it can be shown that the minimum-risk hedge ratio and hedging effectiveness are related to the covariance, or correlation, between spot and futures price changes, and the variance of futures price changes over the period of the hedge. This hedge ratio can be interpreted as the weight of the futures position in a portfolio consisting of both spot and futures positions, or the proportion of the predetermined spot position that is hedged.

In order to find the size of the futures position that minimizes the exposure to price risk, we minimize the variance of the hedged portfolio with respect to the proportion of the portfolio held in futures contracts.

$$\min \mathrm{Var}(C_{ht}) = \mathrm{Var}(C_{st}) + X_f^2\, \mathrm{Var}(C_{ft}) + 2X_f\, \mathrm{Cov}(C_{st}\, C_{ft}) \tag{1}$$

where C_{ht} is the change in the value during period t of the hedged spot position, C_{st}, C_{ft} are the changes in value during period t of the spot position and futures contracts, respectively, X_f is the proportion of the portfolio held in future contracts: X_f*would equal the optimal hedge ratio (HR*) with $X_f < 0$ representing a short position and $X_f > 0$ a long position in futures.

$$\frac{\delta\, \mathrm{Var}(C_{Ht,})}{\delta X_f} = 2X_f\, \mathrm{Var}(C_f) + 2\, \mathrm{Cov}\,(C_s\, C_f) = 0 \tag{2}$$

$$\frac{-\mathrm{Cov}\,(C_S, C_f)}{\mathrm{Var}(C_f)} = X_f^* = HR^* \tag{3}$$

Therefore, the optimum hedge ratio is the equivalent of the negative of the slope coefficient of a regression of spot price changes on futures price changes.

The use of absolute price changes instead of the percentage changes in value is warranted because of the unique circumstances associated with the hedging decision in the portfolio model. One of these circumstances is a result of the objective of a futures hedging strategy. The objective is to minimize potential losses from a fixed, predetermined, position of the portfolio. The futures position should not be viewed as a substitute for the cash position. Futures are combined with the cash position to minimize losses in value of the cash position. Accordingly, effective hedging depends on the amount of covariance between value changes of the spot and futures.

Another basis for the reliance on price changes versus returns is that the futures positions have no initial investment value and thus do not provide returns on investment in the normal sense. The only costs associated with futures hedges are transaction costs, the opportunity cost of funds provided as margin before gains on the spot position are realized, and the costs associated with basis risk. The basis risk cost comes from the fact that with imperfect foresight, gains and losses on spot and futures positions may not exactly offset each other in every period.

The measure of hedging effectiveness (E_f*) for the minimum-risk hedge is defined as the proportional reduction in the variance of changes in the value of the spot position that comes from maintaining the hedge ratios determined above rather than holding an unhedged position ($X_f = 0$). E_f^* is the coefficient of determination for the regression of spot price changes on futures' price changes used to estimate HR*.

$$E_f^* = \frac{\text{Var}(C_s) - \text{Var}(C_H)}{\text{Var}(C_s)} = 1 - \frac{\text{Var}(C_H)}{\text{Var}(C_s)} \tag{4}$$

$$E_f^* = \frac{\text{Cov}(C_s, C_f)^2}{[SD(C_s)SD(C_f)]^2} = R^2 \tag{5}$$

To the extent that the variances and covariance are stable, historical data can be used appropriately to help solve for the minimum-risk hedge ratios and to estimate its potential effectiveness in reducing the variability in spot price changes. Hedge ratios and hedging effectiveness may change over time due to changes in market conditions and in market participants. Hedge ratios and effectiveness may also vary for contracts with different times to delivery.

The correlation structure of price changes can change over time as a function of the direction of spot price movements and their impact on various participants in the futures market. Investors with long positions in the debt securities may increase their hedging activity when they expect price drops larger than anticipated by the market. The opposite behavior would be expected of investors with short positions. The relative amount of hedging participation, and the extent of spot futures arbitrage in rising and falling markets may impact hedge ratios. Also, the cheapest deliverable instrument may change and thereby alter hedging effectiveness.

