GUIDELINES AND CONSIDERATIONS FOR CONSTRUCTION CONTRACTORS USING COMMODITY FUTURES AS HEDGING TOOLS FOR MITIGATING CONSTRUCTION MATERIAL PRICING RISK

By

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Abstract

Many would argue that risk management is the single most important element of a construction contractor's business enterprise. A significant risk to a contractor's profitability is increased costs of construction materials. In many cases construction materials are the largest single component of a construction project budget. Contractors generally utilize contingency funds or contractual price adjustments clauses to address the risk associated with changes in construction material pricing. However, the use of contingency and contractual mechanisms comes at a cost. The additional costs are especially detrimental in construction markets that are competitively bid, because higher bid prices result in winning fewer jobs. An alternative risk mitigation is the use of commodity futures to hedge the risk of increasing construction material prices. A hedge is strategy for limiting losses by holding a portfolio of non-correlated assets. The research of this study evaluates the application of commodity futures for hedging material pricing risk in the construction industry. Through statistical analysis and simulation studies this research concludes that utilizing commodity futures as a hedging strategy is effective risk mitigation against increased construction material costs. In addition, through a literature review this study explains the fundamentals of the commodity future market, and presents the mechanics of trading commodity futures. A guideline for using commodity futures as a hedging tool is included in this study.

Key Words: Construction Contractor, Commodity Future, Construction Material, Price Risk, Volatility, Hedging

GUIDELINES AND CONSIDERATIONS FOR CONSTRUCTION CONTRACTORS USING COMMODITY FUTURES AS HEDGING TOOLS FOR MITIGATING CONSTRUCTION MATERIAL PRICING RISK.

Introduction

This study provides an empirically validated approach to a specific risk to construction contractors engaged in building material intensive projects. In most cases large construction projects require a great deal of construction material. Some examples include new power plants, road projects, marine infrastructure, and buildings. This study does not set out to justify the need to mitigate construction material price risk or introduce commodity futures as a new risk mitigation method. Both concepts have been covered in numerous studies. In addition, the strategy of using commodity futures is evident in financial statements issued by publically traded construction companies [Flour, 2016]. In a study conducted by Al-Zarrad the justifications for addressing construction material pricing risk was thoroughly examined and supported [Al-Zarrad, 2015]. In the Al-Zarrad study commodity futures were evaluated as a hedging strategy, but the examples provided in the study do not specifically addresses construction material risk. Additionally, the Al-Zarrad study does not address fundamental trading guidelines and no empirical evidence is provided to validate the use of commodity futures as a hedge. The research contained herein builds upon the existing published studies by providing empirical validation in support of hedging construction material pricing risk with commodity futures. In addition, this research aims to apply fundamental trading concepts and strategies to the proposed hedging approach, and outline those concepts as a guideline. To achieve these objectives this research took the following steps.

1. Thorough literature review on the topics of construction risk, hedging, commodity futures, and commodity markets.
2. Construction material and commodity futures pricing data sets were recorded and tabulated for analysis.
3. The data were compared graphically for evaluation of trends.
4. The data were checked for correlation using regression analysis, and the regression results were confirmed with statistical significance testing.
5. The most correlated data were further examined by simulating hedging trades during periods of construction material prices increases.
6. The results of the simulations studies were examined for trends and conclusions were drawn for using commodity futures as a hedging strategy.
7. Guidelines were outlined to provide best practices for using commodity futures as hedging tools.

Literature Review

This Literature Review evaluates the risk of material price increases to construction contractors, investigates the mechanics of commodity futures, and investigates some of the considerations of trading commodity futures. The construction business is risky, construction contractors are 16% more likely to fail than other types of business [McIntyre, 2007]. A wide range of anticipated risks can be categorized as contributing factors to unanticipated cost increases. Some of these risk factors include incorrect bid pricing, force majeure events, procurement problems, differing site conditions, delays, production inefficiencies, and project politics [Thomas, 1995]. Unanticipated cost increases to construction project budgets are one of the predominant risks to a construction contractor's profitability [Thomas, 1995]. The importance of addressing construction material cost risk is evident, because construction projects are material dependent. According to a study performed by the Exxon Research and Engineering Company, the cost of materials for energy projects ranged from 28% to 50% of the total construction cost of the project [Hendrickson, 2008]. The risk of escalated material costs is because material costs are not static, and costs are impacted by numerous factors. To address the risk construction contractors cost may include contingency funds in the project budget [Gunhan, 2007]. However, contingency funds add to total cost of the construction budget. The additional contingency costs have a negative impact on companies competitively bidding on projects, because higher bid costs decrease the likelihood of winning bids.

Another example of risk mitigation for material pricing increases is price adjustment clauses. Price adjustment clauses are intended to reduce costs by alleviating the risk to the construction contractor associated with material price changes [Ilbeigi, 2016]. Price adjustment clauses are a contracting mechanism that allows the contracting groups to reconcile costs of materials based on the actual pricing at the time of purchase. Normally the reconciliation price is based on agreed price indices. However, a recent study found that including price adjustment clauses in contracts did not statistically correlate to decreasing bid prices [Ilbeigi, 2016]. The findings of Ilbeigi raise doubts on the value of using price adjustment clauses, and provide justification for exploring other means of risk mitigation.

An alternative approach used address the risk associated with changes in construction material prices is to utilize a hedge. A hedge is a strategy where an action is taken to offset losses from a different area of the business by holding uncorrelated assets [Smirnova, 2016]. An everyday example of a hedge is car insurance. A driver pays a premium to the insurance company to cover the cost of an unplanned event, such as an accident. In the event that an accident occurs the costs of the accident will be incurred, however the driver is protected against the costs with the money provided by the insurance company. It is important to note that a hedge does not eliminate the unexpected costs, but offsets lose from the unplanned event. The use of hedging in the construction business is a common practice, and commodity futures are utilized. A review of financials statements from large construction contractors revealed examples of hedging with all companies [Fluor, 2016]. However, limited data of hedging with commodity futures to address material cost risk were found.

An important concept for understanding a hedge is to understand the concept of assets being long or short. For the intent of this study a position is considered any financial asset or business arrangement an entity enters. The terminology of long or short explains how the changes of the position financially affect the entity. A long position increases in value if the asset price increases, and a short position increases in value if the asset price decreases [Hayes, 2016]. For example, a home owner has a long position in the real estate market. If the real estate market improves and prices go up the home owner will gain by owning a more valuable house. Conversely, the home owner has the risk of losing home value if the real estate market deteriorates. A short position is opposite of long position in that money will be gained if the price of the position decreases [Hayes, 2016]. In the real estate market example a home buyer would be in the short position, because the buyer benefits from lower home prices. In summary, a hedge works by offsetting price movements in either long or short positions. A hedging tool used by numerous industries is the commodity future.

Commodity futures have several characteristics that make them effective tools for hedging. Commodity futures are a contract between two parties for a specified type, quantity, and quality of commodity material [Heakal, 2016]. Assets represented by commodity futures cover multiple markets and millions of commodity futures contracts are traded daily [Heakal, 2016]. Examples of commodity futures include crude oil, lumber, metals, grains, treasuries, and currencies. Commodity futures were originally created as tool for hedging, and a significant portion of trading of commodity futures continues to be for the purpose of hedging [CME Group, 2013]. A specific example is the use of hedges by airlines to protect against price escalation in jet fuel [AL-Zarrad, 2015]. To conduct their business airlines must purchase jet fuel, which puts the airlines in short jet fuel positions. If fuel prices decrease the airlines will profit from lower operating costs. To mitigate the risks of losing money from high fuel costs airlines hedge the short position by entering into long fuel positions by buying jet fuel commodity futures products. In the event that jet fuel costs increase the corresponding long commodity future position increases in value. The net result for the airlines is that the loss from the high fuel cost is offset by the money gained from the more valuable commodity future.

Understanding the mechanics of commodity futures is the initial step to using them as a hedge. Commodity futures are fungible contracts that are traded on open markets. The details outlining the specifics of the commodity futures underlying asset are contained the “specification.” The specification details all of the particulars of the commodity future from the material represented to the pricing mechanisms [Heakal, 2016]. Commodity futures are represented by a symbol, which is a forward slash followed by numbers and letters. For example, the commodity future for Crude Oil is represented by the symbol /CL. Each commodity future represents a quantity of a specific grade of an underlying product.

Symbol	Underlying	Expiration	Margin Requirement	Pricing	Tick Size
/CL	1,000 Barrels of Crude Oil	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec	$2,900	USD per Barrel	$.01 =$10.0
/HG	25,000 lbs. of Copper	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec	$3,100	USD per Pound	$0.0005 = $12.5
/LBS	110,000 nominal board ft.	Jan, Mar, May, Jul, Sep, Nov	$1,650	USD per Board Foot	$0.1 = $11
/HRC	20 Short Tons of Steel	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec	$600	USD per Pound	$1.0 = $1.0

CME Group 2017

Exhibit 1 - Commodity Futures Contract Specifications

In the Crude Oil example the futures contract represent 1,000 barrels of West Texas Intermediate Grade crude oil. The pricing of commodity futures is dependent upon the contract and is different for each product. Generally, the pricing is US dollars per a unit of measure for the underlying product. For example, the pricing of a Crude Oil future is listed by the price per barrel, and is priced in one cent increments. The pricing will move in magnitude depending on the tick size. In the Crude Oil example, the contract will move 10 dollars for each one cent the price changes [CME Group, 2017]. One of the biggest advantages of commodity futures is the capital efficiency of using the product, because a large quantity of product can be held at a low cost. The cost to hold the futures contract is the margin requirement, which is the amount of capital that is required to hold a position in a brokerage account. For example, a copper future contract representing 25,000 pounds of copper can be held for $3,100. Another important specification is that commodity futures contracts have a set date for execution, which is called the expiration date [Heakal, 2016]. Each commodity future contract has a specified expiration date, and on this date the contract expires, and the position will be cash settled at the price at expiration. A crucial understanding with commodity futures is the function of contract expiration and the pricing relationship between different expirations. At any time there are multiple contracts available for any commodity future, and each of the contracts will list a unique price. Commodity future contracts with different expirations are not priced the same, because the price represents what the market expects the price will be at expiration. Exhibit 2 shows the contract prices for the different contract prices in 2017, note that the price of an May 2017 contract is nearly 3.5% lower than a December 2017 Crude Oil contract.

Month	Last	Day High	Day Low	Data Date	Updated
May-17	50.27	50.34	50.22	3-Apr-17	19:40:29 CT
Jun-17	50.74	50.82	50.68	3-Apr-17	19:39:20 CT
Jul-17	51.12	51.17	51.09	3-Apr-17	19:29:46 CT
Aug-17	51.37	51.4	51.37	3-Apr-17	19:10:42 CT
Sep-17	51.58	51.58	51.58	3-Apr-17	19:15:00 CT
Oct-17	51.75	51.8	51.73	3-Apr-17	19:09:55 CT
Nov-17	-	-	-	3-Apr-17	19:03:59 CT
Dec-17	52.01	52.01	51.93	3-Apr-17	19:09:55 CT

CME Group 2017

Exhibit 2 - 2017 Crude Oil Futures Contract Pricing

The pricing difference in the two crude oil contracts represents the markets expectation that the price of oil will be higher in September. Conversely, if crude oil prices are expected to decrease then the price of a contract with an expiration further in the future would be lower.

An important characteristic of commodity futures is the effect of liquidity. Liquidity is defined by the ability to easily sell or buy an asset [CME Group, 2013]. Financial instruments that are sold and bought in large volumes are considered to have high liquidity. High liquidity is a desirable characteristic when dealing with financial instruments [Farley, 2015]. High liquidity allows the financial instrument to be sold and purchased quickly, and decreases the price spread between the seller's asking price and the buyers offer price. In markets with few buyers the party needing to sell the commodity future generally will be forced to lower the selling price to find a buyer. In the commodity futures market liquidity can be identified by the volume of contracts trading, and the difference between the ask and bid price [Sosnoff, 2014]. An example of a liquid commodity future is Crude Oil, which will normally have 1 million contracts change hands daily, and a very tight bid to ask spread.

The relationship between commodity pricing and the realities of commodity production is an important aspect of trading commodity futures. Unlike stocks there is no sustainable scenario where price of a commodity is zero or extremely low. A publicly traded company can go bankrupt and the stock would be deemed worthless. Conversely, commodities always have an intrinsic value and the cost to produce commodities is a natural stop for continuous decreasing prices. In the commodities market, producers generally react to low prices by scaling back production. In normal scenarios the decreased supplies coming out of production eventually supports prices increases. On the other hand very high prices encourage producers to increase production. Consequently the increased supply normally causes prices to come under pressure and eventually decrease. The term used to describe imbalances between supply, demand and pricing is call pricing equilibrium. The realities of the commodity market pricing should be recognized, especially in the cases of historic price extremes. In the case of historic lows anyone trading commodities should recognize that the price has a much easier path the price increases. For the intent of using commodity futures for hedging pricing at historic highs or lows must be viewed with caution.

Research Methodology

The goal of this research is to empirically validate use of commodity futures as a hedge for construction contractors seeking to mitigate material price risk. This research utilizes regression analysis, significance testing and interpretations of trends to support conclusions of the study. The first step of the analysis was to select typical materials used in construction project. The selection of construction materials was based on material used across a range of project types. Six construction materials were selected for this research, which were copper wire, steel, asphalt, concrete cement, framing wood and panel wood. These construction materials were selected because they are typical construction materials to a wide range of construction projects. Four commodity futures were selected as possible hedges for construction materials. The selection of suitable commodity futures contracts considered liquidity criteria, and were based on finding commodity futures that had acceptable liquidity. The data for the initial commodity futures selection was collected from retail financial market trading software. The section of the commodity futures focused on two liquidity requirements.

1. The number of open positions for each commodity future was evaluated as an indication liquidity, and for the intent of this research a floor of 3,000 open contracts was considered the minimum.
2. The bid to ask spread at peak trading time was examined, and for the intent of this research only commodity futures with bid to ask spreads below 1% of the futures price were considered. The allowable spread amount was based on an assumed acceptable loss for simply opening and closing a position.

The results of the liquidity evaluation determined three of the four had sufficient liquidity, which are Crude Oil, Copper, and Random Length Lumber. The steel future was rejected due to the low number of contracts traded and the unacceptable high bid to ask spread.

Symbol	Open Contracts Long and Short	Bid Price	Ask Price	spread	Spread as % of price	Accept/Reject
/CL	2,191,158	53.10	53.11	0.01	0.02%	Accept
/HG	291,924	2.7115	2.7120	0.0005	0.02%	Accept
/LBS	4,437	367.5	368.2	0.7	0.19%	Accept
/HRC	-	600.0	620.0	20	3.33%	Reject

TDAmeritrade 2017

Exhibit 3 - Commodity Futures Liquidity Matrix

Data were collected to perform a regression analysis of the construction materials and the commodity futures. The data were collected for a period of time going back several years, in order to have a sufficient data set for statistical significance. Data for construction material pricing were collected from government agency and industry group sources. Commodity futures pricing information was collected from the retail trading platform. TD Ameritrade's ThinkorSwim trading platform was chosen based on functionality and ease of use. All futures prices were recorded from the beginning of the month at the closing of the market. The data were matched between the construction material and commodity future at beginning each month. Initial review of relationships between construction materials and commodity futures was performed by examination of charts of construction material price graphed against the futures price. Analysis of the graphical comparison was focused on identifying trends in pricing, and comparing the rate of change in pricing of the data sets. Pricing trends evaluated the magnitude of price changes and the duration of the price changes. The evaluation was not determinative of correlation, but only a subjective check for correlation between the construction material and the commodity future.

