THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF FINANCE

COMMODITY FUTURES PRICING: TESTING FOR THE NONZERO PREMIUM AND PREDICTING THE FUTURE SPOT PRICE

CHRISTINE DOLENTE
SPRING 2014

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Finance
with honors in Finance

Reviewed and approved* by the following:

James Miles
Professor of Finance, Joseph F. Bradley Fellow of Finance
Thesis Supervisor
Honors Advisor

Timothy Simin
Associate Professor of Finance, Smeal Research Fellow in Finance
Faculty Reader

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

Conventionally, commodity futures contract prices are calculated as a function of the spot price, interest rate, storage cost, and convenience yield. An alternative pricing theory of commodity futures says that the futures price is broken down into two components: the expected risk premium and the expected future spot price. This thesis tests the theory to determine if commodity futures prices can be used to find the nonzero risk premium and the future spot price.

TABLE OF CONTENTS

LIST OF TABLES

ACKNOWLEDGEMENTS

I would like to acknowledge Dr. James Miles and Professor Tim Simin for their patience guidance, and support of my honors thesis. I appreciate their time and dedication to the honors Finance program and its students.

Chapter 1

Introduction

This thesis tests a pricing theory for commodity futures, which says that the futures price is the sum of the expected risk premium and the expected future spot price. The expected risk premium is the difference between the futures price and the expected future spot price (Fama and French [1987]). For example, a buyer decides to purchase one futures contract on 1,000 barrels of oil instead of purchasing 1,000 barrels of oil in the future. The price of that futures contract reflects the difference between purchasing the futures contract today and purchasing the spot commodity in the future. Namely, the buyer will receive 1,000 barrels of oil valued at the expected future spot price. Also, the buyer will make a return equal to the difference between the futures price and the expected future spot price.

Eugene Fama and Kenneth French tested this commodity futures pricing theory to determine if futures prices contain a nonzero premium and can predict future spot prices. They conducted regression analyses to estimate the relationships between the futures price, the premium, and the future spot price. They found that futures prices could show that the risk premium was nonzero in 5 of 21 commodities. Also, they found that futures prices could predict future spot prices in 10 of 21 commodities (Fama and French [1987]).

This thesis explores a modified version of the Fama and French study of 1987. The commodity futures pricing theory is tested to determine if futures prices contain nonzero premiums and future spot prices. Six commodities are studied spanning 5 years from 2009 to 2014. Regression analyses are modeled after those conducted by Fama and French in multiple studies (Fama and French [1987]), (Fama [1984a]), (Fama [1984b]). The results of this thesis

show that the covariance of the premium and the change in the spot price is negative and the variance of the change in the spot price is greater than the variance of the premium in 5 of 6 commodities.

Chapter 2 is a literature review of previous studies on this topic. Chapter 3 produces the regression equations and explains how the regression tests are conducted. Chapter 4 shows the data and gives an analysis of the findings. Chapter 5 summarizes the study and makes conclusions about the forecasting model based on the study's findings.

Chapter 2

Literature Review

The widely accepted method of commodity futures pricing is based on the theory of storage. The futures price, according to this theory, is a function of the spot price, interest rate, storage cost, and convenience yield (Kaldor [1939]). For example, a buyer decides to purchase one futures contract on 1,000 barrels of oil instead of purchasing 1,000 barrels of oil. The price of that futures contract reflects the effects of the buyer's decision, namely the difference between purchasing the futures contract and purchasing the spot commodity. Because futures contracts require no initial cash payment, the buyer can invest the cash he would have paid on the oil and earn interest. Also, the buyer saves the cost of storing 1,000 physical barrels of oil. Additionally, the buyer sacrifices the benefits of owning 1,000 barrels of oil, such as using it or selling it in the case of an oil shortage.