If hedging effectiveness and ratios differ significantly in rising and falling markets, both passive and selective hedgers may want to incorporate these differences in their hedging strategies. A passive hedger is one who maintains a continuous futures hedge to eliminate all exposures caused by the fluctuations of natural gas prices. If hedging effectiveness and ratios change over time, proper adjustments may be needed in the size of their futures position over time. Selective hedging may be done by using the futures market as an alternative to liquidating or investing in a spot position based on government securities markets forecast. These hedgers may be interested in the hedge ratio that is most relevant to their forecasts. Note that the different optimal hedge strategies in rising and declining markets will not guarantee selective or passive hedgers that they will be able to capitalize on these differences. To capitalize on these differences would require the differences to be stable, and for hedgers to be able to identify the general direction of the market over the hedging period.

Minimum risk hedge ratios and hedging effectiveness may also change over time due to structural changes in treasury securities markets that affect the volatility of spot price changes. Increased volatility of daily prices is transmitted to futures prices through the implied expected future values. An increase in market volatility, whatever the source, should increase the incentive to use futures hedges and, accordingly, should increase participation in the relevant futures market. On top of a changing interest rates environment, the term to delivery of the futures contract may be related with different levels of hedge ratios and hedging performance. Even though daily trading volumes of T-Bonds and T-Notes routinely exceed 1 million contracts, only “front” month contracts are traded heavily. Generally, as the contract gets very close to delivery, investors who do not wish to execute delivery may liquidate their positions.

DATA AND HEDGING RESULTS

Data Set and Methodology

Daily data was acquired from January 2, 2002 to December 31, 2012 (2490 observations). All the price sets (T-Note and T-Bond spots and futures) were drawn from a Bloomberg subscription terminal. Price changes for each contract are grouped according to the number of days remaining. For this study, we utilized 4 delivery months (March, June, September, and December) for both futures. Futures price changes are matched with spot price changes. Ordinary least-square (OLS) regressions of spot price changes on contemporaneous futures price changes provide estimates of hedging effectiveness (R^2) and minimum-risk hedge ratios (regression coefficient on the spot price).

To determine if the estimated hedge parameters differ with respect to time to delivery, separate regressions are run for price changes on contracts with various days remaining to delivery. Days remaining to delivery are subdivided by 1-30 days, 30-60 days, and 60-102 days. Two types of statistical analysis are used to compare estimated levels of hedge ratios and effectiveness across subsets of the sample. First, separate OLS regressions are estimated for each subset of the sample to determine minimum-risk hedge ratios and effectiveness measures. Neter and Wasserman (1972) provide a procedure for estimating a confidence region for coefficients of determination (R^2). This procedure is used to analyze the significance and the stability of the hedging effectiveness measures. The second test gives statistical comparisons of hedge ratios over different market conditions. Two sets of slope and intercept terms, along with an interaction term, are added to the regression model to compare the several subsets of data under analysis. This procedure was first suggested by Gujarati (1970) and facilitates the testing of the hypothesis that hedge ratios are equal under rising vs. declining prices. The full model becomes

$$C_s = \alpha_o + \alpha_1 D(S) + \beta_1 C_f + \beta_2 D(S) C_f \tag{6}$$

where

C_s, C_f = change in spot and futures prices
$D(S) = 1$ if $C_s < 0$ (spot prices rose)
$= 0$ if $C_s > 0$ (spot prices declined)

Empirical Results and Analysis

Table I presents a comparison between the hedge ratio and hedging effectiveness estimates based on the full data set and selected subsets of the data. Results are reported for observations segmented by days remaining to delivery as well as for the full data set. Table II shows the summary of hedge ratio estimation for the full model with dummy variables. The numbers in parenthesis are t-statistics.

Examination of these results leads to several points that are worthy of further discussion. In the case where we utilize T-Note futures to hedge T-Note spot positions, hedges of the spot using the minimum-risk hedge ratio can provide an average proportional reduction in variability from 12.9% to 46.8%, i.e. an increase in effectiveness. Hedging with 1-30 days-to-delivery futures contracts provides a better hedge than any other subset of time-to-delivery for treasury futures contract. In addition, the estimate of the hedge ratios and levels of effectiveness for the nearest days-to-delivery seem to occur because futures and spot price behave similarly as futures contracts near delivery. 61-91 days-to-delivery futures contracts have the second highest hedging effectiveness. 31-60 days-to-delivery futures contracts perform the poorest. Simply put, a futures contract with one to two months-to-delivery is not a good hedging vehicle compared with other delivery month futures. Similar results can be seen in the T-Bond futures case. However, in this case, the estimate of the hedge ratio is highest with 61-91 days-to-delivery futures. The next best futures contract for hedging is 1-30 days-to-delivery futures. Generally speaking, as is expected, the T-Note futures contracts are better hedging tools against T-Note spots than the T-Bond futures to hedge the spot T-Bond positions.