Statistical analysis was used to find the relationship between the construction materials and commodity futures. A regression analysis was used to determine the correlation strength between the commodity future and the construction material. The specific function was the Pearson Correlation Coefficient r. The Pearson Correlation Coefficient provides a measure of the strength of linear association between data sets, with a value between -1 and 1 representing the linear dependence between two variables [Brase, 2011]. The further from zero the coefficient the stronger the correlation is between the two variables, with a value of 1 being a perfect correlation. A value of -1 one would indicate a perfect inverse correlation.

$$Pearson's\ r_{xy} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i{}^2 - (x_i)^2}\sqrt{n\sum y_i{}^2 - (x_i y_i)^2}}$$

To determine the statistical significance of r, a statistical test of p, the population correlation coefficient was conducted [Brase 2011]. The null hypothesis of the statistical significance test assumes that no linear correlation exists.

The null hypothesis: $H_0 : p = 0$

The alternate hypothesis $H_1 : p \neq 0$

Sample test statistic $t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$ $with\ d.f. = n - 2$

P-values are one tailed, depending on – or + value, student's t-distribution using α = .005

From the results of the p-test the values found to be statistically significant were sorted by correlation rank. The relationships between construction material and commodity futures with the highest correlation were accepted for simulation testing. Hedging simulations were performed for each of the construction materials using the most correlated commodity future as the hedge. The purpose of the simulation study was to demonstrate that using a correlated commodity future as a hedge help minimize losses from increased material prices. The simulation was performed by choosing a period with exceptional price increases in each of the construction materials pricing. The simulation calculated the value of both the construction material and commodity future at the beginning and end of the period. The sizing of the construction amount was a hypothetical value based on a size comparable to the notional value of a single commodity future contract. Three simulations were run for each of the construction material. The multiple simulation results were used to determine if the correlated construction materials and commodity futures were experiencing similar price movements. Lastly, the results of the simulation study were tabulated for final analysis. Final analysis included examining the quartile results of the different correlation ranking.

Analysis

The analysis included interpretation of the graphical comparison, regression analysis, and hedging simulation study. Beginning with the graphical comparison, two futures products show a strong graphical correlation to the respective construction materials. The stronger of the two was Copper wire and copper, which had price movements that where nearly identical between the construction material and the commodity future. Similarly, the framing wood and panel wood showed strong trend similarities with lumber futures. The comparisons with copper to asphalt and copper to steel showed some general similarities in price trends, but did not track closely. The graphical comparison between copper futures and concrete show a near perfect inverse relationship. A clear observation from the data was that rate of change in pricing can be rapid and random. For example, in a seven month period the price of steel increased by 27 percent.