An alternative commodity pricing theory says that the futures price is the sum of the expected future spot price and the expected risk premium. One of the first researchers to suggest that risk premiums exist in commodity futures markets was John Keynes in 1930. He theorized that the futures price must always be less than expected future spot price. In other words, the risk premium must always be negative. Keynes coined the term for this condition as "normal backwardation" because he argued that backwardation in the commodity futures market is inherent. Keynes considered the buyer of a futures contract to be a speculator because he agrees to enter a long position in the commodity at the futures price, regardless of whether he can to enter the position at a lower market price in the future. Conversely, the seller of the futures contract is a hedger because she locks in a price at which she can sell the commodity for a profit,

regardless of the market price in the future. Therefore, the buyer must be compensated for his risk with a return equal to the expected future spot price minus the futures price. Also, the seller must pay the premium for the certainty of her hedged position. As the futures contract approaches maturity, the futures price increases and the risk premium decreases. The buyer's risk declines as the maturity date approaches because the time that the expected future spot price has to fall below the futures price decreases (Keynes [1930]).

Further research on the expected risk premium shows that the premium of commodity futures contracts can be positive or negative. Paul Cootner argued that commodity futures speculators are not always long and hedgers are not always short. He demonstrated that, in agriculture commodities, hedgers tend to short futures contracts during the harvest. This heavy selling puts downward pressure on the futures price, which results in a negative premium. However, when the harvest is over, hedgers lift their positions and futures prices rise, resulting in a positive premium. Therefore, the speculators still earn the premium, but only if they are long the futures contract when the hedgers are short and short the futures contract when the hedgers are long (Cootner [1960]).

In addition to the premium, the future spot price is also a component of the futures price according to the commodity futures pricing theory under question in this thesis. Katherine Dusak studied the ability of the futures price to predict the future spot price using the capital asset pricing model (CAPM). Dusak calculated the beta of commodity futures by conducting regression analysis on commodity futures returns against returns of the S&P500. The results show that the beta is not significantly different from zero. In other words, commodity futures prices have no systematic risk. Therefore, according to the CAPM, the price of the futures contracts should not have a tendency to increase or decrease over time. From this finding, Dusak concludes that the futures price is an unbiased estimation of the future spot price (Dusak [1973]).

Thomas Hazuka expanded on Dusak's and other researchers' studies of the CAPM model in relation to commodity futures prices. Hazuka developed a linear model using CAPM to predict the rate of change of the spot price of a commodity. The model fit best for non-storable commodities with little inventory. These commodities are either perishable or the storage costs are too high. On the other hand, the model fit worst for storable commodities with high inventory levels. Hazuka concludes that the futures price of storable commodities is not a strong predictor of the future spot price. The storage costs for these commodities link the futures price and the current spot price. Any information in the futures price about the future spot price is also part of the current spot price. Therefore, the futures price does not contribute any additional forecast power to the current spot price (Hazuka [1984]).

Eugene Fama and Kenneth French studied futures contracts in the mid-1980s. Fama studied foreign exchange forward markets to determine if the forward price contains a nonzero premium and can predict the future spot price. Similar to the findings in this thesis, Fama's findings show that the premium and the change in the spot price have a negative covariance. Therefore, his regression tests are not easily interpreted to determine the relationships between the futures price, the premium, and the future spot price. However, the regression tests show that the premium and the change in the spot price vary through time with the futures price. Also, the variance of the premium is greater than the variance of the change in the spot price (Fama [1984a]).

Fama conducted a similar study on forward contracts on interest rates. He used regression tests to determine if forward interest rates contain nonzero premiums and future spot interest rates. Fama's results show that the premium and the change in the spot rate vary through time with the forward rate. The regression tests show stronger evidence for the predictability of the forward rate. The one-month forward contract has forecast power of the one-month spot rate.

Regressions on longer dated contracts show weaker evidence of forward spot rate predictability (Fama [1984b]).

Fama and French collaborated to study commodity futures contract pricing. They conducted regression tests on commodity futures to determine if the futures price can find the nonzero premium and can predict the future spot price. The results of the regression tests show that the futures price can show that the risk premium is nonzero in 5 of the 21 commodities they studied. The futures price also can predict future spot prices in 10 of 21 commodities. Fama and French found that the commodities with high storage costs and perishability, like agriculture commodities, had the best forecast power of future spot prices. Because stored commodities smooth changes in the spot price due to supply and demand shock, they theorized that high storage costs cause greater variation in the spot price. Forecast power of the future spot price was not found in commodities with low storage costs relative to their value, like metals commodities (Fama and French [1987]).

