The Business Cycle and the Correlation between Stocks and Commodities

Geetesh Bhardwaj and Adam Dunsby†

SummerHaven Investment Management

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Abstract

Measured over long horizons, the correlation between stocks and commodities is close to zero. However, it varies widely over time. Using historical data extending back to 1960 we study the stock-commodity correlation and show: (1) stock-commodity correlation has a business cycle component: it is higher during periods of economic weakness. (2) The same pattern is observed in the average intra-commodity correlation. Our results are consistent with recession-increased risk aversion causing investors to treat all risky assets the same, and also with firms adjusting variable input use more quickly during tough times. (3) This business cycle effect can explain the spikes in the stock-commodity correlation in the early 1980s and the late 2000s. (4) The link between stock-commodity correlation and business cycle is stronger for industrial commodities than for agricultural commodities.

Key words: Stock-Commodities correlation, Business cycle

JEL Classifications: E3, G1

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†Geetesh Bhardwaj, Director, SummerHaven Investment Management. Adam Dunsby, Partner, SummerHaven Investment Management. Correspondence: SummerHaven Investment Management, LLC, Soundview Plaza, 1266 East Main Street, Stamford, CT 06902: 203-352-2704. Email: gbhardwaj@summerhavenim.com. We are grateful to Michel Robe and Rajkumar Janardanan for helpful comments and suggestions.

Introduction

Proponents of commodity investing typically point to the overall low correlation between stocks and commodities as one of the three main benefits of commodity investing (the other two being equity-like returns and a positive correlation with inflation).[1] Over the last fifty years the correlation between stocks and commodities has been close to zero. However, this single number conceals a wide degree of variation. Using weekly returns, correlations measured over quarterly windows have ranged from -0.68 to 0.91.

In this study we explore how the business cycle and inflation affect the correlation between stocks and commodities. We also explore how the business cycle and inflation affect the correlation of commodities to each other.

A business cycle effect on stock-commodity correlation can be motivated by the behavior of firms during different stages of the economic cycle. Models of firm behavior argue that this effect is asymmetric. The asymmetry arises due to what is known as the "financial accelerator," a term coined by Bernanke *et al*. (1996), which posits that adverse shocks to the economy are amplified. Different mechanisms of this accelerator have been suggested; Greenwald and Stiglitz (1993) highlight the role of bankruptcy costs in limiting investments and production activity; Bernanke *et al*. (1996), and Kiyotaki and Moore (1997) focus on amplified credit constraints during bad economic times. Firms use commodities as variable inputs to production. In bad times, firms will be quick to cut variable costs in order to avoid bankruptcy, or in response to constrained credit conditions. Further, when times are bad, firms may take falling stock prices as a signal that things are getting worse (and vice versa), leading to an increase in the stock-commodity correlation.

Firms quickly cutting variable costs during bad times can also motivate a business cycle effect on intra-commodity correlation. The argument is the same: in bad times firms will cut variable costs more quickly than in good times in order to avoid bankruptcy, causing commodities—the variable inputs—to co-move more tightly.

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[1] See Gorton and Rouwenhorst (2006) and Erb and Harvey (2006).

An alternative investor-based explanation of the time-varying correlation between stocks and commodities is that in bad times investor risk aversion is high, and that in these periods investors move in or out of risky assets as a group, leading all risky assets to move together.[2] This notion is captured in the common statement that when bad things happen "all correlations all go to one," or that bad times are more subject to "risk on, risk off" scenarios.

Another motivation that also works through the channel of investors is the "financialization" of commodities hypothesis discussed by Masters (2008), Tang and Xiong (2010), and Juvenal and Petrella (2011), to name a few. According to the financialization hypothesis, the correlation between stocks and commodities has permanently increased due to increased investor involvement in commodity markets.

Previous researchers have explored both the stock-commodity correlation and the average intra-commodity correlation. Chong and Miffre (2010) study the stock-commodity correlation from 1981 to 2006 and find that it has fallen over time and is decreasing in equity volatility. Kat and Oomen (2006) show that the behavior of the correlation of commodities with stocks over the business cycle differs by commodity. Examining the period from 1991 to early 2008, Büyükşahin *et al*. (2011A) conclude that the stock-commodity correlation has not increased over time. Using a longer period that includes the financial crisis of 2008, Tang and Xiong (2010) find that average intra-commodity correlation has increased and the correlation of non-energy commodities with oil has increased. They interpret this as evidence of the financialization of commodities. Büyükşahin and Robe (2010) (and the related Büyükşahin and Robe (2011B)) examine the stock-commodity correlation in conjunction with a unique data set of individual trader positions using the S&P-GSCI (the former Goldman Sachs Commodity Index), over the period 1991 to 2010. Among their conclusions is that the stock-commodity correlation varies with variables meant to gauge financial stress and economic strength (e.g. the TED spread for financial stress and the Kilian (2009) shipping index for global real

[2] Habit formation models in which agent's relative risk aversion is time-varying successfully reproduce average risk premium as well as the counter-cyclical risk premium observed in data; see Campbell and Cochrane (1999), Bakshi and Chen (1996), Constantinides (1990).

economic activity). They conclude that the stock-commodity correlation is positively related to the TED spread.

Our study contributes to the understanding of stock-commodity and intra-commodity correlation in several ways. Our data set extends back to 1960, a much longer sample than used by previous researchers. This is important because, in that the correlations of interest vary over the business cycle, a longer sample will allow for more economic peaks and troughs. Using as indicators of economic activity real GDP growth, the default spread, and NBER dated recessions, we show that when the economy is weak, both the stock-commodity correlation and the average intra-commodity correlation are high. Also, we find that both stock-commodity and intra-commodity correlation are persistent and either not sensitive to inflation (intra-commodity) or mildly negatively related (stock-commodity). Commodities do not lose their diversification value when inflation is high.