CONCLUSION

Sometimes unexpected extreme volatility of interest rates, which often occurs when we are not so well prepared for it, and the sensitivity of the markets to the tapering of the Federal Reserve's bond buying have compelled us to delve into the effectiveness of hedging performance of the longer term government securities futures. In this paper, we studied the optimal timing for hedging in T-Bond and T-Note spots with T-Bond and T-Note futures.

When T-Bond futures are used to hedge T-Bond spot positions, a proper choice of timing and contract can achieve an average proportional reduction in variability from 2.5% to 31.7%. Hedging with the front month futures provides a better hedge than any other subset of time-to-delivery for treasury futures contracts. Also, the estimate of the hedge ratio is highest with 1-30 days-to-delivery futures. The large hedge ratios and levels of effectiveness for the nearest days-to-delivery contracts seem to occur because futures and spot prices behave similarly as futures contracts near delivery. 61-91 days-to-delivery futures contracts have the second highest level of hedging effectiveness. 31-60 days-to-delivery futures contracts perform the poorest. These results roughly state that a futures contract with one to two months to delivery is not a good hedging vehicle compared with other delivery month futures.

Similar results can be seen when T-Bonds futures contracts are used for hedging. The 31-60 days-to-delivery futures contracts show the lowest hedge ratio and hedging effectiveness. But in this case, the estimate of the hedge ratio is highest with 61-91 days-to-delivery futures. The next best futures contracts for hedging is the 1-30 days-to-delivery futures. Overall, as is expected, the T-Note futures contract is a better hedging tool than T-Bond futures contract to hedge the spot positions. Given a different data set, different outcomes might have resulted. Further analysis of different sets of data is needed to reach conclusions regarding optimal futures strategies for hedgers.

TABLE 1
HEDGE RATIOS AND EFFECTIVENESS ESTIMATES
(Jan 2, 2002 – December 31, 2012)
(Daily T-Note, T-Bond Cash and T-Note, T-Bond Futures Prices Changes)

	Days to Delivery	Hedge Ratio (HR)	Hedging Effectiveness (R^2)	N
T-Notes Futures	1-30	0.9782	0.4681	845
(10-year)	31-60	- 0.1640	0.1290	855
	61-91	0.3812	0.3592	790
	All	0.4822	0.0328	2490
T-Bonds Futures	1-30	0.0123	0.3172	845
	31-60	0.0958	0.0250	855
	61-91	0.0081	0.3518	790
	All	0.1324	0.0329	2490

TABLE 2
RESULTS OF HEDGE RATIOS ESTIMATION WITH DUMMY VARIABLES

	T-Note Futures				T-Bond Futures			
Variables	1-30 Days	31-60 Days	61-91 Days	All Data	1-30 Days	31-60 Days	61-91 Days	All Data
D(S)	-1.274	-0.358	-0.184	-0.318	-0.205	-0.429	-0.279	-0.353
	(-9.87)	(-3.48)	(-12.71)	(-5.79)	(-10.85)	(-3.28)	(-13.19)	(-6.43)
C_f	0.728	-0.301	0.403	0.518	0.012	0.072	0.003	0.009
	(9.87)	(-0.35)	(4.98)	(2.17)	(0.85)	(2.07)	(2.81)	(0.94)
D(S)C_f	-0.289	-0.479	-0.238	-0.420	0.024	-0.083	-0.012	-0.007
	(-3.01)	(-0.42)	(0.09)	(-0.87)	(-1.36)	(-0.84)	(-0.29)	(-0.72)
Multiple R^2	0.507	0.022	0.412	0.031	0.314	0.018	0.297	0.019
No. of Observations	845	855	790	2490	845	855	790	2490

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