Chapter 3

Regression Tests

The commodity futures pricing theory that this thesis tests says that the futures price is the sum of the expected risk premium and the expected future spot price. The dependent variable of this theory is the basis [F(t, T) – S(t)], which is the futures price F(t, T) minus the current spot price S(t). The independent variables are the expected risk premium E[P(t, T)] and the expected change in the spot price E[S(T) – S(t)]. The expected risk premium E[P(t, T)] is the difference between the futures price F(t, T) and the expected future spot price E[S(T)]. The pricing model can then be written as follows:

$$F(t,T) - S(t) = E\big(P(t,T)\big) + E(S(T) - S(t))$$

Regression analyses on the pricing model determine if there is a relationship between the dependent variable and the two independent variables. Specifically, a regression analysis of the expected premium on the basis will estimate the relationship between the premium and the basis. Likewise, a regression analysis of the expected change in the spot price on the basis will estimate the relationship between the future spot price and the basis.

The regression equations of the premium on the basis and of the change in the spot price on the basis, respectively, are:

$$F(t,T) - S(T) = A_1 + B_1[F(t,T) - S(t)] + C_1(t,T)$$

$$S(T) - S(t) = A_2 + B_2[F(t,T) - S(t)] + C_2(t,T)$$

The intercepts are A_1 and A_2, the slopes of the regression are B_1 and B_2, and the error terms from time t to time T are $C_1(t, T)$ and $C_2(t, T)$. Time t represents the issue of the futures contract while time T represents the maturity of the futures contract.

In the regression equations, the basis is the independent variable. The regression equation of the premium on the basis shows how changes in the basis cause changes in the premium. Equivalently, the regression shows if the futures price can find the nonzero premium. Likewise, the regression equation of the change in the spot price on the basis shows how changes in the basis cause changes in the future spot price. Equivalently, the regression shows if the futures price can predict the future spot price.

The dependent variables of the regression equations add up to equal the basis. Therefore, adding the regression equations gives:

$$F(t,T) - S(t) = A_1 + A_2 + (B_1 + B_2)[F(t,T) - S(t)] + C_1(t,T) + C_2(t,T)$$

In order for the above equation to be true, both the intercepts A_1 and A_2 and the error terms $C_1(t, T)$ and $C_2(t, T)$ must each add to 0. Also, more importantly to this study, the slopes B_1 and B_2 must add to 1. Therefore, variation in the basis must be entirely due to variation in the premium, variation in the change in the spot price, or a combination of both. For example, if B_1 is 0.5 and B_2 is 0.5, then variation in the premium and variation in the change in the spot price contribute equally to variation in the basis.

Furthermore, if B_1 is positive, then there is a direct relationship between variation in the basis and variation in the premium. Equivalently, the basis can be used to find the nonzero premium. Likewise, if B_2 is positive, then there is a direct relationship between variation in the basis and variation in the change in the spot price. In other words, the basis can be used to predict the future spot price.

In the case where both B_1 and B_2 are positive and not equal, then each regression coefficient must be between 0 and 1. Then, B_1 and B_2 are not significantly different from 0 or one another. Therefore, the regression test alone fails to identify the stronger source of variation in the basis. A closer examination of the regression coefficients B_1 and B_2 may be helpful in clarifying whether the premium or the change in the spot price is a stronger source of variation in the basis. The regression coefficient equals the covariance of the two variables over the variance of the independent variable. Thus, B_1 and B_2 are:

$$B_1 = \frac{cov([F(t,T) - S(T)], [F(t,T) - S(t)])}{\sigma^2[F(t,T) - S(t)]}$$

$$B_1 = \frac{\sigma^2[F(t,T) - S(T)] + cov([F(t,T) - S(T)], [S(T) - S(t)])}{\sigma^2[F(t,T) - S(T)] + \sigma^2[S(T) - S(t)] + 2cov([F(t,T) - S(T)], [S(T) - S(t)])}$$

$$B_2 = \frac{cov([S(T) - S(t)], [F(t,T) - S(t)])}{\sigma^2[F(t,T) - S(t)]}$$

$$B_2 = \frac{\sigma^2[S(T) - S(t)] + cov([F(t,T) - S(T)], [S(T) - S(t)])}{\sigma^2[F(t,T) - S(T)] + \sigma^2[S(T) - S(t)] + 2cov([F(t,T) - S(T)], [S(T) - S(t)])}$$