Our results have implications for the financialization of commodities debate. In particular, our business cycle hypothesis can explain why the two highest peaks of stock-commodity correlation (early 1980's and late 2000's) occurred during the two deepest recessions of the past fifty years. The financialization hypothesis cannot explain the spike in the early 1980s, since that period pre-dates broad acceptance of commodity investing.

Data

The commodities we study are those contained in either the Dow Jones-UBS Commodity Index or the S&P-GSCI, omitting duplicates (e.g. we include WTI crude oil, but not Brent crude oil), and including tin, platinum, and soybean meal, based on the subjective assessment that they are important economically, have liquid futures markets, and are of interest to investors. The twenty-five commodities are listed in Table 1. We construct (excess) investment returns for futures by taking a long position at the end of each month, in the nearest to expiry future that does not have its first notice date[3] or expiration date in the next month. Returns for the

[3] First Notice Day: The first day on which notices of intent to deliver actual commodities against futures market positions can be received.

commodity futures portfolio consists of equally weighted positions in all of the available commodities rebalanced to equal weights monthly.

In January 1960, when this study starts, there are eight commodities in the sample. This number grows to twenty-five with the addition of the natural gas contract in May 1990. Early in the sample the commodity futures available are almost entirely agriculturals. In January 1960, of the eight commodities the only non-agricultural commodity is copper. During the decade of 1960's non-agricultural commodities that enter our sample are Silver (starting July 1963) and Platinum (starting April 1968). The first energy contract, heating oil, does not appear in the sample until December 1978. Our portfolio of commodity futures is thus heavily weighted toward agriculturals early in the sample, a property common to all commodity futures indexes that attempt to characterize commodity returns prior to the 1980's.

Our primary empirical results make use of recent advances in the forecasting of second moments. The success of forecasting of realized volatility through linear models (as opposed the GARCH) has led to the application of this method to the forecasting of realized correlation and covariance[4]. Following Andersen *et al.* (2001) realized volatility for asset i on day t based on h intra-day returns is

$$RV_t^i = \sum\nolimits_{k=t-1,t-1+h,\cdots,t-h} \left(r_i(k,h)\right)^2$$

where $r_i(k,h)$ is the tick by tick return for asset i over the discrete interval $[k, k+h]$. The unbiased covariance estimator between asset i and j can be computed by simply summing all the cross products of returns.[5]

$$RCovV_t^{i,j} = \sum\nolimits_{k=t-1,t-1+h,\cdots,t-h} r_i(k,h) r_i(k,h)$$

The most efficient way to measure realized variance and covariance is to sample the data as frequently as possible. Our commodity data set is daily, ruling out intra-day sampling. But an additional obstacle is the different closing times of the stock and commodity markets. U.S. stock markets close at 4pm EST, while

[4] For a detailed discussion see Andersen *et al.* (2012) and *references cited therein*.

[5] See Audrino and Corsi (2010) for detailed discussion on realized correlation.

commodity markets all close earlier. A further complication is that the commodity markets themselves do not settle at the same time. For instance the London Metals Exchange closes at noon[6] while the NYMEX WTI crude closes at 2:30[7]. We choose to sample the data weekly, using Friday closing prices,[8] as a compromise between smoothing out the nonsynchronicity gaps and sampling at high frequency. Since our study is primarily concerned with horizons of quarterly and longer, we feel this is reasonable.

In measuring the correlation between stocks and commodities there is a trade-off between the efficiency of measurement and the contemporaneousness of measurement. Stocks and commodities have an instantaneous correlation, but that correlation can only be measured by sampling over a horizon. Our choice of weekly returns, however, means that there will only be thirteen weekly returns in the correlation statistics computed over quarters. To potentially increase efficiency we also measure correlations over annual horizons. If the true stock-commodity correlation moves slowly, and since the explanatory variables we use move at business cycle frequencies, measuring realized correlation over annual windows may not sacrifice much in terms of current information.

For the stock-commodity correlation we compute weekly realized correlations between stocks and commodities using quarterly and annual windows. For the average intra-commodity correlation we take the average of the realized weekly correlations of all the commodity pairs measured over quarterly and annual horizons. For simplicity, we sometimes refer to this as the intra-commodity correlation.

For clarity, all returns used in this study are weekly, only the window over which the realized correlation is computed varies. The window is either a quarter or a year.

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[6] London metals exchange ring trading stops AT 5pm London time.

[7] The United States and England enter and leave daylight savings time a week apart, resulting in the LME actually closing an hour earlier relative to NYC during this adjustment period. Settlement times for individual commodities have in some cases changed. For instance, prior to 2001, NYMEX WTI crude closed at 3:10pm; presently it closes at 2:30pm.

[8] If Friday is unavailable we use the previous available day.

The parametric alternative to the nonparametric realized correlation estimate are Dynamic Conditional Correlation (DCC) methods proposed by Engle (2002). The results reported in this paper are not dependent on realized correlation estimation techniques. Our results are robust to estimating the co-movement in equities and commodities based on a DCC specification. For the sake of brevity these results are not reported here, however they are available on request. We prefer realized correlation because, (i) the realized variance-covariance matrix is positive semi-definite by construction, Andersen *et al*. (2003), (ii) realized correlation estimation utilizes only the real time returns in extracting measures of the correlation,[9] and (iii) realized correlation estimates are asymptotically unbiased, Andersen *et al*. (2005).

Business cycle and co-movement of stocks and commodities

i. Summary statistics

Table 2 displays summary statistics for the stock-commodity correlation (using weekly returns) measured over quarterly windows. The mean and the median are slightly positive (0.13 and 0.14). The twenty-fifth percentile correlation between the equally weighted commodity index and S&P 500 index is -0.14 and the seventy-fifth percentile is 0.37. The minimum is -0.68 and the maximum is 0.91. Overall, these results suggest that the correlation between commodities and stocks is moderately positive but wide-ranging. Examining monthly and yearly horizons (not shown) leads to the same conclusions, with monthly horizons moderately more disperse and yearly horizons moderately less.