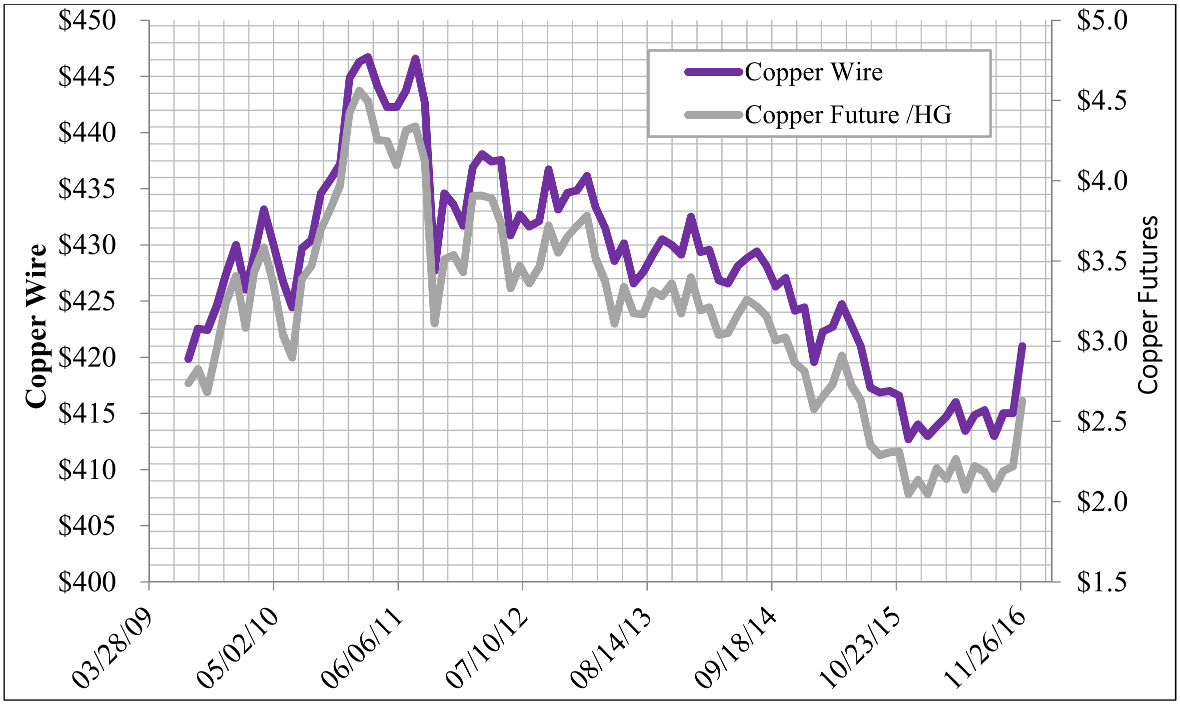

Exhibit 4 - Copper Wire vs. Copper Future /LBS

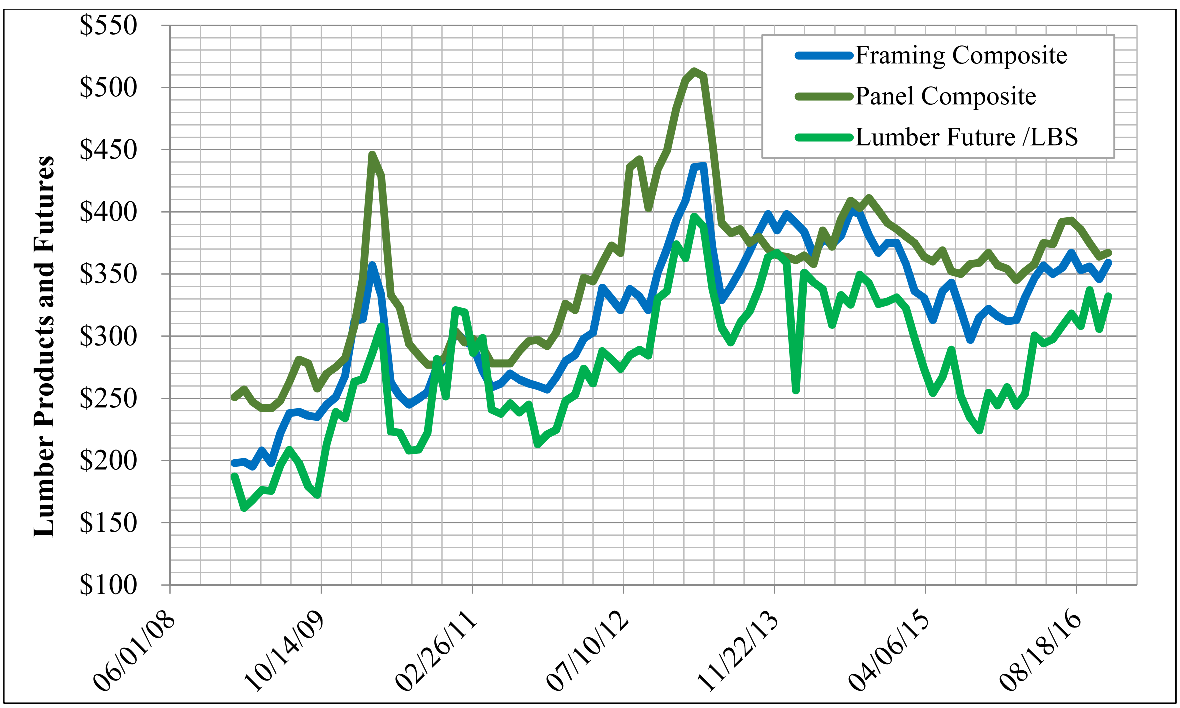

Exhibit 5 - Lumber vs. Lumber Futures /LBS

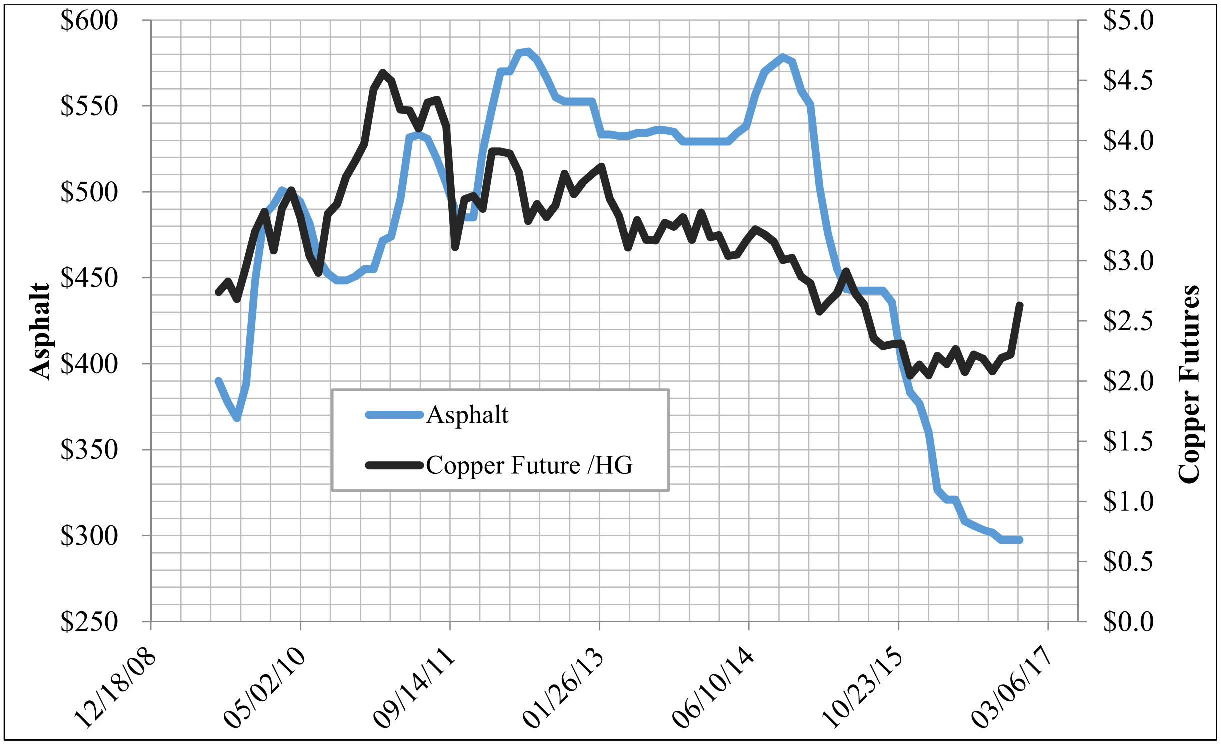

Exhibit 6 - Asphalt vs. Copper Future /HG

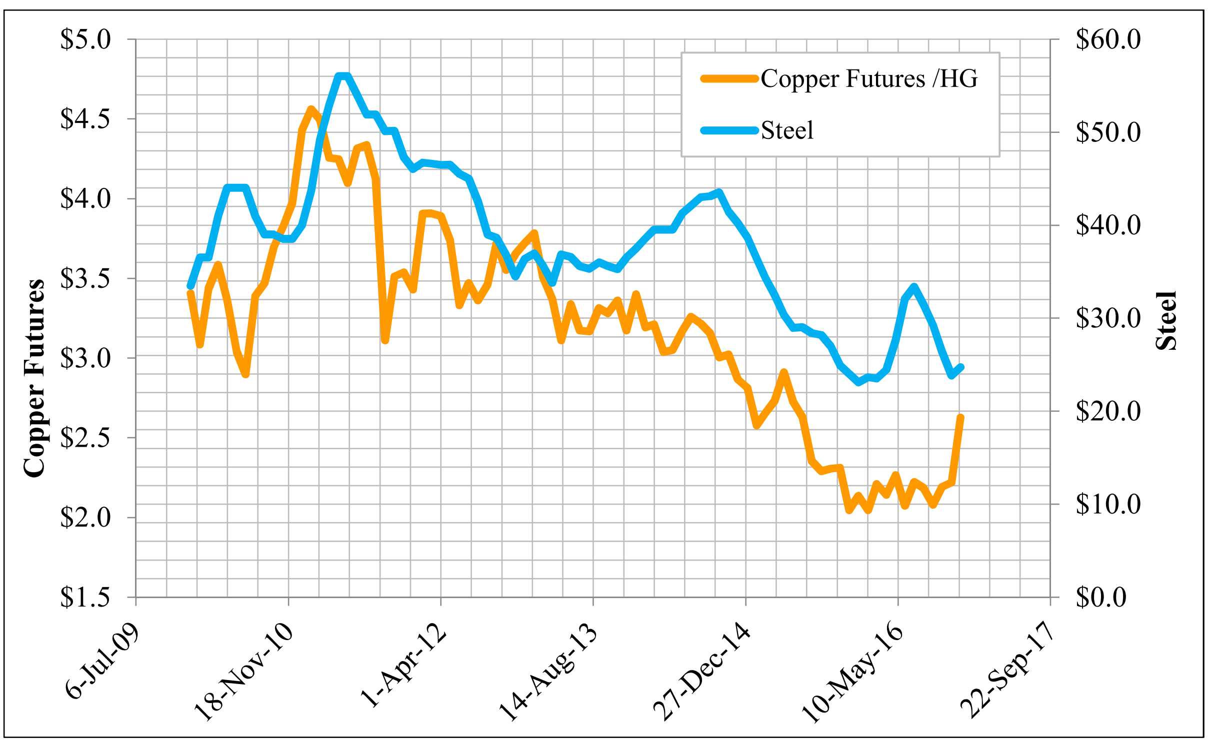

Exhibit 7 - Steel vs. Copper Futures /HG

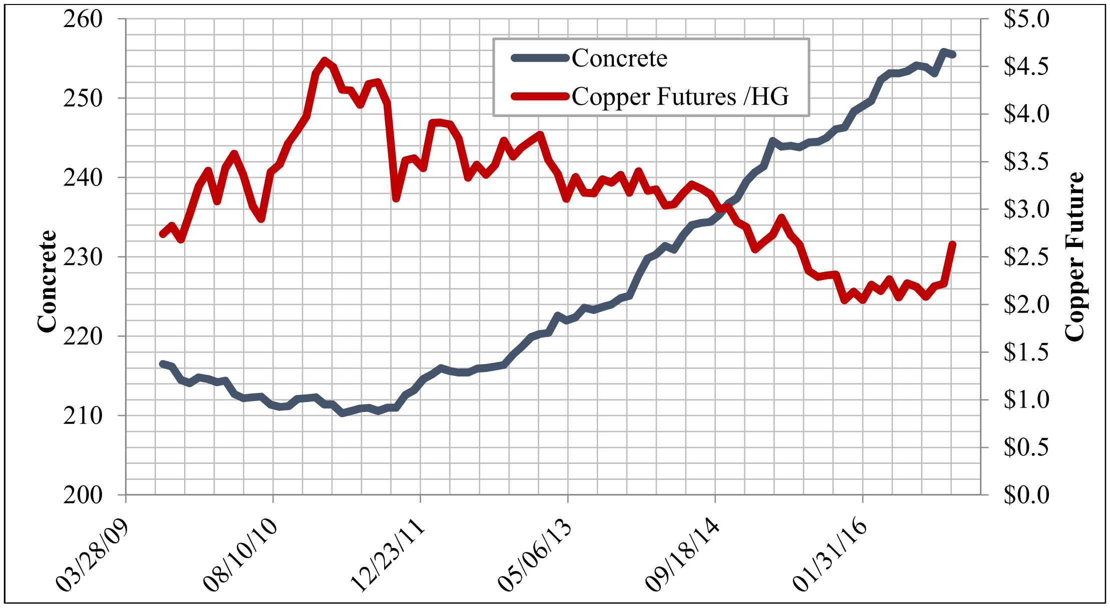

Exhibit 8 - Concrete vs. Copper Future /HG

Regression analyses were performed across all construction material data sets against each different commodity future. The cross examination approach was used to determine if any unexpected relationships existed between the construction materials and the commodity futures. The three futures products each show a strong correlation to certain construction materials. The correlations were not consistently positive or negative. Each construction material had at least one commodity future with a correlation of 0.80, which in general 0.75 is considered a statistically significant value. The magnitude of the correlation number is much more important than if the correlation is negative or positive. The correlation sign can be addressed by holding the appropriate long or short hedge.

CONSTRUCTION MATERIAL	COMMODITY FUTURE: Copper /HG	Crude Oil /CL	Lumber /LBS
Copper Wire	0.99	0.83	0.3
Steel	0.8	0.75	-0.17
Asphalt	0.87	0.79	0.4
Concrete	-0.84	-0.75	0.27
Framing Wood	-0.22	0.05	0.92
Panel Wood	-0.19	0.02	0.80

Exhibit 9 - Regression Analysis Results

The results of the correlation study were evaluated with a statistical significance test. The statistical significance test is used to determine if the data set is sufficient to provide a usable result, and provides a result that is to either accept or reject the correlation. The null hypothesis was that no correlation existed, and by rejecting the null hypothesis the correlation value is accepted. As shown in exhibit 10, the results of the statistical significance test found that 7 correlations be not statistically significant. Conversely, the remaining 11 correlation results were not rejected, and suitable for further analysis. For the intent of this research the highest correlation value between the construction material and commodity future is used for evaluation with simulation testing. Exhibit 11 highlights the he correlations that were chosen for further evaluation. Note that the highest correlation values are not strictly based on the underlying physical relationship. For example, asphalt has a higher correlation to copper future than to crude oil future. The correlation is unexpected because asphalt is a derivative of crude oil.

COMMODITY FUTURE

CONSTRUCTION MATERIAL

	Copper /HG	**Crude /CL**	**Lumber /LBS**
Copper Wire	Reject H_0 Accept Correlation	Reject H_0 Accept Correlation	Reject H_0 Accept Correlation
Steel	Reject H_0 Accept Correlation	Reject H_0 Accept Correlation	Do Not Reject H_0 Reject Correlation
Asphalt	Reject H_0 Accept Correlation	Reject H_0 Accept Correlation	Do Not Reject H_0 Reject Correlation
Concrete	Reject H_0 Accept Correlation	Reject H_0 Accept Correlation	Do Not Reject H_0 Reject Correlation
Framing Wood	Do Not Reject H_0 Reject Correlation	Do Not Reject H_0 Reject Correlation	Reject H_0 Accept Correlation
Panel Wood	Do Not Reject H_0 Reject Correlation	Do Not Reject H_0 Reject Correlation	Reject H_0 Accept Correlation

Exhibit 10 - Significance Test Results

COMMODITY FUTURE

CONSTRUCTION MATERIAL

	Copper /HG	**Crude /CL**	**Lumber /LBS**
Copper Wire	**0.99**	0.83	0.30
Steel	**0.80**	0.75	-0.17
Asphalt	**0.87**	0.79	0.40
Concrete	**-0.84**	-0.75	0.27
Framing Wood	-0.22	0.05	**0.92**
Panel Wood	-0.19	0.02	**0.80**

Exhibit 11 - Relationships Accepted From Regression Analysis

To further validate the approach hedging simulations were performed for each of the construction materials. Each of the hedging simulations evaluated a period of increased construction material prices. The period was chosen based on the greatest price movements in the data time period. The simulations were organized in tables shown the start and finish prices for the construction materials and commodity futures. The changes in prices were totaled and compared between the hedged case and the unhedged case. The correlation direction was accounted for in the simulation calculations. In the concrete to Copper futures hedging scenario the correlation relationship was inverse. As the price of concrete increased the price of copper decreased. To account for the inverse relationship the commodity position was calculated as a short position. Exhibit 12 illustrates the ideal hedging scenario where an increase construction material cost is offset with an increased commodity future value.

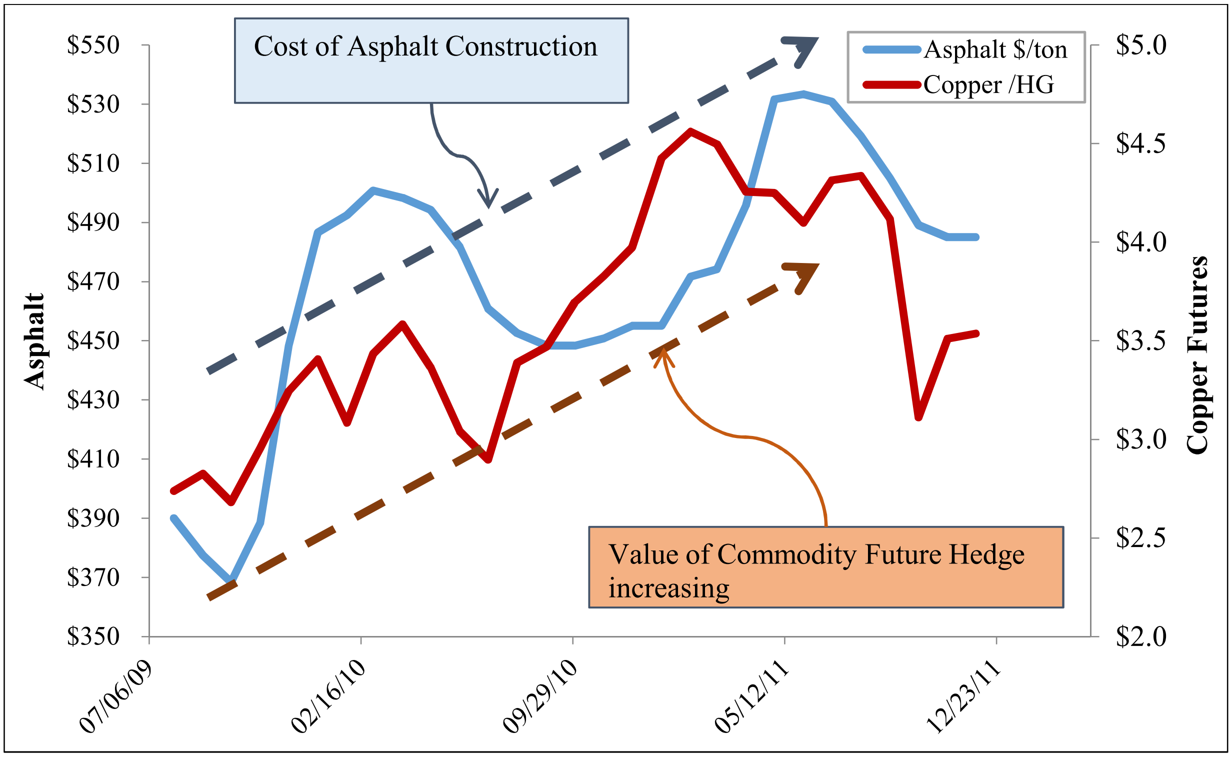

Exhibit 12 – Price Comparison Asphalt versus Copper

Copper Wire Hedged with Copper Futures Contract				
Simulation Period July 1st, 2010 to February 1st, 2011				
Construction Material				
Copper Wire	Cost per Pound		Total Underlying	
Start $/lb	$ 3.21	$	80,250	
Finish $/lb	$ 4.74	$	118,500	
Total Price Increase	$ 1.53	$	38,250	
Hedge				
1 Copper Future Contract	Cost per Pound		Total Underlying	
Start $/lb	$ 2.90	$	72,438	
Finish $/lb	$ 4.56	$	114,000	
Total Price Increase	$ 1.66	$	41,563	
			Loss or Gain Amount	% of Initial Estimate
Unhedged	Loss	$	[-38,250]	-48%
Hedged	Small gain	$	3,312	4%

Exhibit 13 - Sample Hedging Simulation Copper Wire Hedged with Copper Future

The results of the simulation are shown in Exhibit 14. The gains and losses of the hedge were calculated as both the nominal value and as a percentage of starting value. For further evaluation the total value of all 18 simulations was summarized in order to determine the overall performance of the hedge. Cases where the hedge did not work and created losses are highlighted. The largest risk mitigation was a 62% cost savings of the original material value for a price escalation in framing lumber. Where the hedging strategy did not work the largest loss occurred in two cases each losing 5% of the original material value. The simulation results demonstrated that hedging scenarios with higher correlation value had a higher rate of success and better performance. For simulations with a correlation above 0.9 the success rate was 100%, while the success rate for simulations below 0.9 was 75%. The results were summarized in quartile groupings as shown in exhibit 15. In addition the quartile results are shown in graph form in Exhibit 16.

Correlation	Material	Original Material Value ($)	Unhedged Change ($)	Hedged Change ($)	Difference Between Hedged and Unhedged ($)	Saving or Loss as % of Orginal Value
0.99	Copper Wire	$ 86,000	$ (17,250)	$ (1,625)	$ 15,625	18%
0.99	Copper Wire	$ 84,000	$ (10,375)	$ (6,200)	$ 4,175	5%
0.99	Copper Wire	$ 80,250	$ (38,250)	$ 3,312	$ 41,563	52%
0.92	Framing Wood	$ 32,900	$ (7,400)	$ (2,703)	$ 4,697	14%
0.92	Framing Wood	$ 25,700	$ (8,100)	$ (4)	$ 8,096	32%
0.92	Framing Wood	$ 19,800	$ (15,900)	$ (3,668)	$ 12,232	62%
0.87	Asphalt Binder	$ 97,000	$ (19,334)	$ (23,847)	$ (4,513)	-5%
0.87	Asphalt Binder	$ 89,666	$ (16,500)	$ (900)	$ 15,600	17%
0.87	Asphalt Binder	$ 73,666	$ (26,500)	$ (7,663)	$ 18,838	26%
0.84	Concrete	$ 120,350	$ (2,700)	$ 3,950	$ 6,650	6%
0.84	Concrete	$ 111,300	$ (5,900)	$ (513)	$ 5,388	5%
0.84	Concrete	$ 107,700	$ (6,150)	$ (7,112)	$ (962)	-1%
0.8	Steel	$ 97,500	$ (42,500)	$ (23,038)	$ 19,463	20%
0.8	Steel	$ 88,250	$ (20,500)	$ (24,550)	$ (4,050)	-5%
0.8	Steel	$ 57,750	$ (25,750)	$ (23,588)	$ 2,163	4%
0.8	Panel Wood	$ 37,300	$ (13,300)	$ (4,357)	$ 8,943	24%
0.8	Panel Wood	$ 36,700	$ (2,500)	$ 3,385	$ 5,885	16%
0.8	Panel Wood	$ 25,800	$ (18,800)	$ (6,293)	$ 12,507	48%
	Total	**$ 1,271,632**	**$ (297,709)**	**$ (125,411)**	**$ 172,298**	
	Average Savings with Hedge 14%					

Exhibit 24 - Results of Hedging Simulations

Correlation Value	Percent Savings with Hedge	Successful Hedge	Failed Hedge
.95 Up	25%	3	0
.90 to .95	32%	3	0
.85 to .90	11%	2	1
.85 down	8%	7	2