Consider the case where the covariance of the premium [F(t, T) – S(T)] and the change in the spot price [S(T) – S(t)] is zero. Then, B_1 is the ratio of the variance of the premium to the sum of the variance of the premium and the variance of the change in the spot price. Additionally, B_2 is the ratio of the variance of the change in the spot price to the sum of the variance of the premium and the variance of the change in the spot price. Therefore, the portion of variation in the basis due to variation in the premium is simply the variance of the premium. Also, the portion of variation in the basis due to variation in the change in the spot price is simply the variance of the change in the spot price.

In the case where the covariance of the premium and the change in the spot price is not zero, B_1 and B_2 still include the variance of the premium and the variance of the change in the spot price, respectively. Therefore, variation in the basis is still due in part to the variance of the premium and the variance of the change in the spot price. However, the simple interpretation when the covariance is zero is not valid.

Chapter 4

Data and Analysis

This thesis studies six commodities: WTI, natural gas, copper, silver, soybeans, and live cattle. They are categorized as energy commodities, metals commodities, or agriculture commodities. The active 1-month futures contract is used as the spot price. The active 3-month futures contract is used as the futures price. Historical price data is collected monthly over 5 years beginning in February 2009 and ending in March 2014. This timeframe results in 60 observations for each product. Data was collected from Bloomberg.

Table 1 shows the standard deviations of the basis, the premium, and the change in the future spot price for each commodity. The standard deviations are shown in place of the variances.

Table 1. Standard Deviations of the Basis, Premium, and Change in the Spot Price

Commodity	**Basis**	**Premium**	**Change in the Spot Price**
Energy:			
WTI	1.22	24.03	24.39
Natural Gas	0.32	1.10	1.24
Metals:			
Copper	1.77	82.29	83.09
Silver	0.03	6.671	6.667
Agriculture:			
Soybean	59.17	328.18	334.64
Live Cattle	4.94	29.66	32.48

The standard deviations of the change in the spot price in Table 1 are greater than the standard deviations of the premium in 5 of 6 commodities. The exception is silver, whose standard deviation of the premium is greater than its standard deviation of the change in the spot price. However, the difference between the standard deviation of the premium and the standard deviation of the change in the spot price is down to one one-hundredth of a percent. The smallest difference of the other 5 commodities is only as low as one tenth of a percent. Therefore, it is possible that the differing standard deviations for silver are caused by the data sample. Looking at subsets of the data shows that the cause is, in fact, sampling error. The standard deviations of the premium and the change in the spot price are taken over the first and last 2.5 years of the data set. The standard deviations of the change in the spot price are greater than the standard deviations of the premium for both subsets.

Table 1 also shows that the standard deviations of the basis are low relative to the standard deviations of the premium and the standard deviations of the change in the spot price. Therefore, the greater standard deviation of the change in the spot price could indicate that the standard deviation of the forecast error for the change in the spot price is greater than that of the premium. Therefore, the futures price could be better predictor of the future spot price than the current spot price.

Table 2 shows a summary of the regression statistics for the 6 commodities in this study. The coefficients of the regression B_1 and B_2 and their t-statistics $t(B_1)$ and $t(B_2)$ are included. The coefficient of determination R^2 is also shown. The intercepts A_1 and A_2 add to 0, the coefficients of the regressions B_1 and B_2 add to 1, and the error terms $C_1(t, T)$ and $C_2(t, T)$ add to 0 for each commodity. Statistics denoted with 1 are of the regression of the premium on the basis. Statistics denoted with 2 are of the regression of the spot price change on the basis. Complete regression statistics are shown in Appendix A.