Table 3 displays correlations of the stock-commodity correlation and the intra-commodity correlation with real GDP growth, inflation, and the default spread.[10] The correlation between the stock-commodity correlation and GDP growth is -0.16, and the correlation with the default spread is 0.26, both consistent with

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[9] This is an important consideration for the validity of time series regression using the estimated realized correlation. Estimation of parametric models underlying GARCH-DCC, typically require the complete data set.

[10] Default spread is defined as a quarterly average of difference of Moody's Seasoned Baa Corporate Bond Yield (BAA), and Moody's Seasoned Aaa Corporate Bond Yield (AAA).

the co-movement between stocks and commodities being higher during bad economic times. The correlation between stock-commodity correlation and inflation is -0.12. The correlation between intra-commodity correlation and GDP growth is -0.24, and the correlation with the default spread is 0.42, both consistent with the co-movement across commodities being higher during bad economic times.

ii. Graphical evidence

Figure 1A displays the stock-commodity correlation measured over an annual window. The figure also displays the average of the default spread over the twelve month period and recessions as identified by the NBER[11]. Most salient, the two biggest spikes in the correlation between stocks and commodities correspond to the two deepest recessionary periods: the early 1980s and the late 2000s. In the fourth quarter of 1982 the rolling annual stock-commodity correlation reached 66%. Real GDP shrank 1.4% in 1982. Stock-commodity correlation spiked to levels reaching 76% during and just after the seven quarter recession that began in Q4 2007. Spikes in correlation also correspond to the recessions of the early 1970s and the early 2000s. However, the relation is far from perfect. The correlation reached its lowest levels during the recession of the early 1990s. Though the correlation reached its all-time highs during the recession of 2008, it was significantly negative during a portion of that recession. Additionally, the correlation rose in late 1963, a period of strong growth.

The default spread rises during recessions, as expected, and also tracks the stock-commodity correlation fairly well. From the late 1970s through the early 1990s the relation between the default spread and stock-commodity correlation is remarkably tight.

Figure 1B displays the same measure of stock-commodity correlation and inflation (shown on the right axis). The overall inflationary period of the 1970s corresponds to average or below average stock-commodity correlation, whereas the inflationary period of the early 1980s appears to correspond to average or above average stock-commodity correlation. The period of the lowest inflation, 2009, corresponds to relatively high stock-commodity correlation. The relation between

[11] Any twelve month period is identified as recessionary if it contains at least one recessionary month. This is why the entire period January 1980 through November 1982 is greyed, even though it contains two distinct recessions.

stock-commodity correlation and inflation is less apparent than for the business cycle. Spikes in inflation do not correspond with spikes in stock-commodity correlation. However, to better understand the relation, we will need to turn to regression analysis.

iii. Regression results

In this section we present the results of regressing stock-commodity correlation on lagged stock-commodity correlation measured over an annual window, contemporaneous GDP growth, the default spread, inflation, and the Killian shipping index. From the business cycle effects previously discussed, we hypothesize the coefficient on GDP will be negative and the coefficient on the default spread positive.

In the first set of regressions, presented in Table 4A, we use as the dependent variable the stock-commodity correlation computed over quarterly windows. In regression (i) stock-commodity correlation is regressed against lagged stock-commodity correlation measured over the previous year[12]. The coefficient is 0.46 with a t-statistic of 4.81. Stock-commodity correlation is persistent. In regression (ii) we utilize a measure of economic activity proposed in Killian (2009) based on cargo freight rates. It is not statistically significant. Regressions (iii) and (v) contain, separately, the two other measures of economic activity, real GDP growth, and the default spread.[13] Both are statistically significant and consistent with a weak economy corresponding to a high correlation between stocks and commodities. The final single independent variable regression (iv) is of stock-commodity correlation on inflation. The coefficient is negative with a t-statistic of -1.45, not statistically significant.

In regression (vi) we include lagged stock-commodity correlation, GDP, inflation, and the default spread. Lagged stock-commodity correlation and the default spread maintain their signs and statistical significance. The coefficient on GDP maintains its sign but its t-statistic drops to -1.44. This is not surprising since

[12] Adding additional lags of stock-commodity correlation (e.g. measured over the previous quarter) make little difference.

[13] We also performed the regression of Stock-commodity correlation on the Aruoba-Diebold-Scotti Business Conditions Index. The coefficient is negative but the statistical significance is marginal. The ADS index is highly correlated with GDP.

GDP and the default spread have a correlation -0.38 and both measure business conditions.

Table 4B presents the results for overlapping annual horizon regressions (i.e. fifty-two weeks are used for each measurement of the dependent variable, stock-commodity correlation).[14] The pattern of results is the same as for the quarterly horizon regressions. The coefficient on lagged stock-commodity correlation is big and significant. The Killian index and inflation are not statistically significant. The business cycle variables, GDP and the default spread, are both signed consistently with weak economic growth corresponding to a high correlation between stocks and commodities. However, while the t-statistic on the default spread is 2.45, the t-statistic on GDP is now -1.67. When included in the same regression (vi), the default spread maintains its t-statistic, 2.52, while the t-statistic on the GDP recedes further to -1.03.

The annual regression results also show the explanatory power of the business cycle variables. The adjusted R^2 for the regression of stock-commodity correlation on just lagged stock-commodity correlation, regression (i), is 0.16. Adding the business cycle variables, real GDP, inflation, and the default spread increase the adjusted R^2 to 0.27.

Figure 3A displays stock-commodity correlation with the fitted values of regression (vi), which includes lagged stock-commodity correlation, GDP, inflation, and the default spread. The fitted model can explain most of the spikes in the two severe recessionary periods, the early 1980s and the late 2000s.

To summarize the regression results: Lagged correlation between stocks and commodities is a predictor of future correlation. That is, the correlation between stocks and commodities is persistent. Stock-commodity correlation is high during bad economic times, as evidenced by its relation to GDP growth and the default spread. The effect of inflation on stock-commodity correlation is weak. In the single regressor cases (4A and 4B), the coefficient on inflation is statistically insignificant, with a negative sign. In the regressions in which other business cycle variables are included, its coefficient is negative and the statistical significance is marginal.