Exhibit 15 - Relationship between Correlation Value and Hedge Performance

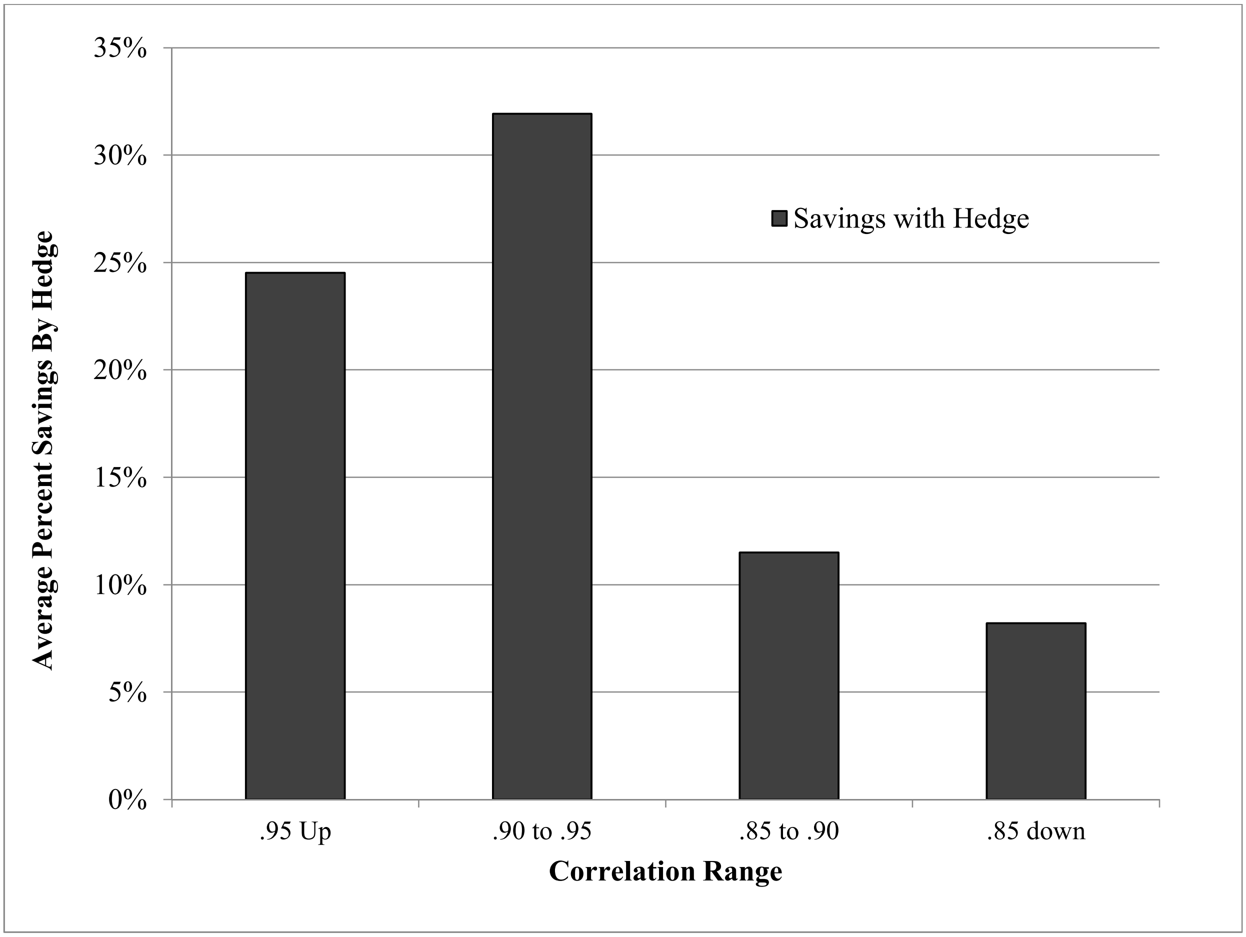

Exhibit 16 - Relationship between Correlation Value and Percent Savings

Results

The results of the correlation study showed several instances of strong relationship between the construction materials and commodity futures. The analysis found 10 of the 18 regression analysis demonstrated a correlation outside of a range of -0.75, 0.75, which is a significant value of correlation. The strongest correlation value was 0.99 between copper wire and copper futures. On the other hand, the lowest correlation was between panel wood and Crude Oil Futures at 0.02. Many of the correlations were anticipated, such as wood products being strongly correlated to the lumber futures. However, the strongest correlations between construction materials and commodity futures were not always as expected. Most surprisingly, the correlation between asphalt prices and copper futures prices was stronger than that of asphalt prices and crude oil prices. For the asphalt example, asphalt is largely made up of the crude oil derivative bitumen. Initially the assumption was that the base commodity for the construction material would have the highest correlation. However, the correlation between asphalt and copper prices proved to have the highest correlation strength. The pricing forces creating the strong correlation between asphalt and copper were not examined as part of this study, but are discussed in the recommendations for further research section. The statistical significant test of the correlation study validated 11 out of 18 regression analysis results as significant. The results of the statistical significance test allowed for further study of the 11 relationships. However, only the relationships with the highest correlation values were examined with simulations. Hedging simulations were used to compare the pricing movement between the construction materials and commodity futures. A hedging simulation that provided positive cost savings was considered a successful hedge. The results of hedging simulations showed that using a commodity future as a hedge was successful in 83% of the cases. In the remaining the hedge was unsuccessful and the strategy compounded the loss. Averaged over the entire simulation study, the losses in the unhedged scenario was 23.4% of the original value of the construction material. Overall a loss was shown despite having the hedge strategy in place. However, the losses were much lower than the unhedged scenarios, by reducing the loss to only 9.8% of the original value of the construction material. The hedging simulations resulted in three scenarios where the hedge contributed to a greater loss. The largest impact of an unsuccessful hedge was a 5% greater loss than an unhedged result. Conversely, the most successful hedging simulation showed a 62% cost saving. The results of the hedging simulations demonstrated that the correlation value had an impact on the success of the hedge. In two quartiles where the correlation was greater than 0.90 (copper and framing wood) the hedge provide a 30% cost savings. In the case where the correlation was below 0.90 the cost savings was only 13%.

Hedging Guidelines & Considerations

The results of the study support the use of commodity futures as risk mitigation for construction material pricing escalation. To replicate the risk mitigations demonstrated in this study construction contractors must follow several guidelines to successfully implement a hedge using commodity futures.

1. Understand the Risk of Hedging with Commodity Futures – The results of the simulations demonstrated a significant improvement in cost performance using commodity futures as hedges against price increases of construction materials. Commodity future hedging was shown to be a valid risk mitigation strategy in both the frequency of success and scale of savings. However, in most cases a loss was still observed even with a commodity future hedge in place. In a small number of cases the hedge was unsuccessful, and contributed to greater loses. For these reasons construction contractors must understand and acknowledge the risks involved with utilizing commodity futures as hedges.
2. Determine Appropriate Commodity Future for Hedge – A successful hedge must utilize a highly correlated commodity future the results of the simulations studies show that a higher correlation resulted in a more successful hedge. Regardless of the physical relationship between the

construction material and the commodity future, the most highly correlated commodity future should be used as the hedge. Before entering a hedge a correlation study through regression analysis should be conducted between the construction material and commodity future.

3. Determine the Correct Direction of the Hedge - The correlation relationship should be noted if it is positive or negative, and factored into the implementation of the hedge. A construction contractor buying material for a project is taking a short position in the material. The short position is demonstrated by the fact that the contractor will lose money as price of the material increases, and will make money as the price of the material decreases. An effective hedge should neutralize the losses of gains from the price movement of the construction material. For example, a long commodity future position would be used to hedge a positively correlated relationship. Conversely, if the construction material and commodity future is negatively correlated a short position should be taken in the commodity future.
4. Determine the Size of the Hedge - The size of the hedge should be determined by the value of the construction material that has been budgeted by the construction contractor. The number of commodity futures contracts should be calculated by matching the value of the construction material to the underlying value of the commodity future. When implementing a commodity futures hedge two scenarios should be avoided. The position should not be grossly under-hedged, which could results in the hedge not fully protecting against construction material price increases. On the other hand, the position should not be grossly over-hedged, which would result in losses if prices drop.
5. Market Awareness – A construction contractor using commodity futures as a hedge must be aware of extremes in commodity pricing. Extremes in commodity pricing are referred to as disequilibrium, and historically result in pricing corrections. In cases of extreme price lows, historically commodity producers respond by curtailing supplies eventually resulting in price increases. Conversely, extreme price highs historically lead to increases in commodity production and subsequent price corrections. These market realities should be considered when implementing a commodity futures hedging strategy. Historic price highs could provide the construction contractor evidence to not implement a commodity futures hedge, and utilize a different risk mitigation. Conversely, extreme price lows should be viewed with caution as the risk lies to the price upside, which justifies the utilization of a commodity futures hedge.
6. Open the Hedge Position – The hedging strategy should be implemented to correspond to the start and finish of the construction material procurement cycle. The commodity future position should be opened at the same time as the construction material is budgeted for. Delays in opening the commodity future could result in prices increases of the construction material that would not be hedged. Price increase with unhedged construction materials would result in a loss. When

opening a commodity future position as a hedge, attention must be given to the contract date of the contract. The commodity futures contract should have an expiration as close to the expected purchase date of the construction material as possible. In addition, the liquidity of the commodity futures contract must be considered, and should take precedence. It is important to remember that commodity futures contracts with poor liquidity result in poor pricing and immediate losses if the contract must be exited.

7. Monitor the Hedge Position – The commodity futures hedge position should be monitored and restructured if required. Attention must be given to the date of expiration of the contract. As discussed above, in some cases the contract expiration dates may not align with the construction material purchase dates. If the contract expiration date is before the construction material purchase date the contract will have to be closed and a new contract opened with an expiration further in the future. The process of closing and reopening contract should be maintained through the life of the hedge.
8. Close Hedge Position – The commodity futures hedge should be closed to correspond to the purchase date of the construction material. Similar to coordinating the opening of the commodity futures hedge, losses could be incurred with unhedged positions if either the commodity future position or construction material position is closed early.

Conclusions

The results of this study support the use of commodity futures as a hedge for construction material pricing increases. The success of using commodity futures as hedge was demonstrated in both the frequency and scale of successfully mitigating risk. In the instances where the hedge was unsuccessful, the magnitude of the hedging losses was acceptable when compared against the frequency and scale of success. Implementing a successful hedge is dependent upon the correlation between the construction material and commodity future. More highly correlated relationships provided better hedging results. In addition the findings of the study provide information that supports the importance of following general trading guidelines of using liquid contracts and maintaining an awareness on the market. These guidelines should be considered by construction contractor choosing to use commodity futures as hedging tools. The business of construction contractors is typically associated with profit margins which are sensitive to unexpected cost escalation. The results of this study demonstrate an approach that should be considered as a mitigation for construction contractors seeking address construction material price risk.

Recommendations for Further Research

The efforts and conclusions of this study exposed several items for further investigation. The research made several assumptions in order to remain within the constraints of the study, and the results of study could be strengthened with additional analysis. In this study the construction materials examined were limited to a small set of materials commonly utilized in the construction industry. Future study should examine additional material further down supply change, such as steel pipe, rebar, precast concrete, finished cable, prefabricated structural wood members. This study utilized a monthly pricing frequency. Future investigation should examine pricing on a greater frequency. Construction materials and commodity futures historically have shown the capacity to swing drastically in periods less than a month. Although a more frequent pricing period would strengthen the study, the results of this study have been proven statistically significant. The pricing data for the commodity futures only considered the pricing of the current month contract. Futures research should evaluated the pricing of the active contract at the time of the hedge, and consider the roll. The study revealed several instances of correlations that were not expected. As discussed above, the correlation between asphalt and copper futures was greater than the correlation between asphalt and crude oil futures. Most would assume that by the physical relationship between asphalt and crude oil would create a stronger relationship than other commodities. The pricing forces creating the strong correlation between asphalt and copper were not examined as part of this study. However, it is suspected that because copper and asphalt are primarily used as building materials they may be subject to the same swings in construction activity. Conversely, crude oil is subject to different market forces such as the refining industry, consumption by drivers, and financial market speculation. An investigation of the dynamics driving the unexpected price correlation between certain construction materials and commodity futures could further validate using commodity futures as a hedge for construction materials.

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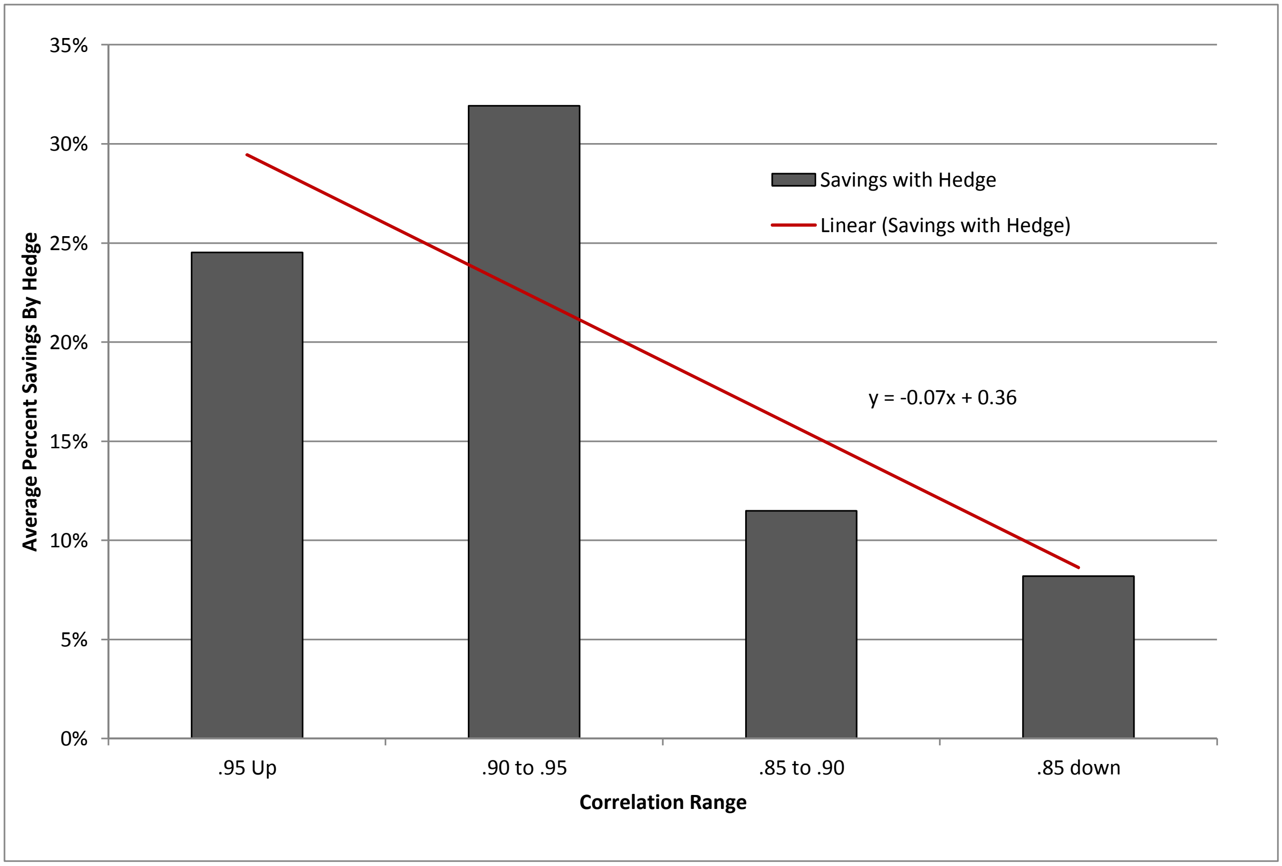
Appendix 1 - Simulation Results Summary