Table 2. Regressions of the Premium and the Change in the Spot Price on the Basis

Commodity	$\mathbf{B_1}$	$\mathbf{B_2}$	$\mathbf{t(B_1)}$	$\mathbf{t(B_2)}$	$\mathbf{R_1^2}$	$\mathbf{R_2^2}$
Energy:						
WTI	-8.87	9.87	-3.86	4.30	0.20	0.24
Natural Gas	-1.07	2.07	-2.51	4.86	0.10	0.29
Metals:						
Copper	-20.60	21.60	-3.81	3.99	0.20	0.21
Silver	43.20	-42.20	1.47	-1.47	0.04	0.04
Agriculture:						
Soybean	-0.11	1.11	-0.15	1.54	0.00	0.04
Live Cattle	-3.09	4.09	-4.61	6.10	0.27	0.39

The coefficients of determination R_1^2 and R_2^2 are low for all 6 commodities. This can be explained by the low standard deviations of the basis relative to the standards deviations of the premium and the standard deviations of the change in the spot price shown in Table 1.

The coefficient of regression B_1 of the premium on the basis is negative in 5 of 6 commodities. Since B_1 and B_2 must add to 1, B_2 is conversely positive in 5 of 6 commodities. The exception, as in Table 1, is silver. Regressions for silver on the two data subsets produce coefficients in line with the other 5 commodities. Specifically, the coefficients of regression of the premium on the basis B_1 are negative for both subsets. The coefficients of regression of the change in the spot price on the basis B_2 is positive. Complete regression statistics on the data subsets for silver are found in Appendix B.

The negative coefficient of regression B_1 clouds the relationship between the premium and the futures price. B_1 and B_2 are not easily interpreted as the proportion of variation in the basis due to the variance of the premium and the variance of the change in the spot price, respectively.

Given the equations for B_1 and B_2 examined in the previous chapter, the negative coefficient of regression B_1 can be explained. The variance of the premium in the numerator of B_1 must be positive, so the covariance of the premium and the change in the spot price in the numerator must be negative and greater in magnitude than the variance of the premium. In order for B_2 to be positive, the covariance must also be smaller in magnitude than the variance of the change in the spot price. Therefore, the variance of the change in the spot price must be greater than the variance of the premium. The higher standard deviations of the change in the spot price than the standard deviations of the premium in Table 1 are consistent with this finding.

The covariance being negative makes sense considering the premium has an inverse relationship with the future spot price and the change in the spot price has a direct relationship with the future spot price. Specifically, the premium [F(t, T) – S(T)] decreases when the future spot price increases, all else equal. On the other hand, the change in the spot price [S(T) – S(t)] increases when the future spot price increases, all else equal. For example, the expected future spot price of soybeans increases due to predictions that the next harvest will produce fewer soybeans than previously predicted. As a result, the change in the spot price will increase and the premium on the futures contract will decrease.

The negative covariance makes determining the exact proportion of variation in the basis due to the variance of the premium and the variance of the change in the spot price difficult. However, the regressions show that the premium and the change in the spot price vary through time as components of the futures price. Also, the variance of the change in the spot price is greater than the variance of the premium.

Chapter 5

Conclusion

This thesis tests a pricing theory for commodity futures contracts. The pricing theory says that the futures price is equal to the sum of the expected risk premium and the expected future spot price. Regression analysis is conducted to estimate the relationships between the futures price, the premium, and the future spot price. The futures price is hypothesized to contain the nonzero premium and to predict the future spot price.

The results of this study show that variation in the futures price is due to variation in the premium and variation in the change in the spot price. Therefore, the premium and the future spot price are components of the futures price, as the pricing theory suggests.

However, the futures price cannot be used to find the nonzero premium or to predict the future spot price in the 6 commodities in this study. The coefficients of regression for the premium on the futures price are negative. Conversely, the coefficients of regression for the change in the spot price on the futures price are positive. Therefore, the relationships between the futures price, the premium, and the future spot price are not easily interpreted.

The premium and the change in the spot price were found to have a negative covariance in all 6 commodities. This condition was determined to make sense due to the inverse relationship between the premium and the change in the spot price. However, the negative covariance of the premium and the change in the spot price inhibit the ability of the regression tests to estimate the variance of the premium or the variance of the change in the spot price. Nevertheless, regression analyses show that the premium and the change in the spot price vary through time as

components of the futures price. Also, the variance of the change in the spot price is greater than the variance of the premium.