[14] t-statistics reported in table 4B are based on Newey-West heteroscedasticity and autocorrelation consistent standard errors.

iv. Agricultural vs. non-agricultural commodities

An unavoidable fact of all broadly diversified commodity futures indices is that the further back in time they go, the more heavily weighted toward agriculturals the indexes are. Energy and base metal futures are relatively recent innovations.[15] For instance, at the end of 1970 ten of the thirteen commodities are agriculturals (77%). At the end of 2011, the end of our sample, only twelve out of twenty-five commodities (48%) are agriculturals. Bhardwaj and Dunsby (2011) have shown that different commodity sector returns have different sensitivities to the business cycle. Agricultural commodities tend to be less affected by the business cycle than industrial commodities such as base metals and oil.

In order to explore whether the changing composition of the index affects our results, we repeat our regression results for agriculturals-only and for non-agriculturals-only.[16] Table 5 displays the regressions results for stock-commodity correlation constructed over an annual horizon. The results for the non-agriculturals are stronger. The R-squared for the non-agricultural commodities is almost twice the R-squared for the agricultural commodities — 0.31 compared to 0.16. This makes sense, since one would naturally presume that industrial commodities (i.e. non-agricultural) are more affected by the business cycle.

The business cycle and intra-commodity co-movement

The correlation of commodities to one another is important to investors because lower intra-commodity correlation means that a portfolio of commodities will have more diversification and thus lower volatility. Conversely, high intra-commodity correlation means lower diversification and higher volatility. Erb and Harvey (2006) show that the historical correlation of commodities to each other is low. Tang and Xiong (2011) show that the intra-commodity correlation varies over time, increasing from 2007 through the end of their sample in 2010, and that the correlation between oil and several other commodities has increased since the

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[15] For instance, WTI Crude appears in our sample in April 1983. Natural gas, the last commodity included, enters the sample in May 1990, see table 1 the list of all the commodities.

[16] The agricultural commodities are corn, soybean oil, soybeans, wheat, soymeal, cocoa, coffee, sugar, cotton, feeder cattle, lean hogs, and live cattle. The non-agricultural commodities are aluminum, copper, nickel, zinc, tin, lead, platinum, silver, gold, oil, gasoline, heating oil, and natural gas.

beginning of their sample in the mid-1980s. They interpret this result as supporting the financialization hypothesis.

Figure 2 displays the average intra-commodity correlation for the commodities in our data set[17] with the default spread and grey bars for recessions. The business cycle pattern previously seen in the correlation between stocks and commodities is apparent in the intra-commodity correlation series. During periods of economic weakness, intra-commodity correlation is highest. Also, as with the correlation between stocks and commodities, the two highest peaks of intra-commodity correlation are during the 2008 recession and the recessionary period of the early 1980s. The intra-commodity correlation also shows a pronounced spike during the recessionary period of the early 1970s—a pattern not present in the stock-commodity correlation. The relation is not perfect, however, the correlation spikes for a period in the mid-1960s during which there is no recession and no elevation in the default spread.

Table 6A displays the regression results for the average intra-commodity correlation, in which intra-commodity correlation is calculated using weekly commodity returns over a quarterly window. The first regression shows that the average intra-commodity correlation is highly persistent. The coefficient on the lagged correlation (measured over a window of one year) is 0.67 with a t-statistic of 8.73 and an adjusted R-squared of 0.27. In regression (ii) the Killian SHIP index generates a positive coefficient of 0.05 and a t-statistic of 2.14. The coefficient on GDP growth, shown in regression (iii) is negative and statistically significant. In a weak economy, commodities move more closely with one another. The coefficient on the default spread (regression v) is positive and also statistically significant, further confirming that intra-commodity correlation is higher during periods of economic weakness. The coefficient on inflation, regression (iv), is not statistically different from zero.

Regression (vi) uses as regressors lagged correlation, GDP, inflation, and the default spread. Both business cycle variables see their t-statistics attenuate, with

[17] Figure 2 retains its same basic shape if only the eight commodities that exist for the entire sample are included, though the overall level of correlation is higher since most of the full sample commodities are agriculturals.

the coefficient on GDP dropping to -1.5 and the t-statistic on the default spread dropping to 2.36. The coefficient on inflation remains statistically insignificant.

Table 6B presents regression results with the intra-commodity correlation measured over annual windows. The pattern of results is similar to those in 6A. The average intra-commodity correlation is 1) highly persistent, 2) higher during periods of economic weakness, and 3) not affected by inflation.

Figure 3B displays the average intra-commodity correlation (measured over the annual window) with the line from the fitted model. The fitted correlation tracks actual correlation fairly closely. It tracks, with a lag, most of the major spikes in the first half of the sample, the lull period during the 1990s and early 2000s, and most—but by no means all—of the spike during the 2008 recession.

Conclusion

The correlation between stocks and commodities is higher during periods of economic weakness. This is consistent with recession-increased risk aversion causing investors to treat all risky assets the same, and with firms adjusting input use more quickly during tough times. The relation between correlation and the business cycle is stronger for industrial commodities. This affects the historical relationship in the sense that commodity futures indices are more weighted toward agriculturals in the decades prior to the 1990s.

The intra-commodity correlation is also higher during periods of economic weakness. Again, this is consistent with investors treating all risky assets the same during recessions. It is also consistent with firms adjusting commodity inputs more quickly during bad times.

There is some weak evidence that stock-commodity correlation is lower when inflation is high, but the statistical significance is marginal. The correlation of commodities to each other is not related to inflation. Both the correlation of stocks to commodities and the correlation of commodities to each other are persistent.

Our work contains implications for commodity investors. While the stock-commodity correlation is low in general, it is not low during bad economic times. This is also true for the intra-commodity correlation. On the other hand, the stock-commodity correlation is possibly lower during periods of above average inflation, and is certainly not higher, while the intra-commodity correlation does not appear to vary with inflation.