Correlation	Material	Original Material Value ($)	Unhedged Change ($)	Hedged Change ($)	Difference Between Hedged and Unhedged ($)	Saving or Loss as % of Orginal Value
0.99	Copper Wire	$ 86,000	$ (17,250)	$ (1,625)	$ 15,625	18%
0.99	Copper Wire	$ 84,000	$ (10,375)	$ (6,200)	$ 4,175	5%
0.99	Copper Wire	$ 80,250	$ (38,250)	$ 3,312	$ 41,563	52%
0.92	Framing Wood	$ 32,900	$ (7,400)	$ (2,703)	$ 4,697	14%
0.92	Framing Wood	$ 25,700	$ (8,100)	$ (4)	$ 8,096	32%
0.92	Framing Wood	$ 19,800	$ (15,900)	$ (3,668)	$ 12,232	62%
0.87	Asphalt Binder	$ 97,000	$ (19,334)	$ (23,847)	$ (4,513)	-5%
0.87	Asphalt Binder	$ 89,666	$ (16,500)	$ (900)	$ 15,600	17%
0.87	Asphalt Binder	$ 73,666	$ (26,500)	$ (7,663)	$ 18,838	26%
0.84	Concrete	$ 120,350	$ (2,700)	$ 3,950	$ 6,650	6%
0.84	Concrete	$ 111,300	$ (5,900)	$ (513)	$ 5,388	5%
0.84	Concrete	$ 107,700	$ (6,150)	$ (7,112)	$ (962)	-1%
0.8	Steel	$ 97,500	$ (42,500)	$ (23,038)	$ 19,463	20%
0.8	Steel	$ 88,250	$ (20,500)	$ (24,550)	$ (4,050)	-5%
0.8	Steel	$ 57,750	$ (25,750)	$ (23,588)	$ 2,163	4%
0.8	Panel Wood	$ 37,300	$ (13,300)	$ (4,357)	$ 8,943	24%
0.8	Panel Wood	$ 36,700	$ (2,500)	$ 3,385	$ 5,885	16%
0.8	Panel Wood	$ 25,800	$ (18,800)	$ (6,293)	$ 12,507	48%
	Total	**$ 1,271,632**	**$ (297,709)**	**$ (125,411)**	**$ 172,298**	
	Average Savings with Hedge 14%					

Correlation Value	Savings with Hedge	Successful Hedge	Failed Hedge
.95 Up	25%	3	0
.90 to .95	32%	3	0
.85 to .90	11%	2	1
.85 down	8%	7	2

Appendix 1 - Simulation Results Summary



Appendix 2 - Simulation Calculations

Copper Wire Hedged With Copper Future					
Simulation Period July 1st, 2010 to February 1st, 2011					
Construction Material					
Copper Wire		Cost		Total Underlying	
Start $	$	3.21	$	80,250	
Finish $	$	4.74	$	118,500	
Total Price Change	$	1.53	$	38,250	
Hedge					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	2.90	$	72,438	
Finish $	$	4.56	$	114,000	
Total Price Change	$	1.66	$	41,563	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(38,250)	-48%
		Hedged	$	3,312	4%

Copper Wire Hedged With Copper Future					
Simulation Period October 1st, 2011 to May, 1st 2012					
Construction Material					
Copper Wire		Cost		Total Underlying	
Start $	$	3.44	$	86,000	
Finish $	$	4.13	$	103,250	
Total Price Change	$	0.69	$	17,250	
Hedge					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	3.11	$	77,788	
Finish $	$	3.74	$	93,413	
Total Price Change	$	0.63	$	15,625	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(17,250)	-20%
		Hedged	$	(1,625)	-2%

Copper Wire Hedged With Copper Future					
Simulation Period July 1st, 2013 to January 1st, 2014					
Construction Material					
Copper Wire		Cost		Total Underlying	
Start $	$	3.36	$	84,000	
Finish $	$	3.78	$	94,375	
Total Price Change	$	0.42	$	10,375	
Hedge					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	3.17	$	79,300	
Finish $	$	3.34	$	83,475	
Total Price Change	$	0.17	$	4,175	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(10,375)	-12%
		Hedged	$	(6,200)	-7%

Appendix 2 - Simulation Calculations

Steel Hedged with Copper Future					
Simulation Period September 1st, 2010 to May 1st, 2011					
Construction Material					
Steel		Cost		Total Underlying	
Start $	$	39.00	$	97,500	
Finish $	$	56.00	$	140,000	
Total Price Change	$	17.00	$	42,500	
Hedge					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	3.47	$	86,750	
Finish $	$	4.25	$	106,213	
Total Price Change	$	0.78	$	19,463	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(42,500)	-44%
		Hedged	$	(23,038)	-24%

Steel Hedged with Copper Future					
Simulation Period January 1st, 2016 to July 1st, 2016					
Construction Material					
Steel		Cost		Total Underlying	
Start $	$	35.30	$	88,250	
Finish $	$	43.50	$	108,750	
Total Price Change	$	(8.20)	$	(20,500)	
Hedge					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	3.17	$	79,163	
Finish $	$	3.00	$	75,113	
Total Price Change	$	(0.16)	$	(4,050)	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(20,500)	-23%
		Hedged	$	(24,550)	-28%

Steel Hedged with Copper Future					
Simulation Period August 1st 2013 to October 1st, 2014					
Construction Material					
Steel		Cost		Total Underlying	
Start $	$	23.10	$	57,750	
Finish $	$	33.40	$	83,500	
Total Price Change	$	(10.30)	$	(25,750)	
Hedge					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	2.14	$	53,375	
Finish $	$	2.22	$	55,538	
Total Price Change	$	0.09	$	2,163	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(25,750)	-45%
		Hedged	$	(23,588)	-41%

Asphalt Binder Hedged with Copper Future					
Simulation Period October 1st, 2010 to July 1st, 2011					
Construction Material					
Asphalt Binder		Cost		Total Underlying	
Start $	$	448.33	$	89,666	
Finish $	$	530.83	$	106,166	
Total Price Change	$	82.50	$	16,500	
Hedge					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	3.69	$	92,250	
Finish $	$	4.31	$	107,850	
Total Price Change	$	0.62	$	15,600	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(16,500)	-18%
		Hedged	$	(900)	-1%

Asphalt Binder Hedged with Copper Future					
Simulation Period November 1st, 2011 to July 1st, 2012					
Construction Material					
Asphalt Binder		Cost		Total Underlying	
Start $	$	485.00	$	97,000	
Finish $	$	581.67	$	116,334	
Total Price Change	$	(96.67)	$	(19,334)	
Hedge					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	3.51	$	87,775	
Finish $	$	3.33	$	83,263	
Total Price Change	$	(0.18)	$	(4,513)	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(19,334)	-20%
		Hedged	$	(23,847)	-25%

Asphalt Binder Hedged with Copper Future					
Simulation Period October 1st, 2009 to March 1st, 2010					
Construction Material					
Asphalt Binder		Cost		Total Underlying	
Start $	$	368.33	$	73,666	
Finish $	$	500.83	$	100,166	
Total Price Change	$	(132.50)	$	(26,500)	
Hedge					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	2.68	$	67,038	
Finish $	$	3.44	$	85,875	
Total Price Change	$	0.75	$	18,838	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(26,500)	-36%
		Hedged	$	(7,663)	-10%

Appendix 2 - Simulation Calculations

Concrete Hedged with Copper Future					
Simulation Period October 1st, 2014 to May 1st, 2015					
Construction Material					
Concrete		Cost		Total Underlying	
Start $	$	215.40	$	107,700	
Finish $	$	227.70	$	113,850	
Total Price Change	$	(12.30)	$	(6,150)	
Hedge - Short					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	3.74	$	93,413	
Finish $	$	3.78	$	94,375	
Total Price Change	$	0.04	$	(962)	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(6,150)	-6%
		Hedged	$	(7,112)	-7%

Concrete Hedged with Copper Future					
Simulation Period April 1st, 2013 to March 1st, 2010					
Construction Material					
Concrete		Cost		Total Underlying	
Start $	$	222.60	$	111,300	
Finish $	$	234.40	$	117,200	
Total Price Change	$	(11.80)	$	(5,900)	
Hedge - Short					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	3.37	$	84,325	
Finish $	$	3.16	$	78,938	
Total Price Change	$	(0.22)	$	5,388	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(5,900)	-5%
		Hedged	$	(513)	0%

Concrete Hedged with Copper Future					
Simulation Period February 1st, 2015 to November 1st, 2015					
Construction Material					
Concrete		Cost		Total Underlying	
Start $	$	240.70	$	120,350	
Finish $	$	246.10	$	123,050	
Total Price Change	$	(5.40)	$	(2,700)	
Hedge - Short					
1 Copper Future Contract		Cost		Total Underlying	
Start $	$	2.58	$	64,438	
Finish $	$	2.31	$	57,788	
Total Price Change	$	(0.27)	$	6,650	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(2,700)	-2%
		Hedged	$	3,950	3%

Framing Wood				
Simulation Period May 1st, 2009 to April 1st, 2010				
Construction Material				
Framing Wood		Cost		Total Underlying
Start $	$	198.00	$	19,800
Finish $	$	357.00	$	35,700
Total Price Change	$	(159.00)	$	(15,900)
Hedge				
1 Lumber Future Contract		Cost		Total Underlying
Start $	$	175.00	$	19,250
Finish $	$	286.20	$	31,482
Total Price Change	$	111.20	$	12,232
			Loss or Gain Amount	% of Initial Value
		Unhedged	$ (15,900)	-80%
		Hedged	$ (3,668)	-19%

Framing Wood				
Simulation Period November 1st, 2011 to August 1st, 2012				
Construction Material				
Framing Wood		Cost		Total Underlying
Start $	$	257.00	$	25,700
Finish $	$	338.00	$	33,800
Total Price Change	$	(81.00)	$	(8,100)
Hedge				
1 Lumber Future Contract		Cost		Total Underlying
Start $	$	213.00	$	23,430
Finish $	$	286.60	$	31,526
Total Price Change	$	73.60	$	8,096
			Loss or Gain Amount	% of Initial Value
		Unhedged	$ (8,100)	-32%
		Hedged	$ (4)	0%

Framing Wood				
Simulation Period June 1st, 2013 to Sept 1st, 2014				
Construction Material				
Framing Wood		Cost		Total Underlying
Start $	$	329.00	$	32,900
Finish $	$	403.00	$	40,300
Total Price Change	$	(74.00)	$	(7,400)
Hedge				
1 Lumber Future Contract		Cost		Total Underlying
Start $	$	306.90	$	33,759
Finish $	$	349.60	$	38,456
Total Price Change	$	42.70	$	4,697
			Loss or Gain Amount	% of Initial Value
		Unhedged	$ (7,400)	-22%
		Hedged	$ (2,703)	-8%

Panel Wood						
Simulation Period October 1st, 2009 to April 1st, 2010						
Construction Material						
Panel Wood		Cost		Total Underlying		
Start $	$	258.00	$	25,800		
Finish $	$	446.00	$	44,600		
Total Price Change	$	(188.00)	$	(18,800)		
Hedge						
1 Lumber Future Contract		Cost		Total Underlying		
Start $	$	172.50	$	18,975		
Finish $	$	286.20	$	31,482		
Total Price Change	$	113.70	$	12,507		
				Loss or Gain Amount	% of Initial Value	
		Unhedged	$	(18,800)	-73%	
		Hedged	$	(6,293)	-24%	

Panel Wood					
Simulation Period June 1st, 2012 to February 1st, 2013					
Construction Material					
Panel Wood		Cost		Total Underlying	
Start $	$	373.00	$	37,300	
Finish $	$	506.00	$	50,600	
Total Price Change	$	(133.00)	$	(13,300)	
Hedge					
1 Lumber Future Contract		Cost		Total Underlying	
Start $	$	281.40	$	30,954	
Finish $	$	362.70	$	39,897	
Total Price Change	$	81.30	$	8,943	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(13,300)	-36%
		Hedged	$	(4,357)	-12%

Panel Wood					
Simulation Period November 1st, 2015 to July 1st, 2016					
Construction Material					
Panel Wood		Cost		Total Underlying	
Start $	$	367.00	$	36,700	
Finish $	$	392.00	$	39,200	
Total Price Change	$	(25.00)	$	(2,500)	
Hedge					
1 Lumber Future Contract		Cost		Total Underlying	
Start $	$	254.50	$	27,995	
Finish $	$	308.00	$	33,880	
Total Price Change	$	53.50	$	5,885	
				Loss or Gain Amount	% of Initial Value
		Unhedged	$	(2,500)	-7%
		Hedged	$	3,385	9%

Appendix 3 - Regression Analysis and Significance Test Results

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

Regression Analysis Results

	Copper /HG	Crude /CL	Lumber /LBS
Copper Wire	0.99	0.83	0.30
Steel	0.80	0.75	-0.17
Asphalt	0.87	0.79	0.40
Concrete	-0.84	-0.75	0.27
Framing Wood	-0.22	0.05	0.92
Panel Wood	-0.19	0.02	0.80

t Calculation

	Copper /HG	Crude /CL	Lumber /LBS
Copper Wire	93.9	13.7	3.1
Steel	12.0	10.3	-1.6
Asphalt	10.5	7.6	2.6
Concrete	-14.5	-10.5	2.597
Framing Wood	-2.2	0.5	23.2
Panel Wood	-1.9	0.2	13.0

Right or Left Side Test

	Copper /HG	Crude /CL	Lumber /LBS
Copper Wire	Right Side Test	Right Side Test	Right Side Test
Steel	Right Side Test	Right Side Test	left Side Test
Asphalt	Right Side Test	Right Side Test	Right Side Test
Concrete	Left Side Test	Left Side Test	Right Side Test
Framing Wood	Left Side Test	Right Side Test	Right Side Test
Panel Wood	Left Side Test	Right Side Test	Right Side Test

Degrees of Freedom α= 0.005

		97 /HG	89 /CL	96 /LBS
97	Copper Wire	95	87	94
84	Steel	82	82	82
36	Asphalt	34	34	34
89	Concrete	87	87	87
96	Framing Wood	94	87	94
96	Panel Wood	94	87	94

Student t-Distribution Value

	Copper /HG	Crude /CL	Lumber /LBS
Copper Wire	2.629	2.634	2.629
Steel	2.637	2.637	-2.637
Asphalt	2.728	2.728	2.728
Concrete	-2.634	-2.634	2.634
Framing Wood	-2.629	2.634	2.629
Panel Wood	-2.629	2.634	2.629

Significance Test Result

	Copper /HG	Crude /CL	Lumber /LBS
Copper Wire	Reject H_0	Reject H_0	Reject H_0
Steel	Reject H_0	Reject H_0	Do Not Reject H_0
Asphalt	Reject H_0	Reject H_0	Do Not Reject H_0
Concrete	Reject H_0	Reject H_0	Do Not Reject H_0
Framing Wood	Do Not Reject H_0	Do Not Reject H_0	Reject H_0
Panel Wood	Do Not Reject H_0	Do Not Reject H_0	Reject H_0