Appendix A

Regression Statistics

WTI Regression Statistics

The Premium on the Basis

Regression Statistics	
Multiple R	0.449286869
R Square	0.201858691
Adjusted R Square	0.188330872
Standard Error	21.64537324
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	6991.169521	6991.169521	14.9217471	0.000281061
Residual	59	27642.80878	468.5221827		
Total	60	34633.9783			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	11.70807829	3.51916572	3.326947129	0.001515304	4.666243949	18.74991263	4.666243949	18.74991263
X Variable 1	-8.872444022	2.296854213	-3.86286773	0.000281061	-13.46843869	-4.276449357	-13.46843869	-4.276449357

The Change in the Spot Price on the Basis

Regression Statistics	
Multiple R	0.488326946
R Square	0.238463206
Adjusted R Square	0.225555803
Standard Error	21.64537324
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	8655.908498	8655.908498	18.47491713	6.53804E-05
Residual	59	27642.80878	468.5221827		
Total	60	36298.71728			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-11.70807829	3.51916572	-3.326947129	0.001515304	-18.74991263	-4.666243949	-18.74991263	-4.666243949
X Variable 1	9.872444022	2.296854213	4.29824582	6.53804E-05	5.276449357	14.46843869	5.276449357	14.46843869

Natural Gas Regression Statistics

The Premium on the Basis

Regression Statistics	
Multiple R	0.310820235
R Square	0.096609218
Adjusted R Square	0.08129751
Standard Error	1.057301404
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	7.053303032	7.053303032	6.30949972	0.014765368
Residual	59	65.95528923	1.117886258		
Total	60	73.00859226			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.608749115	0.160905815	3.78326362	0.000363954	0.286777324	0.930720907	0.286777324	0.930720907
X Variable 1	-1.069558269	0.425801304	-2.511871756	0.014765368	-1.92158471	-0.217531828	-1.92158471	-0.217531828

The Change in the Spot Price on the Basis

Regression Statistics	
Multiple R	0.534711214
R Square	0.285916082
Adjusted R Square	0.273812965
Standard Error	1.057301404
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	26.40820975	26.40820975	23.62334232	9.03366E-06
Residual	59	65.95528923	1.117886258		
Total	60	92.36349898			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.608749115	0.160905815	-3.78326362	0.000363954	-0.930720907	-0.286777324	-0.930720907	-0.286777324
X Variable 1	2.069558269	0.425801304	4.860384997	9.03366E-06	1.217531828	2.92158471	1.217531828	2.92158471

Copper Regression Statistics

The Premium on the Basis

Regression Statistics	
Multiple R	0.44394683
R Square	0.197088788
Adjusted R Square	0.183480124
Standard Error	74.35791883
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	80075.72146	80075.72146	14.48259574	0.000338585
Residual	59	326216.9054	5529.100092		
Total	60	406292.6269			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	47.32648936	13.54321606	3.494479387	0.000907871	20.22657662	74.4264021	20.22657662	74.4264021
X Variable 1	-20.59894842	5.412798324	-3.805600576	0.000338585	-31.42993285	-9.767963991	-31.42993285	-9.767963991

The Change in the Spot Price on the Basis

Regression Statistics	
Multiple R	0.461002776
R Square	0.212523559
Adjusted R Square	0.199176501
Standard Error	74.35791883
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	88039.17711	88039.17711	15.92287635	0.000184784
Residual	59	326216.9054	5529.100092		
Total	60	414256.0825			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-47.32648936	13.54321606	-3.494479387	0.000907871	-74.4264021	-20.22657662	-74.4264021	-20.22657662
X Variable 1	21.59894842	5.412798324	3.990347899	0.000184784	10.76796399	32.42993285	10.76796399	32.42993285

Silver Regression Statistics

The Premium on the Basis

Regression Statistics	
Multiple R	0.18805365
R Square	0.035364175
Adjusted R Square	0.019014415
Standard Error	6.607650042
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	94.4378791	94.4378791	2.162978277	0.146683854
Residual	59	2576.001306	43.66103908		
Total	60	2670.439185			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-2.133164281	2.100598464	-1.015503114	0.31401247	-6.336452098	2.070123536	-6.336452098	2.070123536
X Variable 1	43.1983524	29.37251296	1.470706727	0.146683854	-15.57591027	101.9726151	-15.57591027	101.9726151

