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The Tactical and Strategic Value of Commodity Futures

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Overview

- The term structure of commodity prices has been the driver of past returns
 and it will most likely be the driver of future returns
- Many previous studies suffer from serious shortcomings
 - Much of the analysis in the past has confused the "diversification return" (active rebalancing) with a risk premium
- Keynes' theory of "normal backwardation" is rejected in the data
 - Hence, difficult to justify a 'long-only' commodity futures exposure
- Commodity futures provide a dubious inflation hedge
- Commodity futures are tactical strategies that can be overlaid on portfolios
 The most successful portfolios use information about the term structure

What can we learn from historical returns? December 1969 to May 2004

- The GSCI is a cash collateralized portfolio of long-only commodity futures
 - Began trading in 1992, with history backfilled to 1969



Note: GSCI is collateralized with 3-month T-bill.

What can we learn from historical returns? January 1991 to May 2004

	Average	Standard	Correlation						
	return	deviation	1	2	3	4	5		
1. GSCI	6.81%	17.53%							
2. DJ AIG	7.83%	11.71%	0.89						
3. CRB	3.64%	8.30%	0.66	0.83					
4. Wilshire 5000	11.60%	14.77%	0.06	0.13	0.18				
5. EAFE	5.68%	15.53%	0.14	0.22	0.27	0.70			
6. Lehman Aggregate	7.53%	3.92%	0.07	0.03	-0.02	0.07	0.03		



Erb-Harvey (2005)

Comparison begins in January 1991 because this is the initiation date for the DJ AIG Commodity Index. Cash collateralized returns

Market Value of Long Open Interest As May 2004

- There are three commonly used commodity futures indices
 - The GSCI futures contract has the largest open interest value
 - The equally weighted CRB index is seemingly the least popular index
- Long open interest value is not market capitalization value
 - Long and short open interest values are always exactly offsetting



The Composition of Commodity Indices in May 2004

- Commodity futures index weighting schemes vary greatly
 - An important reason that commodity index returns vary
 - <u>Commodity indices are active portfolios</u>

_				<u>Portfolio</u> V	Veights				
<u>Commodity</u>	CRB	GSCI	DJ AIG	''Market''	<u>Commodity</u>	CRB	<u>GSCI</u>	DJ AIG	''Market''
Aluminum	-	2.9%	7.1%	11.4%	Live Cattle	5.9%	3.6%	6.7%	1.9%
Cocoa	5.9%	0.3%	2.0%	0.9%	Natural Gas	5.9%	9.5%	9.9%	12.4%
Coffee	5.9%	0.6%	2.8%	2.1%	Nickel	-	0.8%	1.9%	2.1%
Copper	5.9%	2.3%	6.7%	10.4%	Orange Juice	5.9%	-	-	0.2%
Corn	5.9%	3.1%	5.1%	2.6%	P latinum	5.9%	0.0%	-	0.1%
Cotton	5.9%	1.1%	1.8%	1.1%	Silver	5.9%	0.2%	2.2%	1.3%
Crude Oil	5.9%	28.4%	16.7%	16.8%	Soybeans	5.9%	1.9%	5.1%	3.4%
Brent Crude Oil	-	13.1%	-	7.7%	Soybean Oil	-	0.0%	1.7%	0.8%
Feeder Cattle	-	0.8%	-	0.5%	Sugar	5.9%	1.4%	3.8%	1.3%
GasOil	-	4.5%	-	3.3%	Tin	-	-	-	0.3%
Gold	5.9%	1.9%	5.3%	5.1%	Unleaded Gas	-	8.5%	5.4%	4.2%
Heating Oil	5.9%	8.1%	4.7%	4.3%	Wheat	5.9%	2.9%	3.8%	1.6%
Lead	-	0.3%	-	0.6%	Red Wheat	-	1.3%	0.0%	0.2%
Hogs	5.9%	2.1%	5.1%	0.9%	Zinc	-	0.5%	2.3%	2.5%
					Total	100%	100%	100%	100%
Portfolio Weight	Correlatio r	1							
	CRB	GSCI	DJ AIG	''Market''					