Appendix 4 - Data

Year	Copper Wire $/lb	/HG $/lb	Ohio Binder $/ton	NC asphalt $/ton	Concrete	Steel $/CWT	$/barrel /CL	Framing Composite	Panel Composite	/LBS
12/1/2008	1.88	1.60	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
1/1/2009	1.66	1.41	No Data	No Data	No Data	No Data	No Data	198.00	251.00	187.00
2/1/2009	1.73	1.43	No Data	No Data	No Data	No Data	No Data	199.00	257.00	162.00
3/1/2009	1.79	1.69	No Data	No Data	No Data	No Data	No Data	195.00	247.00	168.00
4/1/2009	2.10	1.85	No Data	No Data	No Data	No Data	No Data	208.00	242.00	176.20
5/1/2009	2.32	2.10	No Data	No Data	No Data	No Data	No Data	198.00	242.00	175.50
6/1/2009	2.47	2.30	No Data	No Data	No Data	No Data	No Data	222.00	248.00	196.30
7/1/2009	2.53	2.31	No Data	No Data	No Data	No Data	No Data	238.00	263.00	208.40
8/1/2009	2.89	2.74	390.00	No Data	216.50	No Data	69.45	239.00	281.00	198.00
9/1/2009	3.08	2.83	377.50	No Data	216.20	No Data	68.05	236.00	278.00	179.10
10/1/2009	3.07	2.68	368.33	No Data	214.50	No Data	70.82	235.00	258.00	172.50
11/1/2009	3.22	2.96	388.33	No Data	214.10	No Data	78.12	245.00	270.00	213.70
12/1/2009	3.42	3.25	448.33	No Data	214.80	No Data	79.04	251.00	275.00	239.00
1/1/2010	3.60	3.41	486.67	No Data	214.60	33.50	79.28	268.00	282.00	234.00
2/1/2010	3.32	3.08	492.50	No Data	214.20	36.50	74.43	312.00	308.00	263.20
3/1/2010	3.54	3.44	500.83	No Data	214.40	36.50	78.70	314.00	347.00	265.50
4/1/2010	3.82	3.58	498.33	No Data	212.70	41.00	84.87	357.00	446.00	286.20
5/1/2010	3.61	3.37	494.17	No Data	212.20	44.00	86.22	333.00	429.00	307.80
6/1/2010	3.37	3.04	481.67	No Data	212.30	44.00	71.90	263.00	333.00	223.50
7/1/2010	3.21	2.90	460.83	No Data	212.40	44.00	72.64	252.00	323.00	222.40
8/1/2010	3.58	3.39	452.50	No Data	211.40	41.00	81.46	245.00	294.00	208.00
9/1/2010	3.63	3.47	448.33	No Data	211.10	39.00	73.95	250.00	285.00	208.70
10/1/2010	3.92	3.70	448.33	No Data	211.20	39.00	81.73	255.00	277.00	222.30
11/1/2010	4.01	3.83	450.83	No Data	212.10	38.50	82.94	275.00	277.00	281.60
12/1/2010	4.10	3.97	455.00	No Data	212.20	38.50	86.81	282.00	284.00	251.50
1/1/2011	4.64	4.43	455.00	No Data	212.30	40.00	91.04	304.00	304.00	321.00
2/1/2011	4.74	4.56	471.67	No Data	211.40	43.75	90.50	296.00	295.00	319.00
3/1/2011	4.77	4.50	474.16	No Data	211.40	49.20	100.58	292.00	298.00	286.50
4/1/2011	4.59	4.26	495.83	No Data	210.30	52.90	108.31	272.00	291.00	298.50
5/1/2011	4.46	4.25	531.67	No Data	210.60	56.00	112.98	259.00	278.00	241.00
6/1/2011	4.46	4.10	533.33	No Data	210.90	56.00	99.72	262.00	278.00	237.50
7/1/2011	4.56	4.31	530.83	No Data	211.00	54.00	94.75	270.00	278.00	246.00
8/1/2011	4.76	4.34	519.16	No Data	210.60	51.90	94.96	265.00	288.00	238.50
9/1/2011	4.48	4.12	505.00	No Data	211.00	51.90	88.75	262.00	296.00	245.00
10/1/2011	3.44	3.11	489.16	No Data	211.00	50.11	78.75	260.00	297.00	213.00
11/1/2011	3.92	3.51	485.00	No Data	212.60	50.12	91.58	257.00	292.00	221.10
12/1/2011	3.85	3.54	485.00	No Data	213.20	47.30	99.99	267.00	303.00	224.60
1/1/2012	3.72	3.43	523.33	No Data	214.60	46.05	99.06	280.00	326.00	247.80
2/1/2012	4.09	3.91	548.33	No Data	215.20	46.74	97.17	285.00	321.00	252.70
3/1/2012	4.17	3.91	570.00	No Data	216.00	46.63	108.60	298.00	347.00	273.80
4/1/2012	4.12	3.89	570.00	No Data	215.60	46.50	102.93	303.00	344.00	262.10
5/1/2012	4.13	3.74	580.83	No Data	215.40	46.50	105.97	339.00	359.00	288.00
6/1/2012	3.66	3.33	581.67	No Data	215.40	45.52	86.50	330.00	373.00	281.40
7/1/2012	3.79	3.47	576.67	No Data	215.90	45.00	84.87	321.00	367.00	273.50
8/1/2012	3.72	3.36	566.67	No Data	216.00	42.54	88.88	338.00	436.00	284.60
9/1/2012	3.75	3.46	555.00	No Data	216.20	39.00	96.56	332.00	442.00	289.00
10/1/2012	4.07	3.72	552.50	No Data	216.40	38.63	92.38	321.00	403.00	284.50
11/1/2012	3.82	3.55	552.50	No Data	217.70	36.80	86.82	351.00	434.00	330.20
12/1/2012	3.93	3.65	552.50	No Data	218.70	34.50	88.94	370.00	449.00	336.20
1/1/2013	3.94	3.72	552.50	No Data	219.90	36.39	91.79	393.00	483.00	374.00
2/1/2013	4.03	3.78	533.33	No Data	220.30	36.95	97.61	409.00	506.00	362.70
3/1/2013	3.84	3.52	533.33	No Data	220.40	35.73	91.02	436.00	513.00	396.00
4/1/2013	3.71	3.37	532.50	No Data	222.60	33.81	96.97	437.00	509.00	388.00
5/1/2013	3.50	3.11	532.50	No Data	222.00	36.86	90.92	372.00	456.00	338.00
6/1/2013	3.61	3.34	534.17	No Data	222.40	36.59	91.62	329.00	391.00	306.90
7/1/2013	3.36	3.17	534.17	No Data	223.60	35.58	98.02	340.00	383.00	295.00
8/1/2013	3.43	3.17	535.83	No Data	223.30	35.30	107.81	353.00	386.00	311.00
9/1/2013	3.54	3.31	535.83	No Data	223.70	36.00	107.76	368.00	375.00	320.00

Appendix 4 - Data

10/1/2013	3.64	3.28	535.00	No Data	224.00	35.60	101.63	384.00	380.00	338.20
11/1/2013	3.60	3.36	529.17	No Data	224.80	35.26	94.60	398.00	370.00	363.70
12/1/2013	3.54	3.17	529.17	No Data	225.10	36.53	93.95	385.00	365.00	366.90
1/1/2014	3.78	3.40	529.17	76.20	227.70	37.47	98.70	398.00	364.00	359.00
2/1/2014	3.56	3.19	529.17	76.08	229.80	38.59	97.41	391.00	361.00	256.30
3/1/2014	3.57	3.21	529.17	76.01	230.30	39.50	102.76	384.00	365.00	351.10
4/1/2014	3.38	3.04	529.17	75.89	231.40	39.50	99.69	365.00	358.00	343.20
5/1/2014	3.36	3.05	534.17	76.95	230.90	39.50	99.21	378.00	385.00	337.90
6/1/2014	3.47	3.17	538.33	77.47	232.70	41.26	102.45	374.00	372.00	309.20
7/1/2014	3.52	3.26	556.67	78.34	234.00	42.07	105.20	381.00	394.00	333.00
8/1/2014	3.56	3.22	570.00	79.50	234.30	43.00	97.62	401.00	409.00	325.20
9/1/2014	3.47	3.16	574.17	80.68	234.40	43.10	93.25	398.00	403.00	349.60
10/1/2014	3.34	3.00	578.33	80.30	235.30	43.52	90.70	381.00	411.00	342.90
11/1/2014	3.40	3.02	575.83	79.28	236.70	41.48	80.70	367.00	401.00	325.70
12/1/2014	3.19	2.87	559.17	78.63	237.40	40.22	69.31	375.00	391.00	327.90
1/1/2015	3.21	2.81	550.83	76.98	239.50	38.69	53.71	375.00	386.00	331.30
2/1/2015	2.87	2.58	502.50	75.60	240.70	36.41	49.83	358.00	380.00	322.50
3/1/2015	3.06	2.66	475.83	74.50	241.40	34.35	49.79	336.00	375.00	298.40
4/1/2015	3.09	2.73	455.00	72.57	244.60	32.50	49.55	331.00	364.00	274.10
5/1/2015	3.23	2.91	443.33	70.75	243.90	30.35	59.26	313.00	360.00	254.40
6/1/2015	3.10	2.73	442.50	69.90	244.00	28.94	60.24	336.00	369.00	267.20
7/1/2015	2.97	2.63	442.50	70.10	243.80	29.03	56.87	343.00	352.00	288.90
8/1/2015	2.71	2.35	442.50	70.53	244.40	28.39	46.77	321.00	350.00	252.30
9/1/2015	2.68	2.29	442.50	69.55	244.50	28.18	44.19	297.00	358.00	234.30
10/1/2015	2.69	2.31	435.83	67.78	245.00	26.98	45.02	315.00	359.00	224.30
11/1/2015	2.66	2.31	402.50	66.86	246.10	24.97	46.08	322.00	367.00	254.50
12/1/2015	2.39	2.05	383.33	66.00	246.30	24.04	41.65	316.00	357.00	244.30
1/1/2016	2.48	2.14	376.67	66.19	248.30	23.12	37.07	312.00	354.00	258.80
2/1/2016	2.41	2.05	360.00	63.92	249.00	23.66	31.32	313.00	345.00	244.10
3/1/2016	2.47	2.21	326.67	62.87	249.70	23.51	33.89	331.00	352.00	253.40
4/1/2016	2.53	2.14	320.83	62.01	252.30	24.45	36.63	347.00	358.00	300.70
5/1/2016	2.62	2.27	320.83	61.11	253.10	27.60	45.99	357.00	375.00	294.20
6/1/2016	2.44	2.07	308.33	61.74	253.10	32.09	48.91	350.00	374.00	297.40
7/1/2016	2.54	2.22	305.83	62.80	253.40	33.39	49.28	355.00	392.00	308.00
8/1/2016	2.57	2.19	303.33	62.57	254.10	31.49	40.08	367.00	393.00	318.10
9/1/2016	2.41	2.08	301.67	62.04	253.90	29.27	45.53	353.00	386.00	308.00
10/1/2016	2.55	2.19	297.50	61.27	253.10	26.40	48.05	356.00	375.00	336.90
11/1/2016	2.55	2.22	297.50	60.74	255.80	23.81	46.33	346.00	364.00	305.70
12/1/2016	2.97	2.63	297.50	60.74	255.50	24.73	50.91	359.00	367.00	332.00
Count	97	97	89	36	89	84	89	96	96	96

Concrete https://www.bls.gov/regions/mid-atlantic/data/producerpriceindexconcrete_us_table.htm
Copper http://www.awcwire.com/copper-prices.aspx
Asphalt http://www.stwcorp.com/construction-materials/hot-warm-mix-asphalt/asphalt-pricing-index/
Lumber http://www.randomlengths.com/In-Depth/Monthly-Composite-Prices/#revised lumber
Asphalt Binder https://connect.ncdot.gov/projects/construction/Pages/Pavement-Construction-Prices.aspx
Steel http://www.dot.state.oh.us/Divisions/ConstructionMgt/Admin/Pages/PriceIndexes.aspx

Abstract

Many would argue that risk management is the single most important element of a construction contractor's business enterprise. A significant risk to the contractor's profitability is increased costs of construction materials. Construction materials are generally the largest single component of a construction project budget. Contractors generally utilize contingency funds or in some cases contractual price adjustments clauses to address the risk associated with changes in construction material pricing. However, the use of contingency and contractual mechanisms comes at a cost. The additional costs are especially detrimental in contraction markets that are competitively bid, because higher bid prices result in winning few jobs. A risk mitigation alternative is the use of commodity futures to hedge the risk of increasing construction material. A hedge is strategy for limiting losses by holding offsetting assets. The research of this study evaluates the application of commodity futures for hedging material pricing risk in the construction industry. Through statistical analysis and simulations with historic data this study concludes that utilizing commodity futures as hedging strategy is an effective risk mitigation against increased material costs. In addition, through a literature review this study explains the fundamentals of the commodity future market, and discusses the major risk involved with trading commodity futures.

Key Words: Construction Contractor, Commodity Future, Construction Material, Price Risk, Volatility, Hedging

Introduction

This study provides an empirically validated approach to a specific risk to construction contractors engaged in building material intensive projects. Any large construction project building something new will require a great deal of construction material. Some examples include, new power plants, road projects, marine infrastructure, and buildings. This study does not set out to justify the need to hedge construction material price risk or introduce commodity futures as a new risk mitigation method. Both concepts have been covered in numerous studies. Nonetheless, the strategy of using commodity futures is evident in financial statements issued by publically traded construction companies [Flour 2016]. In a study conducted by Al-Zarrad the justifications addressing construction material pricing risk was thoroughly examined and supported [Al-Zarrad 2015]. In the Al-Zarrad study commodity futures were evaluated as hedging strategies, but the examples provided in the study do not addresses construction material risk. Additionally, the Al-Zarrad study does not address fundamental trading guidelines and no empirical evidence is provided to validate the use of commodity futures as a construction material hedge. This research contained herein builds upon the existing published research by providing empirical validation in support of hedging construction material pricing risk using commodity futures. In addition, this research aims to apply fundamental trading concepts and strategies to the proposed hedging approach, and outline those approaches as a guideline.

Literature Review

This Literature Review evaluates the history and success of using commodity futures as a hedge for typical materials used in construction projects through empirical analysis, and provides basic guidance on trading commodity futures. Construction business is inherently risky, and 16% more likely to fail than other types of business [McIntyre 2007]. Unanticipated cost increases to construction project budgets are the predominant risk to a construction contractor's profitability and are inherent to the construction business [Thomas 1995]. A wide range of anticipated risks can be categorized as contributing factors to unanticipated cost increases. Some of these risk factors include incorrect bid pricing, force majeure events, procurement problems, differing site conditions, delays, production inefficiencies, and project politics [Thomas 1995]. This research focuses on procurement risk, specifically the risk of commodity pricing impacts to the cost of construction materials. The importance of addressing construction material cost risk is evident because construction projects are material dependent, and the budgets of construction projects reflect the significance of material costs. According to a study performed by the Exxon Research and Engineering Company, the cost of materials for an energy project ranged from 28% to 50% of the total construction cost of the project [Hendrickson 2008]. Pricing for construction materials varies with time, and is impacted by numerous factors. In many cases, construction companies address construction cost risk by including contingency funds in the project budget [Gunhan 2007]. Contingency funds add to total cost of the construction budget, and have a negative impact on companies competitively bidding on projects. Material pricing risks must be accounted for in construction contractors bid prices in order to remain profitable. The business reality for many organizations is that contingency budgets result in segregating funds which then become unavailable to conduct other business operations [Gunhan 2007].