The Change in the Spot Price on the Basis

Regression Statistics	
Multiple R	0.183849216
R Square	0.033800534
Adjusted R Square	0.017424272
Standard Error	6.607650042
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	90.11619546	90.11619546	2.063995667	0.156096084
Residual	59	2576.001306	43.66103908		
Total	60	2666.117501			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.133164281	2.100598464	1.015503114	0.31401247	-2.070123536	6.336452098	-2.070123536	6.336452098
X Variable 1	-42.1983524	29.37251296	-1.436661292	0.156096084	-100.9726151	16.57591027	-100.9726151	16.57591027

Soybean Regression Statistics

The Premium on the Basis

Regression Statistics	
Multiple R	0.02011135
R Square	0.000404466
Adjusted R Square	-0.016537831
Standard Error	330.8785179
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2613.649295	2613.649295	0.023873174	0.877735389
Residual	59	6459355.023	109480.5936		
Total	60	6461968.672			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	13.76382277	47.69027955	0.288608557	0.773892519	-81.66420618	109.1918517	-81.66420618	109.1918517
X Variable 1	-0.111541103	0.721904668	-0.154509464	0.877735389	-1.556069007	1.332986801	-1.556069007	1.332986801

The Change in the Spot Price on the Basis

Regression Statistics	
Multiple R	0.196546291
R Square	0.038630445
Adjusted R Square	0.022336045
Standard Error	330.8785179
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	259554.4608	259554.4608	2.370780539	0.128971752
Residual	59	6459355.023	109480.5936		
Total	60	6718909.484			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-13.76382277	47.69027955	-0.288608557	0.773892519	-109.1918517	81.66420618	-109.1918517	81.66420618
X Variable 1	1.111541103	0.721904668	1.539733918	0.128971752	-0.332986801	2.556069007	-0.332986801	2.556069007

Live Cattle Regression Statistics

The Premium on the Basis

Regression Statistics	
Multiple R	0.514792401
R Square	0.265011216
Adjusted R Square	0.252553779
Standard Error	25.64096705
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	13986.34882	13986.34882	21.27333377	2.18969E-05
Residual	59	38790.09229	657.4591913		
Total	60	52776.44111			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	13.57961027	3.627186692	3.743841005	0.000413234	6.321626464	20.83759408	6.321626464	20.83759408
X Variable 1	-3.089399975	0.669817302	-4.612302437	2.18969E-05	-4.429701301	-1.749098649	-4.429701301	-1.749098649

The Change in the Spot Price on the Basis

Regression Statistics	
Multiple R	0.622226684
R Square	0.387166047
Adjusted R Square	0.37677903
Standard Error	25.64096705
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	24506.15962	24506.15962	37.27403912	8.64371E-08
Residual	59	38790.09229	657.4591913		
Total	60	63296.25191			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-13.57961027	3.627186692	-3.743841005	0.000413234	-20.83759408	-6.321626464	-20.83759408	-6.321626464
X Variable 1	4.089399975	0.669817302	6.105246852	8.64371E-08	2.749098649	5.429701301	2.749098649	5.429701301

Appendix B

Regression Statistics for Silver Data Subsets

Data Subset 1: February 2009 – August 2011

The Premium on the Basis

Regression Statistics	
Multiple R	0.002776915
R Square	7.71126E-06
Adjusted R Square	-0.034474781
Standard Error	5.616107942
Observations	31

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.007053383	0.007053383	0.000223628	0.988171126
Residual	29	914.6793841	31.54066842		
Total	30	914.6864375			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.813624212	2.579620424	-0.703058556	0.48762545	-7.089540369	3.462291946	-7.089540369	3.462291946
X Variable 1	-0.748741116	50.06894036	-0.014954203	0.988171126	-103.1512221	101.6537399	-103.1512221	101.6537399

The Change in the Spot Price on the Basis

Regression Statistics	
Multiple R	0.006485582
R Square	4.20628E-05
Adjusted R Square	-0.034439245
Standard Error	5.616107942
Observations	31