1.00

Contracts

1.00

0.08

0.42

0.10

1.00

0.72

0.78

1.00

0.81

CRB

GSCI

DJ AIG

"Market"

20

28

24

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GSCI Portfolio Weights Have Changed Over Time

- Individual GSCI commodity portfolio weights vary as a result of
 - (1) Changes in "production value" weights and (2) New contract introductions
- As a result, it is hard to determine the "commodity asset class" return



CRB Portfolio Weights Have Changed Over Time

- CRB index weights look like they have changed in an orderly way
- However, this only shows weights consistent with the <u>current</u> composition of the CRB
 - Actual historical CRB weight changes have been more significant,
 - for example, in 1959 there were 26 commodities



Cash Collateralized Commodity Futures Total Returns December 1982 to May 2004

• If individual commodity futures returns cluster around the returns of an index, an index might be a good representation of the "commodity asset class" return



Annualized Standard Deviation of Return

Commodities Index Return vs. Asset Class Return

- A commodity futures index is just a portfolio of commodity futures. Returns are driven by:
 - 1. The portfolio weighting scheme and
 - 2. The return of individual securities
- It is important to separate out the "active" component (portfolio weights change) from the underlying "asset class" returns
- Ultimately, a "commodity asset class" return estimate requires a view as to what drives <u>individual</u> commodity returns

The Diversification Return and Rebalancing

• A 50% heating oil/50% stock portfolio had an excess return of 10.95%

Hasting Oil

- Heating oil had an excess return of 8.21%, this might have been a "risk premium"
- Stocks had an excess return of 6.76%, this might have been a "risk premium" S&D 500

		Excess Return	Excess Return	Excess Return	Excess Return	
	1994	19.96%	-2.92%	8.52%	8.52%	
	1995	7.73%	31.82%	19.78%	18.51%	
	1996	67.37%	17.71%	42.54%	42.66%	
	1997	-35.06%	28.11%	-3.48%	-9.13%	
	1998	-50.51%	23.51%	-13.50%	-7.67%	
	1999	73.92%	16.30%	45.11%	29.31%	
	2000	66.71%	-15.06%	25.82%	9.77%	
	2001	-36.62%	-15.97%	-26.30%	-25.49%	
	2002	41.40%	-23.80%	8.80%	1.78%	
	2003	21.90%	27.62%	24.76%	24.50%	
	Geometric Return	8.21%	6.76%	10.95%	7.51%	
	Standard Deviation	46.07%	21.06%	23.11%	20.34%	
	Average Weights					
	Equal Weight	50.00%	50.00%		Diversific	ation return
	Let-It-Run	44.94%	55.06%		is not just reducti	t a variance ion effect
	Weighted Average					
	Geometric Mean			7.49%	7.41%	
Erb-Harvey (2005	Diversification Return			3.46%	0.10%	11

Faugl Weighted

Lat It Dun

Classic Bodie and Rosansky Commodity Futures Portfolio 1949 to 1976

- Bodie and Rosansky looked at a universe of up to 23 commodity futures and calculated the return of an equally weighted portfolio
- How large was the diversification return in their study?



B-R Commodity — T-Bill

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Classic Bodie and Rosansky Commodity Futures Portfolio 1949 to 1976

- The Bodie and Rosansky rebalanced equally weighted commodity futures portfolio had a geometric excess return of 8.5% and a diversification return of 10.2%
- Bodie and Rosansky mistook a diversification return for a risk premium