Another example of a risk mitigation for material pricing increases is a purchase agreement with fixed prices for materials regardless of future prices changes. Price adjustment clauses as part of a construction contract also mitigate risk. Price adjustment clauses are intended to reduce costs by alleviating the risk to the construction contractor associated with material price changes [Ilbeigi 2016]. Price adjustment clause are a contracting mechanism that allows the contracting groups to reconcile costs of materials based on the actual pricing at the time of purchase. Normally the reconciliation price is linked to agreed price indices. However, a recent study found that including price adjustment clauses in contracts did not statistically correlate to decreasing bid prices [Ilbeigi 2016]. The findings of Ilbeigi raise doubts on the value of using price adjustment clauses, and provides justification for exploring hedging as a risk mitigation.

An alternative method to address the risk associated with changes in construction material prices is to utilize hedging against the risk. The use of hedging in the construction business is a common practice, and commodity futures are utilized. A review of financials statements from large construction contractors revealed examples of hedging with all companies [Fluor 2016]. However, limited data of hedging with commodity futures to address material cost risk were found. A hedge is a strategy where an action is taken to offset losses from a different area of the business by holding uncorrelated assets [Smirnova 2016]. An everyday example of a hedge is car insurance. A driver pays a premium to the insurance company to cover the cost of an unplanned event, such as an accident. In the event that an accident occurs the costs of the accident will be incurred, however the driver is protected against the costs with the money provided by the insurance company. It is important to note that a hedge does not eliminate the unexpected costs, but offsets loses from the unplanned event. A hedging tool used by numerous industries is the commodity future.

Commodity futures are a contract between two parties for a specified type, quantity, and quality of commodity material [Heakal 2016]. Examples of commodity futures include crude oil, lumber, metals, grains, and currencies. Commodity futures offer a number of advantages as hedging tools, and a significant portion of trading of commodity futures is for the purpose of hedging [CME Group 2013]. Assets represented by commodity futures cover multiple markets, and millions of commodity futures contracts are traded daily [Heakal 2016]. Many industries use the advantages of commodity futures as a hedge to maintain long term profitability. However, understanding the mechanics of commodity futures is the initial step to using them as a hedge.

Commodity futures are fungible contracts that are traded on open markets. The details outlining the specifics of the commodity futures underlying asset are contained the "specification." The specification details all of the particulars of the commodity future from the material represented to the pricing mechanisms [Heakal 2016]. Commodity futures are represented by a symbol, which is a forward slash followed by numbers and letters. For example, the commodity future for Crude Oil is represented by the symbol /CL. Each commodity future represents a quantity of a specific grade of an underlying product. In the Crude Oil example the futures contract represent 1,000 barrels of West Texas Intermediate Grade crude oil. The pricing of commodity futures is dependent upon the contract and will be different for each. Generally, the pricing is US dollars per a unit of measure for the underlying product. The pricing of a Crude Oil future is listed by the price per barrel, and is priced in one cent increments. The pricing will move in magnitude depending on the tick size. In the Crude Oil example, the contract will move 10 dollars for each one cent the price changes. [CME Group 2017]. One of the biggest advantages of commodity futures is the capital efficiency of using the product, because a large quantity of product can be held at a low cost. The cost to hold the futures contract is the margin requirement, which is the amount of capital that is required to hold a position in a brokerage account. For example, a copper future contract representing 25,000 pounds of copper can be held in a commodity future for $3,100. Another important specification is that commodity futures contracts have a set date for execution, which is called the expiration date [Heakal 2016]. Each commodity future contract has a specified expiration date, and on this date the contract expire, and the position will be cash settled at the price at expiration.

An important characteristic of commodity futures is the effect of liquidity. Liquidity is defined by the ability to easily sell or buy an asset [CME Group 2013]. Financial instruments that are sold and bought in large volumes are considered to have high liquidity. High liquidity is a desirable characteristic when dealing with financial instruments [Farley 2015]. High liquidity allows the financial instrument to be sold and purchased quickly, and decreases the price spread between the sellers asking price and the buyers offer price. In markets with few buyers the party needing to sell the commodity future generally will be forced to lower the selling price to find a buyer. In the commodity futures market liquidity can easily be identified by the volume of contracts trading, and the difference between the ask and bid price [Sosnoff 2014]. An example of a highly liquid commodity future is Crude Oil, which will normally have 1 million contracts change hands daily.

The relationship between commodity pricing and the realities of commodity production is an important concept to understand. Unlike stocks there is no sustainable scenario where price of a commodity is zero or extremely low. A publicly traded company can go bankrupt and the stock would be deemed worthless. Conversely, commodities always have an intrinsic value and the cost to produce commodities is a natural stop for decreasing commodity prices. In the commodities market, commodity producers generally react to low prices by scaling back production. In normal scenarios the decreased commodity pricing limits supply, which supports prices increases. On the other hand very high prices encourage producers to increase production. Consequently the increased supply generally causes prices to come under pressure and decrease. The term used to describe the balance between supply and demand with is call pricing equilibrium. The realities of the market movements should be recognized, especially in the cases of historic price extremes. In the case of historic lows anyone trading commodities should recognize that the price has a much easier path the price increases.

Research Methodology

The goal of this research is to support the use of commodity futures as a hedge for construction contractors through empirically validated information. This research utilizes regression analysis, significance testing and interpretations of trends to support conclusions of the study. The first step of the analysis selected construction materials and viable commodity futures for the regression analysis. In order to select suitable commodity futures contracts several criteria were evaluated. The criteria were based on finding commodity futures that had acceptable liquidity. The data for the initial commodity future selection was collected from a retail financial market trading software. The section of the commodity futures focused on two requirements.

1. The number of open positions for each commodity future was evaluated as an indication liquidity, and for the intent of this research a floor of 3,000 open contracts was considered the minimum.
2. The bid to ask spread at peak trading time was examined, and for the intent of this research only commodity futures with bid to ask spreads below 1% of the futures price were considered. The allowable spread amount was based on an assumed acceptable loss for simply opening and closing a position.

Six construction materials were selected for this research, which were copper wire, steel, asphalt, concrete cement, framing wood and panel wood. The four materials were selected because they are typical construction materials to a wide range of construction projects. Four commodity futures were evaluated using the liquidity criteria, which were Crude Oil, Copper, Random Length Lumber, and Steel. The four commodity futures were chosen based on the assumed physical relationship with the selected construction materials. The data used to evaluate the commodity future liquidity was collected from the retail trading platform. The results of the evaluation determined three of the four as viable hedging tools, which are Crude Oil, Copper, and Random Length Lumber. The steel future was rejected due to the low number of contracts traded and the unacceptable high bid to ask spread.

Data were collected to perform a regression analysis of the construction materials and the commodity futures. The data were collected for a period of time going back several years. Data for construction material pricing were collected from government agency and industry group sources. Commodity futures pricing information was collected from the retail trading platform. TD Ameritrade's ThinkorSwim trading platform chosen based on functionality and ease of use. All futures prices were recorded from the beginning of the month at the closing of the market. The data were matched between the construction material and commodity future at beginning each month. Initial review of relationships between construction materials and commodity futures was performed by examination of charts of construction material price graphed against the futures price. Analysis of the graphical comparison was focused on identifying corresponding trends in pricing, and comparing the rate of change in pricing of the data sets. Pricing trends evaluated the graphical magnitude of price changes and the duration of the price changes. The evaluation was not determinative of correlation, but only an initial check for correlation between the construction material and the commodity future.

Statistical analysis was used to draw an empirical comparison between the construction material and commodity future. A regression analysis was used to determine the correlation strength between the commodity future and the construction material. The specific function was the Pearson Correlation Coefficient r. The Pearson Correlation Coefficient provides a measure of the strength of linear association between data sets, with a value between -1 and 1 representing the linear dependence between two variables [Brase 2011]. The further from zero the coefficient the stronger the correlation is between the two variables, with a value of 1 being a perfect correlation. A value of -1 one would indicate a perfect inverse correlation.

$$Pearson's\ r_{xy} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i{}^2 - (x_i)^2}\ \sqrt{n\sum y_i{}^2 - (x_i y_i)^2}}$$

To determine the statistical significance of the calculated correlation coefficients a statistical test of p, the population correlation coefficient was conducted [Brase 2010]. The null hypothesis of the statistical significance test assumes that no linear correlation exists.

The null hypothesis: $H_0 : p = 0$

The alternate hypothesis $H_1 : p \neq 0$

Sample test statistic $t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}\ with\ d.f. = n - 2$

P-values are one tailed, depending on – or + value, student's t-distribution using α = .005

From the results of the p-test the values found to be statistically significant were sorted by correlation value. The relationships between construction material and commodity futures with the highest correlation were accepted for simulation testing. Hedging simulations were performed for each of the construction materials. The purpose of the simulation was to determine what comparable trends exist within the actual historic valuations. The simulation was performed by choosing a period with exceptional price increases in each of the construction materials pricing. The simulation calculated the value of both the construction material and commodity future at the beginning and end of the period. The sizing of the construction amount was a hypothetical value based on a size comparable to the notional value of a single commodity future contract. Three simulations were ran for each of the construction material versus commodity future hedges. Through multiple trials the simulation study was used to determine if the correlated construction materials and commodity futures were experiencing similar price movements. Lastly, the results of the simulation study were tabulated for final analysis.

Analysis

Regression analyses was performed across all construction material data sets against each different commodity future. The cross examination approach was used to determine if any unexpected relationships existed between the construction materials and the commodity futures. The three futures products all show a strong correlation to certain construction materials. The correlations were not consistently positive or negative. Each construction material had at least one commodity future with a correlation of 0.80. The magnitude of the correlation number is much more important than if the correlation is negative or positive. The correlation sign can be addressed by holding the appropriate long or short hedge.

The results of the correlation study were evaluated with a statistical significance test. The statistical significance test provided a result that either accepted or rejected the correlation. The null hypothesis was that no correlation existed, and by rejecting the null hypothesis the correlation value is accepted. As shown in table 5, the results of the statistical significance test found that 7 correlations be not statistically significant. More importantly the remaining 11 correlation results were accepted, and suitable for further analysis. For the intent of this research the highest correlation value between the construction material and commodity future is used for evaluation with simulation testing. Table 6 highlights the he correlations that were chosen for further evaluation.

Table 1 - Relationships Accepted From Regression Analysis

COMMODITY FUTURE

CONSTRUCTION MATERIAL

	Copper /HG	**Crude /CL**	**Lumber /LBS**
Copper Wire	**0.99**	0.83	0.30
Steel	**0.80**	0.75	-0.17
Asphalt	**0.87**	0.79	0.40
Concrete	**-0.84**	-0.75	0.27
Framing Wood	-0.22	0.05	**0.92**
Panel Wood	-0.19	0.02	**0.80**

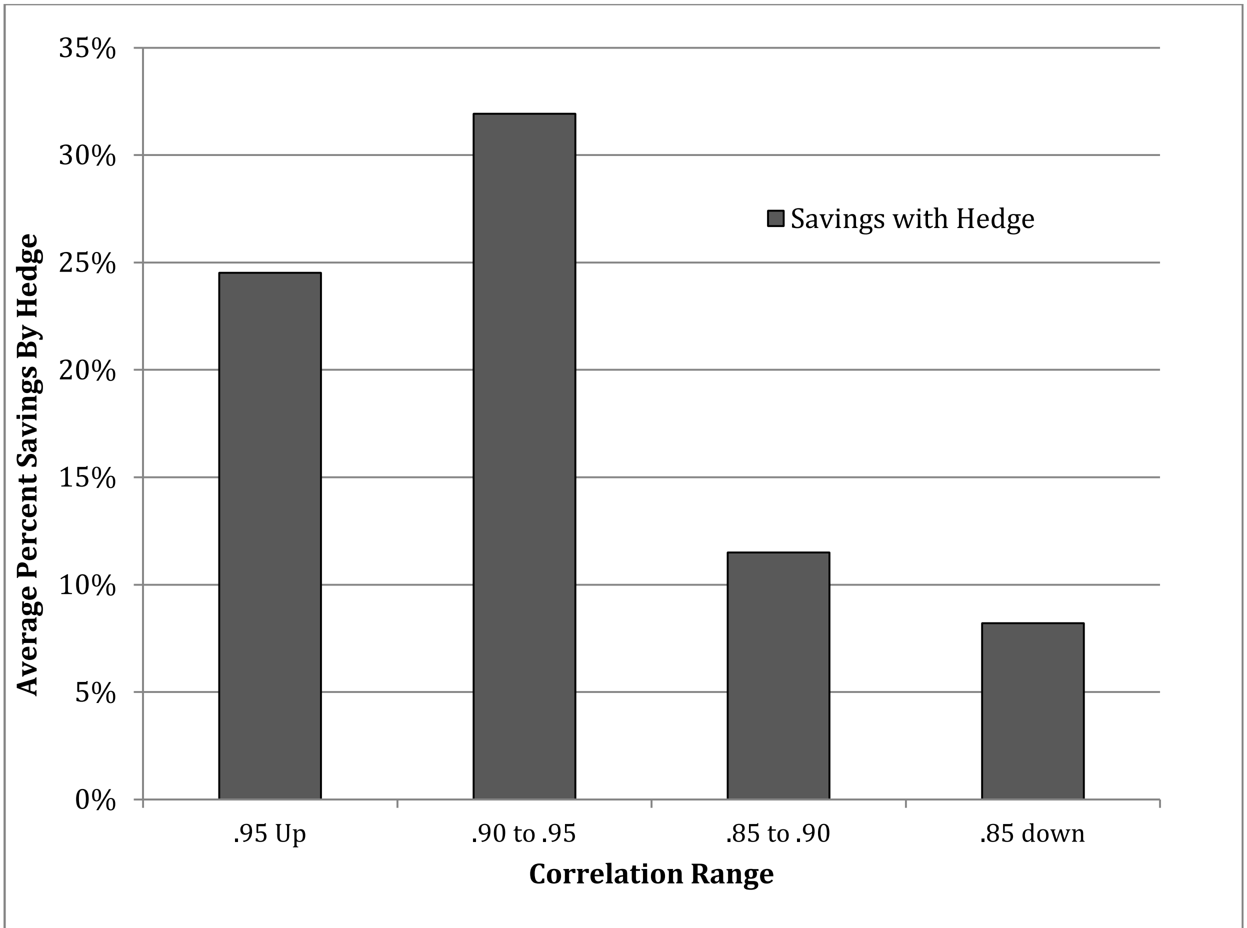
In order to further validate the approach, hedging simulations were performed for each of the construction materials. Each of the hedging simulations evaluated a period of increased construction material prices. The period was chosen based on the greatest price movements in the data time period. The simulations were organized in tables shown the start and finish prices for the construction materials and commodity futures. The changes in prices were totaled and compared between the hedged case and the unhedged case. The correlation direction was accounted for in the simulation calculations. In Concrete to Copper futures hedging scenario the correlation relationship was inverse. For the inverse relationship the commodity position was calculated as a short position. Figure 6 illustrates the ideal hedging scenario where an increase construction material cost is offset with an increased commodity future value.