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.038475576	0.038475576	0.001219872	0.97237752
Residual	29	914.6793841	31.54066842		
Total	30	914.7178597			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.813624212	2.579620424	0.703058556	0.48762545	-3.462291946	7.089540369	-3.462291946	7.089540369
X Variable 1	1.748741116	50.06894036	0.034926665	0.97237752	-100.6537399	104.1512221	-100.6537399	104.1512221

Data Subset 2: September 2011 – March 2014

The Premium on the Basis

Regression Statistics	
Multiple R	0.143429771
R Square	0.020572099
Adjusted R Square	-0.014407469
Standard Error	6.8665243
Observations	30

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	27.72924786	27.72924786	0.588117587	0.449566195
Residual	28	1320.176367	47.14915597		
Total	29	1347.905615			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	6.669515281	4.540225687	1.468983205	0.152983882	-2.630715442	15.969746	-2.630715442	15.969746
X Variable 1	-39.79169974	51.88722054	-0.76688825	0.449566195	-146.0778529	66.49445338	-146.0778529	66.49445338

The Change in the Spot Price on the Basis

Regression Statistics	
Multiple R	0.146957375
R Square	0.02159647
Adjusted R Square	-0.013346513
Standard Error	6.8665243
Observations	30

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	29.14048076	29.14048076	0.618048832	0.438376298
Residual	28	1320.176367	47.14915597		
Total	29	1349.316848			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-6.669515281	4.540225687	-1.468983205	0.152983882	-15.969746	2.630715442	-15.969746	2.630715442
X Variable 1	40.79169974	51.88722054	0.786160818	0.438376298	-65.49445338	147.0778529	-65.49445338	147.0778529

BIBLIOGRAPHY

Cootner, Paul H. "Returns to Speculators: Telser Versus Keynes." *Journal of Political Economy* (1960): 396-404. Print.

Dusak, Katherine. "Futures Trading and Investor Returns: An Investigation of Commodity Market Risk Premiums." *Journal of Politcal Economy* (1973): 1387-406. Print.

Fama, Eugene F. "Forward and Spot Exchange Rates." *Journal of Monetary Economics* 14.3 (1984a): 319-38. *EconPapers*. Web. 5 Mar. 2014.

Fama, Eugene F. "The Information in the Term Structure." *Journal of Financial Economics* 13.4 (1984b): 509-28. *ScienceDirect*. Web. 5 Mar. 2014.

Fama, Eugene F., and Kenneth R. French. "Commodity Futures Prices: Some Evidence on Forecast Power, Premiums, and the Theory of Storage." *The Journal of Business* 60.1 (1987): 55-73. *JSTOR*. Web. 5 Mar. 2014.

Hazuka, Thomas B. "Consumption Betas and Backwardation in Commodity Markets." *Journal of Finance* (1984): 647-55. Print.

Kaldor, Nicholas. "Speculation and Economic Stability." *The Review of Economic Studies* 7.1 (1939): 1-27. *JSTOR*. Oxford University Press. Web. 5 Mar. 2014.

Keynes, John M. *Treatise on Money*. 2nd ed. Vol. 5. London: Macmillan, 1930. Print.

ACADEMIC VITA

Christine Dolente
318 Vista Drive
Phoenixville, PA 19460
christine.dolente@gmail.com

Education

The Pennsylvania State University, Schreyer Honors College — University Park, PA
Smeal College of Business: B.S. Finance, International Business Minor — Spring 2014
College of Liberal Arts: Economics Minor, Spanish Minor

Council on International Educational Exchange (CIEE) — Seville, Spain
Language and Culture Program — June 2012

Honors and Awards

Villa Maria Academy High School
Valedictorian, 2010

The College Board
AP Scholar with Distinction, 2010

Professional Experience

Goldman, Sachs & Co.
Securities Division Summer Analyst, 2013

Activities

Nittany Lion Fund, LLC
Secretary & Treasurer, 2013
Fund Manager, 2012
Summer Intern, 2011

Delta Zeta Sorority
Vice President of Programming, 2012
Active Member, 2011 – 2014

Student Pink Zone Organization
President, 2014
Treasurer, 2013
Director of Special Events, 2012
Marketing Committee Member, 2011

Wall Street Boot Camp
Certified Graduate, 2011