This study also suggests an alternative explanation to what is commonly referred to as the “financialization of commodities,” the hypothesis that commodities are currently both more correlated to stocks and more correlated to each other because of increased interest in commodities from investors. Using a longer history than has been typical in this literature, we show that spikes in both stock-commodity correlation and intra-commodity correlation occur during the early 1980s and the late 2000s, the two weakest economies. The business cycle explanation can explain both spikes, while the financialization hypothesis can only explain the spike of the late 2000s.

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Table 1 Commodities and start date for futures returns, Jan 1960 - Dec 2012

Commodity Group	Sectors	Commodity	Futures Returns Start Date
Non-Agricultural Commodities	Industrial metals	Aluminum	July 1987
		Copper	Jan 1960
		Nickel	May 1979
		Zinc	Feb 1977
		Tin	Aug 1989
		Lead	Mar 1977
	Precious metals	Platinum	Apr 1968
		Silver	Jul 1963
		Gold	Jan 1975
	Energy	Crude Oil	Apr 1983
		Gasoline	Jan 1985
		Heating Oil	Dec 1978
		Natural Gas	May 1990
Agricultural Commodities	Grains	Corn	Jan 1960
		Soybean Oil	Jan 1960
		Soybean	Jan 1960
		Wheat	Jan 1960
		Soybean Meal	Jan 1960
	Softs	Cocoa	Jan 1960
		Coffee	Sep 1972
		Sugar	Feb 1961
		Cotton	Jan 1960
	Livestock	Feeder Cattle	Dec 1971
		Lean Hogs	Mar 1966
		Live Cattle	Dec 1964

Source:

1. Futures returns for copper and commodities in all the sectors except industrial metals are based on data from Commodity Research Bureau (CRB) and Bloomberg.
2. For industrial metals, other than copper, we use data from London Metals Exchange and Bloomberg.

Table 2 Realized correlation, Q1 1960 to Q4 2012

	Stock-commodity correlation (All commodities)	Stock-commodity correlation (agricultural commodities)	Stock-commodity correlation (non-agricultural commodities)	Intra-commodity correlation
Mean	0.13	0.11	0.12	0.15
Minimum	-0.68	-0.60	-0.60	-0.04
25th Percentile	-0.14	-0.12	-0.13	0.07
Median	0.14	0.14	0.14	0.13
75th Percentile	0.37	0.33	0.34	0.21
Max	0.91	0.78	0.89	0.59

Note: The table reports the realized correlation between commodities and equities measured over quarterly horizon. Equity returns are based on S&P 500 price index. In the first column commodities returns are based on a commodity futures portfolio consisting of equally weighted positions in all of the available commodities. The second column reports the same for a portfolio of equally weighted positions in all agricultural commodities (grains, softs and livestock), and the third column reports the same for non-agricultural commodities (industrial metals, precious metals, and energy), Last column reports intra-commodity correlation.

Table 3 Correlation matrix, Q1 1960 to Q4 2012

	Stock-commodity correlation	Intra-Commodity correlation	Real GDP Growth	Inflation	Default Spread
Stock-commodity correlation	1				
Intra-Commodity correlation	0.26	1			
Real GDP Growth	-0.16	-0.24	1		
Inflation	-0.12	0.12	-0.05	1	
Default Spread	0.26	0.42	-0.37	0.07	1

Note: Table reports correlations of quarterly stock-commodity correlation, and intra-commodity correlation (see notes to table 2) with real GDP growth, inflation, and the default spread measured over quarterly frequency. Inflation is based on Consumer Price Index for All Urban Consumers: All Items, Index 1982-84=100, Monthly, Seasonally Adjusted (source: U.S. Department of Labor - Bureau of Labor Statistics). Real GDP growth is defined as the log difference of Real Gross Domestic Product, Billions of Chained 2005 Dollars, Seasonally Adjusted Annual Rate (source: U.S. Department of Labor - Bureau of Labor Statistics). Default spread is defined as a quarterly average of difference of Moody's Seasoned Baa Corporate Bond Yield (BAA), and Moody's Seasoned Aaa Corporate Bond Yield (AAA) (source: Board of Governors of the Federal Reserve System).

Table 4A Stock-commodity correlation Regression results
Quarterly data, Q1 1960 to Q4 2012

Variable	(I)	(II)	(III)	(IV)	(V)	(VI)
Constant	0.071	0.068	0.072	0.073	-0.068	-0.045
	(2.78)	(2.51)	(2.83)	(2.85)	(-1.25)	(-0.79)
Stock-commodity correlation (previous year)	0.460	0.545	0.457	0.447	0.396	0.388
	(4.81)	(5.56)	(4.83)	(4.67)	(4.1)	(4.02)
Killian SHIP Index		-0.040				
		(-0.44)				
Real GDP Growth			-0.052			-0.034
			(-2.36)			(-1.44)
Inflation				-0.033		-0.039
				(-1.45)		(-1.79)
Default Spread					0.143	0.122
					(2.89)	(2.3)
Number of Observations	208	180	208	208	208	208
Rbar-squared	0.10	0.14	0.12	0.10	0.13	0.14

Table 4B Stock-commodity Regression results
Overlapping annual data, 1960 to 2012

Variable	(I)	(II)	(III)	(IV)	(V)	(VI)
Constant	0.081	0.081	0.081	0.083	-0.079	-0.068
	(3.07)	(2.84)	(3.08)	(3.24)	(-1.28)	(-1.11)
Stock-commodity correlation (previous year)	0.417	0.481	0.418	0.399	0.353	0.327
	(3.36)	(4.17)	(3.61)	(3.2)	(2.69)	(2.71)
Killian SHIP Index		0.000				
		(-0.15)				
Real GDP Growth			-0.049			-0.027
			(-1.67)			(-1.03)
Inflation				-0.029		-0.048
				(-0.9)		(-1.93)
Default Spread					0.163	0.155
					(2.45)	(2.52)
Number of Observations	205	177	205	205	205	205
Rbar-squared	0.16	0.21	0.20	0.17	0.24	0.27

Note: Dependent variable for these regressions is Stock-commodity correlation measured over quarterly (4A) and annual (4B) horizon. Table reports the least square estimates, the numbers in brackets are t-statistics for test of significance. T-statistics reported in table 4B are based on Newey-West heteroscedasticity and autocorrelation consistent standard errors. GDP growth and Inflation are measured over the same period as the dependent variable. GDP and Inflation variables are standardized by dividing the variables by their standard deviation, so that the coefficient has the interpretation of change in realized correlation for one standard deviation change in GDP or inflation. Default spread is the average of monthly default spread (Baa-Aaa yield) over the same time period as the dependent variable.