	Arithmetic Excess Return	Standard Deviation	Variance	Average Correlation	Number of Years		Arithmetic Excess Return	Standard Deviation	Variance	Average Correlation	Number of Years
-						Ī					
1 Wheat	3.18%	30.75%	9.45%	0.28	27	19 Hogs	13.28%	36.62%	13.41%	0.30	10
2 Corn	2.13%	26.31%	6.92%	0.34	27	20 Broilers	13.07%	39.20%	15.37%	0.22	8
3 Oats	1.68%	19.49%	3.80%	0.25	27	21 Propane	68.26%	202.09%	408.40%	0.07	8
4 Soybeans	13.58%	32.32%	10.44%	0.28	27	22 Lumber	13.07%	34.67%	12.02%	0.19	7
5 Soybean Oil	25.84%	57.67%	33.26%	0.25	27	23 Plywood	17.97%	39.96%	15.97%	0.17	6
6 Soybean Meal	11.87%	35.60%	12.67%	0.20	27						
7 Potatoes	6.91%	42.11%	17.73%	0.18	27						
8 Wool	7.44%	36.96%	13.66%	0.19	27						
9 Cotton	8.94%	36.24%	13.13%	0.20	27						
10 Eggs	-4.74%	27.90%	7.78%	0.11	27						
11 Cocoa	15.71%	54.63%	29.84%	0.06	23						
12 Copper	19.79%	47.21%	22.28%	0.12	23						
13 Sugar	25.40%	116.22%	135.06%	0.15	23						
14 Silver	3.59%	25.62%	6.56%	0.23	13						
15 Cattle	7.36%	21.61%	4.67%	0.17	12						
16 Pork Bellies	16.10%	39.32%	15.46%	0.25	12						
17 Platinum	0.64%	25.19%	6.34%	0.21	11						
18 Orange Juice	2.51%	31.77%	10.09%	0.07	10						

Note: Zvi Bodie and Victor Rosansky study covered 23 commodity futures over the period 1949 to 1976.

Portfolio Geometric Retur	12.14%	
T-Bill Return	3.62%	
Excess Return	8.52%	
Diversification Return	10.23%	(Average Variance-Portfolio Varaince)/2
"Risk Premium"	-1.71%	

Classic Bodie and Rosansky Commodity Futures Portfolio

- Bodie and Rosanksy report the geometric total return of their portfolio
- However, investors are interested in a "risk premium"
- After accounting for the T-bill return and the diversification return
 - The "risk premium" is close to zero



All Data Exclude 1973

Gorton and Rouwenhorst Commodities Futures Portfolio 1959 to 2004

- 20 years later, Gorton and Rouwenhorst (2005) consider another equally weighted portfolio
 - Had a geometric excess return of about 4% and a diversification return of about 4%

	Geometric	Geometric				Number		Geometric	Geometric				Number
	Total	Excess	Standard		Average	of		Total	Excess	Standard		Average	of
	Return	Return	Deviation	Variance	Correlation	Months		Return	Return	Deviation	Variance	Correlation	Months
1 Copper	12.16%	6.42%	27.04%	7.31%	0.15	546	19 Coffee	7.68%	1.33%	39.95%	15.96%	0.04	388
2 Cotton	5.38%	-0.36%	23.27%	5.41%	0.05	546	20 Gold	2.65%	-3.63%	19.34%	3.74%	0.13	360
3 Cocoa	4.18%	-1.56%	31.59%	9.98%	0.04	546	21 Palladium	6.67%	0.33%	36.24%	13.13%	0.13	335
4 Wheat	0.74%	-5.00%	22.73%	5.17%	0.14	546	22 Zinc	5.99%	-0.35%	22.11%	4.89%	0.13	335
5 Corn	-1.90%	-7.64%	22.16%	4.91%	0.16	546	23 Lead	4.78%	-1.56%	22.74%	5.17%	0.13	334
6 Soybeans	5.84%	0.10%	26.02%	6.77%	0.17	546	24 Heating Oil	13.62%	7.28%	32.74%	10.72%	0.11	313
7 Soybean Oil	9.03%	3.29%	31.28%	9.78%	0.12	546	25 Nickel	10.51%	4.23%	36.83%	13.56%	0.10	308
8 Soybean Meal	9.38%	3.64%	31.67%	10.03%	0.16	546	26 Crude Oil	15.24%	9.98%	33.59%	11.28%	0.11	261
9 Oats	-1.22%	-6.96%	29.24%	8.55%	0.09	546	27 Unleaded Gas	18.73%	13.84%	34.49%	11.90%	0.11	240
10 Sugar	2.12%	-3.71%	44.58%	19.87%	0.05	527	28 Rough Rice	-5.59%	-10.27%	30.42%	9.25%	0.03	220
11 Pork Bellies	3.35%	-2.53%	35.98%	12.95%	0.10	519	29 Aluminum	3.72%	-0.91%	24.07%	5.79%	0.10	210
12 Silver	2.83%	-3.19%	31.60%	9.99%	0.14	498	30 Propane	20.61%	15.99%	49.40%	24.40%	0.08	208
13 Live Cattle	11.39%	5.28%	17.96%	3.23%	0.10	481	31 Tin	0.91%	-3.38%	17.77%	3.16%	0.11	185
14 Live Hogs	11.81%	5.64%	26.78%	7.17%	0.13	466	32 Natural Gas	1.70%	-2.40%	51.93%	26.97%	0.07	176
15 Orange Juice	6.30%	0.10%	32.76%	10.73%	-0.02	454	33 Milk	3.93%	0.25%	19.42%	3.77%	-0.01	107
16 Platinum	6.06%	-0.19%	28.49%	8.12%	0.15	441	34 Butter	17.06%	13.50%	40.06%	16.05%	0.01	99
17 Lumber	1.91%	-4.35%	29.80%	8.88%	0.04	422	35 Coal	-4.47%	-5.93%	22.01%	4.84%	0.16	41
18 Feeder Cattle	7.90%	1.61%	17.17%	2.95%	0.07	397	36 Electricity	-54.56%	-55.77%	40.24%	16.19%	0.09	20