The results of the simulation are shown in Table 8. The gains and losses of the hedge were calculated as both the nominal value and as a percentage of starting value of the construction material purchase prices. In addition, the total value of all 18 simulations was summarized in order to describe the overall performance of the hedge. Cases where the hedge did not work and created losses are highlighted. The largest risk mitigation was a 62% cost savings of the original material value for a price escalation in framing lumber. Where the hedging strategy did not work the largest loss occurred in two cases each losing 5% of the original material value. The simulation results demonstrated that hedging scenarios with higher correlation value had a higher rate of success and better performance. For simulations with a correlation above 0.9 the success rate was 100%, while the success rate for simulations below 0.9 was 75%.

Table 2 - Relationship Between Correlation Value and Hedge Performance

Correlation Value	Savings with Hedge	Successful Hedge	Failed Hedge
.95 Up	25%	3	0
.90 to .95	32%	3	0
.85 to .90	11%	2	1
.85 down	8%	7	2

Figure 1 - Relationship Between Correlation Value and Hedge Performance



Results

The results of the correlation study showed several instances of strong relationship between the construction materials and commodity futures. The analysis found 10 of the 18 regression analysis demonstrated a correlation outside of a range of -0.75 , 0.75, which is a significant value of correlation. The strongest correlation value was 0.99 between copper wire and copper futures,. On the other hand, the lowest correlation was between panel wood and Crude Oil Futures at 0.02. Many of the correlations were anticipated, such as wood products being strongly correlated to the lumber futures. However, the strongest correlations between construction materials and commodity futures was not always as expected. Most surprisingly, the correlation between asphalt prices and copper futures prices was stronger than that of asphalt prices and crude oil prices. For the asphalt example, asphalt is largely made up of the crude oil derivative bitumen. Initially the assumption was that the base commodity for the construction material would have the highest correlation. However, the correlation between asphalt and copper prices proved to have the highest correlation strength. The pricing forces creating the strong correlation between asphalt and copper were not examined as part of this study, but are discussed in the recommendations for further research section. The statistical significant test of the correlation study validated 11 out of 18 regression analysis results as significant. The results of the statistical significance test allowed for further study of the 11 relationships. However, only the relationships with the highest correlation values were examined with simulations. Hedging simulations were used to compare the pricing movement between the construction materials and commodity futures. A hedging simulation that provided positive cost savings was considered a successful hedge. The results of hedging simulations showed that using a commodity future as a hedge was successful in 83% of the cases. In the remaining 17% of cases, the simulation resulted in an unsuccessful hedge with the strategy compounding the loss. Averaged over the entire simulation study, the losses in the unhedged scenario 24.4% of the original value of the construction material. Overall a loss was shown despite having the hedge strategy in place. However, the losses were much lower than the unhedged scenarios at 9.7% of the original value of the construction material. The hedging simulations resulted in three periods where the hedge contributed to a greater loss. The largest impact of an unsuccessful hedge was a 5% greater loss than an unhedged result. Conversely, the most successful hedging simulation showed a 62% cost saving. It is important to highlight that the results of the hedging simulations demonstrated that the correlation value had an impact on the success of the hedge. Figure 7 illustrates the relationship between correlation strength and In two cases where the correlation was greater than 0.90 (copper and framing wood) the hedge provide a 30% cost savings. In the case where the correlation was below 0.90 the cost savings was only 13%.

Conclusions

The results of this study support the use of commodity futures as a hedge for construction material pricing increases. The success of using commodity futures as hedge was demonstrated in both the frequency and scale of successfully mitigating risk. In the instances where the hedge was unsuccessful, the magnitude of the hedging losses was acceptable when compared against the frequency and scale of success. Implementing a successful hedge is dependent upon the correlation between the construction material and commodity future. More highly correlated relationships provided better hedging results. In addition the findings of the study provide information that supports the importance of following general trading guidelines of using liquid contracts and maintaining an awareness on the market. These guidelines should be considered by construction contractor choosing to use commodity futures as hedging tools. The business of construction contractors is typically associated with small profit margins that are sensitive to unexpected cost escalation. The results of this study demonstrates an approach that should be considered as a mitigation for construction contractors seeking address construction material price risk.

Recommendations For Further Research

The efforts and conclusions of this study exposed several items for further investigation. The study made several assumptions in order to remain within the constraints of the study, and the results of study could be strengthened with additional analysis. In this study the construction materials examined were limited to some of the most common materials utilized in the construction industry. Future study should examine additional material further down supply change, such as steel pipe, rebar, precast concrete, finished cable, prefabricated structural wood members. This study utilized a monthly pricing frequency. Future investigation should consider examining pricing on a greater frequency. Construction materials and commodity futures historically have shown the capacity to swing drastically in periods less than a month. Although a more frequent pricing period would strengthen the study, the results of this study have been proven statistically significant. The study revealed several instances of correlations that were not expected. As discussed above, the correlation between asphalt and copper futures was greater than the correlation between asphalt and crude oil futures. Most would assume that by the physical relationship between asphalt and crude oil would create a stronger relationship than other commodities. The pricing forces creating the strong correlation between asphalt and copper were not examined as part of this study. However, it is suspected that because copper and asphalt are primarily used as building materials they may be subject to the same swings in construction activity. Conversely, crude oil is subject to different market forces such as the refining industry, consumption by drivers, and financial market speculation. An investigation of the dynamics driving the unexpected price correlation between certain construction materials and commodity futures could further validate using commodity futures as a hedge for construction materials.

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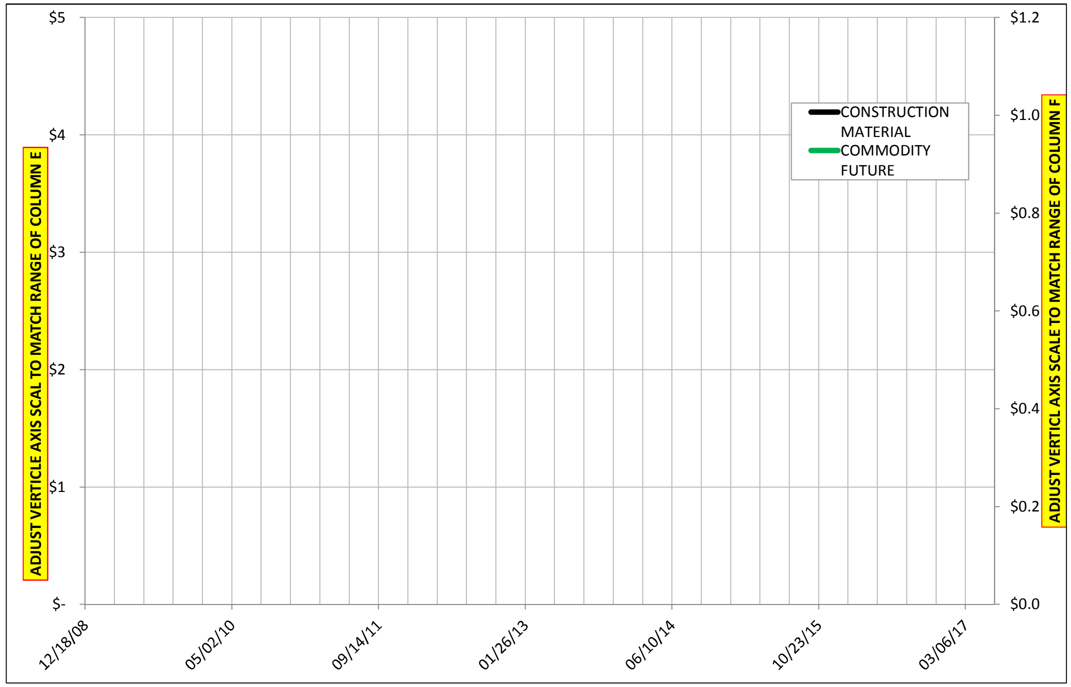
EXAMPLE			ENTER DATA HERE		
Year	Copper Wire $/lb	/HG $/lb	DATE	CONSTRUCTION MATERIAL HISTORIC PRICES	COMMODITY FUTURE HISTORIC PRICE
12/1/2008	1.88	1.60			
1/1/2009	1.66	1.41			
2/1/2009	1.73	1.43			
3/1/2009	1.79	1.69			
4/1/2009	2.10	1.85			
5/1/2009	2.32	2.10			
6/1/2009	2.47	2.30			
7/1/2009	2.53	2.31			
8/1/2009	2.89	2.74			
9/1/2009	3.08	2.83			
10/1/2009	3.07	2.68			
11/1/2009	3.22	2.96			
12/1/2009	3.42	3.25			
1/1/2010	3.60	3.41			
2/1/2010	3.32	3.08			
3/1/2010	3.54	3.44			
4/1/2010	3.82	3.58			
5/1/2010	3.61	3.37			
6/1/2010	3.37	3.04			
7/1/2010	3.21	2.90			
8/1/2010	3.58	3.39			
9/1/2010	3.63	3.47			
10/1/2010	3.92	3.70			
11/1/2010	4.01	3.83			
12/1/2010	4.10	3.97			
1/1/2011	4.64	4.43			
2/1/2011	4.74	4.56			
3/1/2011	4.77	4.50			
4/1/2011	4.59	4.26			
5/1/2011	4.46	4.25			
6/1/2011	4.46	4.10			
7/1/2011	4.56	4.31			
8/1/2011	4.76	4.34			
9/1/2011	4.48	4.12			
10/1/2011	3.44	3.11			
11/1/2011	3.92	3.51			
12/1/2011	3.85	3.54			
1/1/2012	3.72	3.43			
2/1/2012	4.09	3.91			
3/1/2012	4.17	3.91			
4/1/2012	4.12	3.89			
5/1/2012	4.13	3.74			
6/1/2012	3.66	3.33			
7/1/2012	3.79	3.47			
8/1/2012	3.72	3.36			
9/1/2012	3.75	3.46			
10/1/2012	4.07	3.72			
11/1/2012	3.82	3.55			
12/1/2012	3.93	3.65			
1/1/2013	3.94	3.72			
2/1/2013	4.03	3.78			
3/1/2013	3.84	3.52			

CORRELATION CALCULATION

Count	0
Correlation	#DIV/0!
Deg Freedom	-2
t - Dist Value	#DIV/0!

1. Correlation should be greater than .90 for best probablility of success

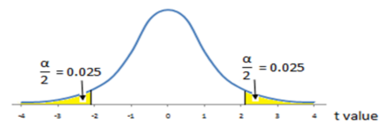
2. Look up value in students t distribution table below. If value calculated in cell T-DIST is greater than the value in the t distribution table the result is statistically significant and valid.



4/1/2013	3.71	3.37	
5/1/2013	3.50	3.11	
6/1/2013	3.61	3.34	
7/1/2013	3.36	3.17	
8/1/2013	3.43	3.17	
9/1/2013	3.54	3.31	
10/1/2013	3.64	3.28	
11/1/2013	3.60	3.36	
12/1/2013	3.54	3.17	
1/1/2014	3.78	3.40	
2/1/2014	3.56	3.19	
3/1/2014	3.57	3.21	
4/1/2014	3.38	3.04	
5/1/2014	3.36	3.05	
6/1/2014	3.47	3.17	
7/1/2014	3.52	3.26	
8/1/2014	3.56	3.22	
9/1/2014	3.47	3.16	
10/1/2014	3.34	3.00	
11/1/2014	3.40	3.02	
12/1/2014	3.19	2.87	
1/1/2015	3.21	2.81	
2/1/2015	2.87	2.58	
3/1/2015	3.06	2.66	
4/1/2015	3.09	2.73	
5/1/2015	3.23	2.91	
6/1/2015	3.10	2.73	
7/1/2015	2.97	2.63	
8/1/2015	2.71	2.35	
9/1/2015	2.68	2.29	
10/1/2015	2.69	2.31	
11/1/2015	2.66	2.31	
12/1/2015	2.39	2.05	
1/1/2016	2.48	2.14	
2/1/2016	2.41	2.05	
3/1/2016	2.47	2.21	
4/1/2016	2.53	2.14	
5/1/2016	2.62	2.27	
6/1/2016	2.44	2.07	
7/1/2016	2.54	2.22	
8/1/2016	2.57	2.19	
9/1/2016	2.41	2.08	
10/1/2016	2.55	2.19	
11/1/2016	2.55	2.22	
12/1/2016	2.97	2.63	

Student's t Distribution Table

For example, the t value for 18 degrees of freedom is 2.101 for 95% confidence interval (**2-Tail** $\alpha = 0.05$).



	90%	95%	97.5%	99%	99.5%	99.95%	**1-Tail Confidence Level**
	80%	90%	95%	98%	99%	99.9%	**2-Tail Confidence Level**
	0.100	0.050	0.025	0.010	0.005	0.0005	**1-Tail Alpha**
df	0.20	0.10	0.05	0.02	0.01	0.001	**2-Tail Alpha**
1	3.0777	6.3138	12.7062	31.8205	63.6567	636.6192	
2	1.8856	2.9200	4.3027	6.9646	9.9248	31.5991	
3	1.6377	2.3534	3.1824	4.5407	5.8409	12.9240	
4	1.5332	2.1318	2.7764	3.7469	4.6041	8.6103	
5	1.4759	2.0150	2.5706	3.3649	4.0321	6.8688	
6	1.4398	1.9432	2.4469	3.1427	3.7074	5.9588	
7	1.4149	1.8946	2.3646	2.9980	3.4995	5.4079	
8	1.3968	1.8595	2.3060	2.8965	3.3554	5.0413	
9	1.3830	1.8331	2.2622	2.8214	3.2498	4.7809	
10	1.3722	1.8125	2.2281	2.7638	3.1693	4.5869	
11	1.3634	1.7959	2.2010	2.7181	3.1058	4.4370	
12	1.3562	1.7823	2.1788	2.6810	3.0545	4.3178	
13	1.3502	1.7709	2.1604	2.6503	3.0123	4.2208	
14	1.3450	1.7613	2.1448	2.6245	2.9768	4.1405	
15	1.3406	1.7531	2.1314	2.6025	2.9467	4.0728	
16	1.3368	1.7459	2.1199	2.5835	2.9208	4.0150	
17	1.3334	1.7396	2.1098	2.5669	2.8982	3.9651	
18	1.3304	1.7341	2.1009	2.5524	2.8784	3.9216	
19	1.3277	1.7291	2.0930	2.5395	2.8609	3.8834	
20	1.3253	1.7247	2.0860	2.5280	2.8453	3.8495	
21	1.3232	1.7207	2.0796	2.5176	2.8314	3.8193	
22	1.3212	1.7171	2.0739	2.5083	2.8188	3.7921	
23	1.3195	1.7139	2.0687	2.4999	2.8073	3.7676	
24	1.3178	1.7109	2.0639	2.4922	2.7969	3.7454	
25	1.3163	1.7081	2.0595	2.4851	2.7874	3.7251	
26	1.3150	1.7056	2.0555	2.4786	2.7787	3.7066	
27	1.3137	1.7033	2.0518	2.4727	2.7707	3.6896	
28	1.3125	1.7011	2.0484	2.4671	2.7633	3.6739	
29	1.3114	1.6991	2.0452	2.4620	2.7564	3.6594	
30	1.3104	1.6973	2.0423	2.4573	2.7500	3.6460	