Table 5 Regression results for realized correlation between equities and agricultural and non-agricultural commodities, overlapping annual data, 1960 to 2012

Variable	(I) Stock-commodity correlation (agricultural commodities)	(II) Stock-commodity correlation (non-agricultural commodities)
Constant	-0.032	-0.054
	(-0.6)	(-0.86)
Stock-commodity correlation (previous year)	0.136	0.376
	(1.24)	(3.12)
Real GDP Growth	-0.022	-0.048
	(-1.07)	(-1.79)
Inflation	-0.043	-0.043
	(-1.73)	(-1.92)
Default Spread	0.124	0.126
	(2.4)	(1.97)
Number of Observations	205	205
Rbar-squared	0.16	0.31

Table 6A Intra-commodity correlation Regression results
Quarterly data, Q1 1960 to Q4 2012

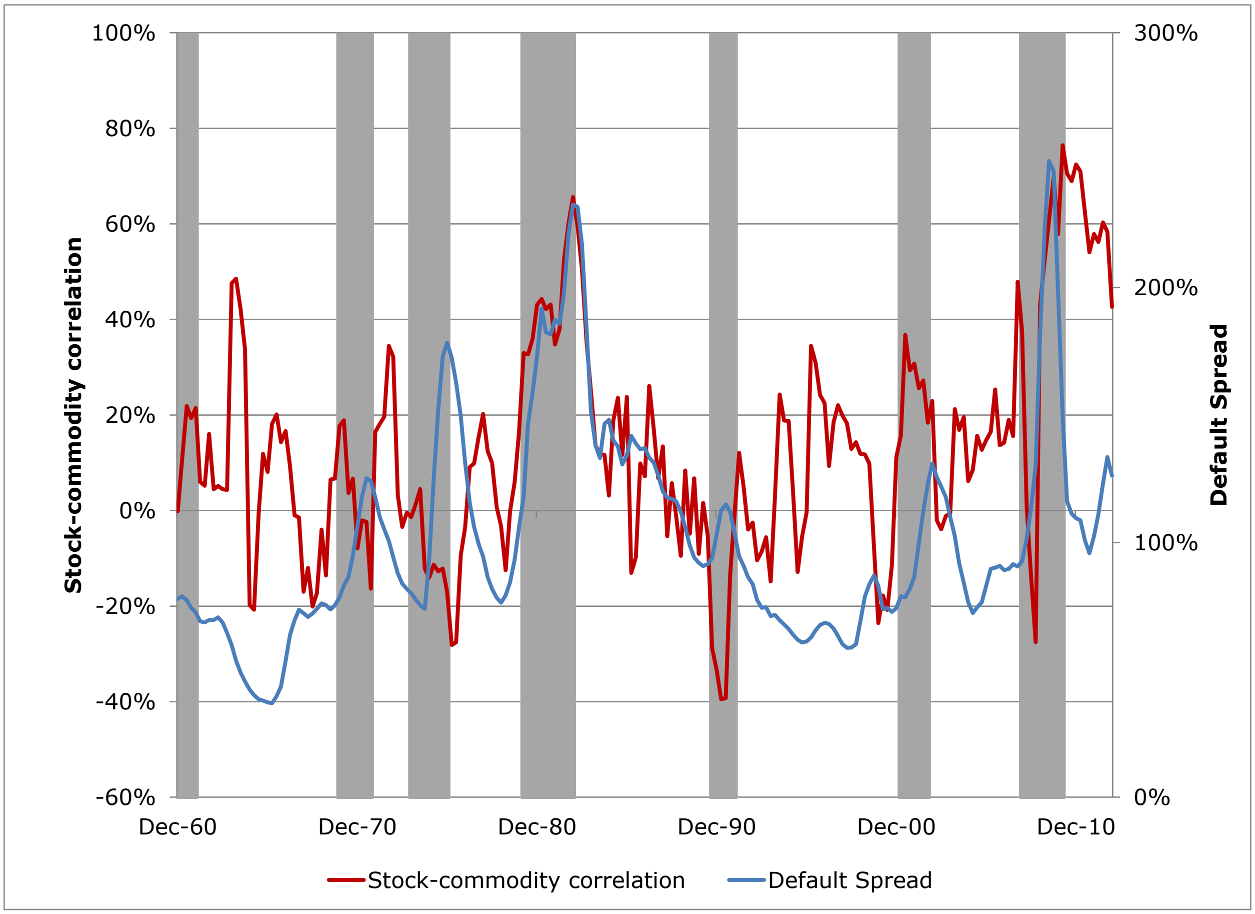
Variable	(I)	(II)	(III)	(IV)	(V)	(VI)
Constant	0.049	0.051	0.054	0.050	0.022	0.032
	(3.73)	(3.86)	(4.12)	(3.8)	(1.44)	(1.92)
Intra-commodity correlation (previous year)	0.667	0.662	0.632	0.658	0.529	0.523
	(8.73)	(8.69)	(8.22)	(8.54)	(6.04)	(5.94)
Killian SHIP Index		0.051				
		(2.14)				
Real GDP Growth			-0.015			-0.010
			(-2.4)			(-1.5)
Inflation				0.005		0.005
				(0.86)		(0.83)
Default Spread					0.046	0.038
					(3.01)	(2.36)
Number of Observations	208	180	208	208	208	208
Rbar-squared	0.27	0.33	0.28	0.27	0.29	0.30

Table 6B Intra-commodity Regression results
Overlapping annual data, 1960 to 2012

Variable	(I)	(II)	(III)	(IV)	(V)	(VI)
Constant	0.054	0.059	0.061	0.056	0.014	0.025
	(4.98)	(4.53)	(4.95)	(5.13)	(0.7)	(1.33)
Intra-commodity correlation (previous year)	0.651	0.639	0.608	0.637	0.488	0.489
	(8.68)	(7.45)	(8.36)	(7.89)	(5.72)	(5.93)
Killian SHIP Index		0.001				
		(2.28)				
Real GDP Growth			-0.017			-0.008
			(-1.67)			(-0.85)
Inflation				0.008		0.004
				(0.9)		(0.48)
Default Spread					0.063	0.052
					(2.48)	(2.4)
Number of Observations	205	177	205	205	205	205
Rbar-squared	0.40	0.47	0.44	0.41	0.49	0.49

Note: Dependent variable for these regressions is intra-commodity correlation measured over quarterly (6A) and annual (6B) horizon.

Figure 1.A Commodities and equities correlation, and Default spread, Overlapping annual Data (1960-2012)



Note: Figure displays Stock-commodity correlation measured over an annual horizon. The figure also displays average default spread for the year, and recessions as identified by the NBER (shaded Region). Any twelve month period is identified as recessionary if it contains at least one recessionary month. This is why the entire period January 1980 through November 1982 is greyed, even though it contains two distinct recessions.

Figure 1.B Commodities and equities correlation, and Inflation

Overlapping annual Data (1960-2012)

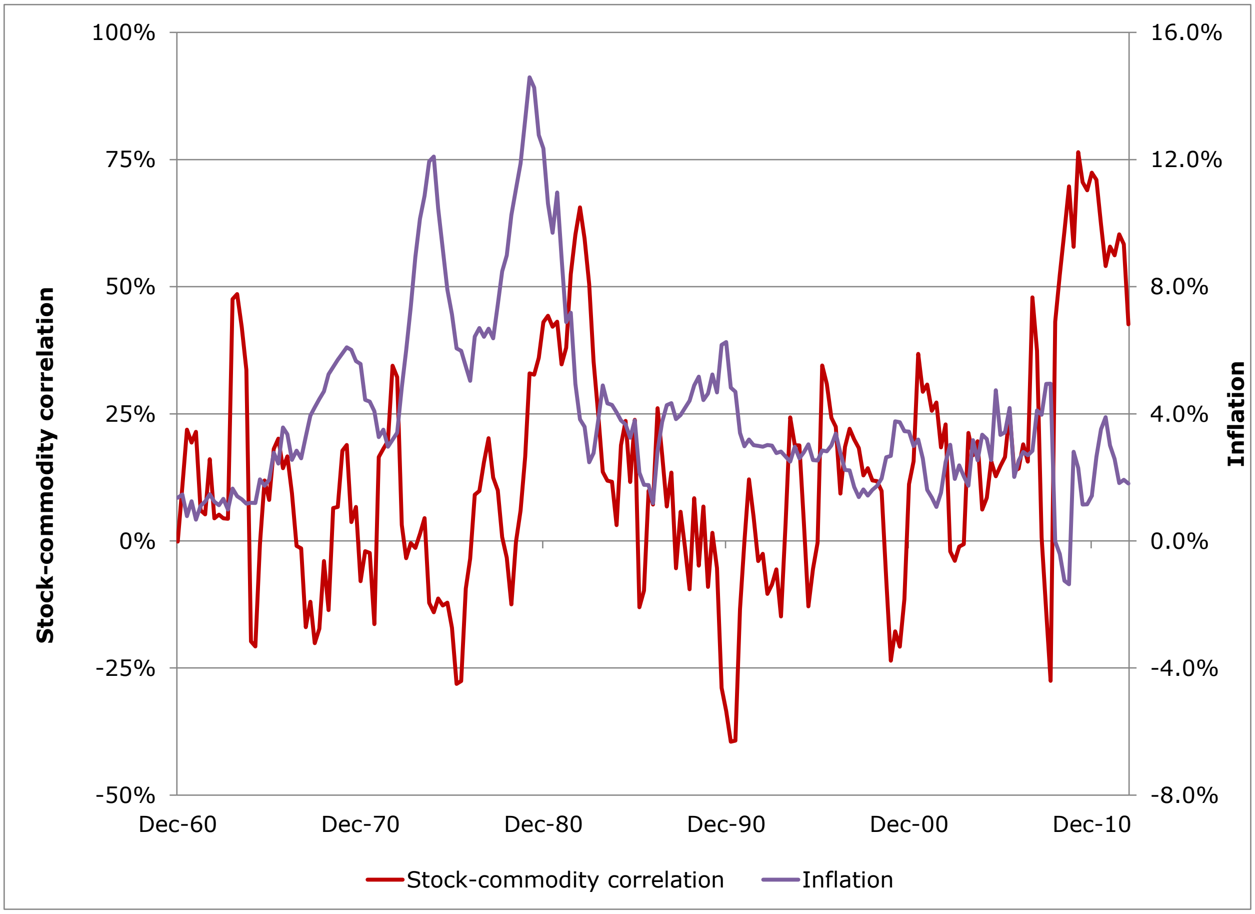
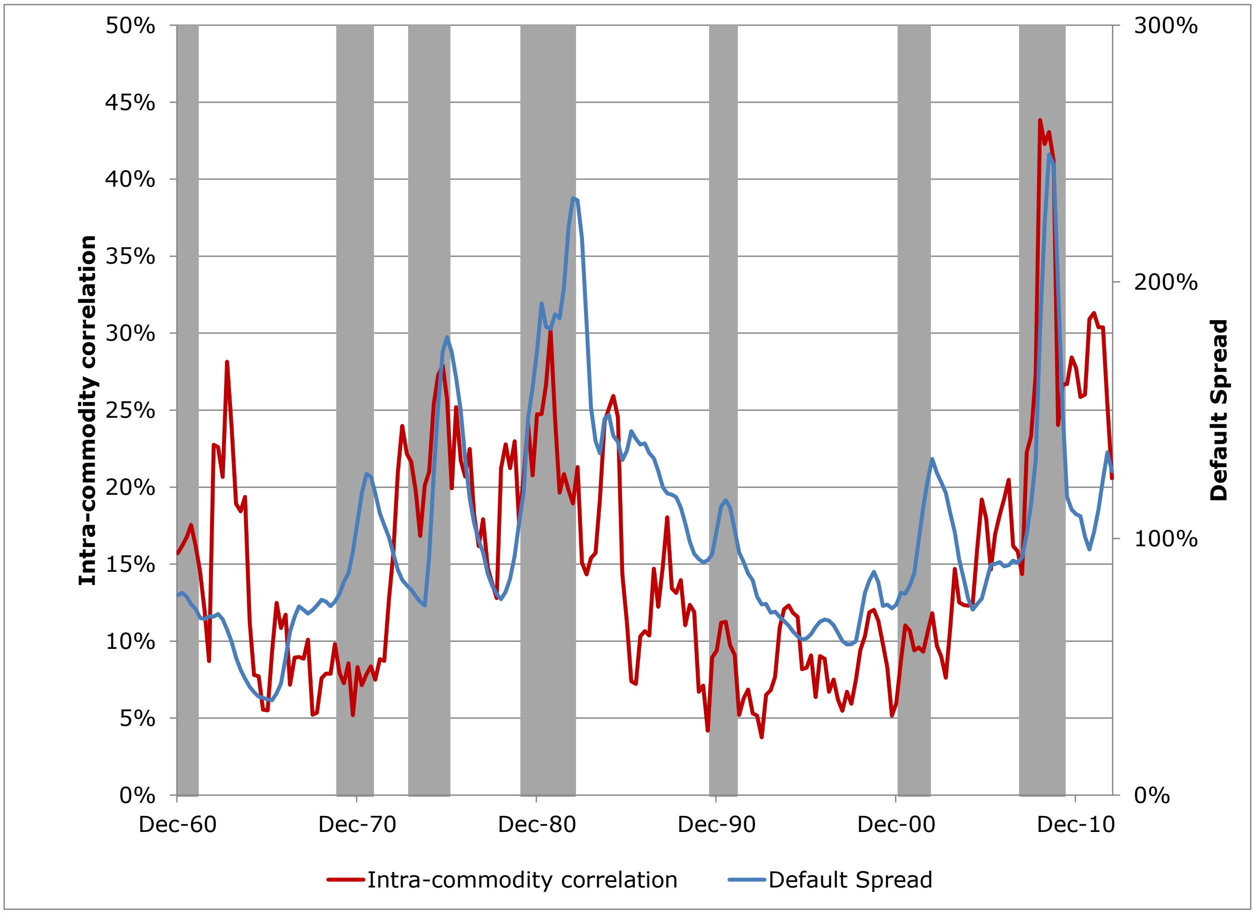


Figure 2 Intra-commodities correlation, and Default spread, Overlapping annual Data (1960-2012)



Note: Figure displays Intra-commodity correlation measured over an annual horizon. The figure also displays average default spread for the year, and recessions as identified by the NBER (shaded Region).

Figure 3.A Observed and model fitted Stock-commodity correlation

Overlapping Annual Data (1961-2012)

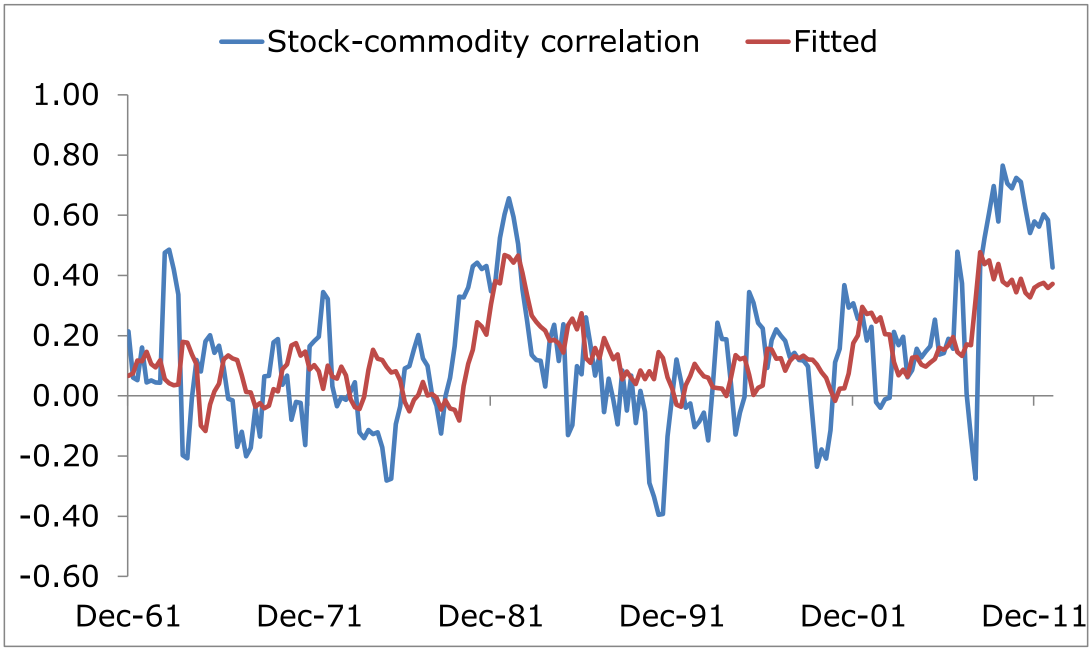


Figure 3.B Observed and model fitted Intra-commodity correlation

Overlapping Annual Data (1961-2012)