Portfolio Geometric Return	9.98%	from Table 1, page 10, February 2005 version
T-Bill Return	5.60%	
Excess Return	4.38%	
Diversification Return	3.82%	(Average Varaince - Portfolio Variance)/2
Risk Premium	0.56%	

Gorton and Rouwenhorst Commodities Futures Portfolio 1959 to 2004

- After accounting for the T-bill return and the diversification return
 - The "risk premium" is close to zero



Factors that drive the diversification return

- A number of factors drive the size of the diversification return
 - Time period specific security correlations and variances
 - Number of assets in the investment universe
 - Rebalancing frequency
- The pay-off to a rebalancing strategy is not a risk premium



Common risk factors do not drive commodity futures

eturns	S&P 500					
	Excess	Term	Default			
-	Return	Premium	Premium	SMB	HML	ΔDollar
GSCI	-0.05	-0.05	-0.25	0.07	-0.06	-0.57 **
Non-Energy	0.10 **	-0.11	-0.03	0.05	0.00	-0.05
Energy	-0.14	-0.17	-0.07	0.04	-0.07	-1.05 **
Livestock	0.06	0.05	-0.23	0.05	0.04	0.09
Agriculture	0.09	-0.01	-0.12	0.06	-0.02	0.10
Industrial Metals	0.16 *	-0.32 **	1.18 ***	0.19	-0.05	-0.35
Precious Metals	-0.08	-0.15	0.42	0.14 *	-0.03	-0.83 **
Heating Oil	-0.13	-0.22	-0.14	0.06	-0.16	-0.91 **
Cattle	0.07	0.01	-0.10	0.11	-0.01	0.21
Hogs	0.03	0.15	-0.45	-0.04	0.13	-0.08
Wheat	0.11	0.04	-0.42	0.19 *	-0.12	-0.18
Corn	0.11	0.00	0.13	0.09	-0.01	0.55 *
Soybeans	0.04	-0.07	0.13	-0.02	0.08	-0.07
Sugar	0.05	-0.11	-0.43 *	0.16	-0.09	0.12
Coffee	0.13	-0.15	0.38	-0.25 *	0.16	-0.22
Cotton	0.18	-0.41	0.88	-0.08	0.03	0.46
Gold	-0.15 **	-0.12	0.39	0.12 ***	-0.04	-0.91 ***
Silver	0.08	-0.52 ***	• 1.16 ***	0.32 **	-0.02	-0.39
Copper	0.21 **	-0.31 *	1.15 ***	0.16	0.00	-0.42
Twelve Commodity Average	0.06	-0.14 **	0.22	0.07	0.00	-0.15

Erb-Harvey (2005)

Note: *, **, *** significant at the 10%, 5% and 1% levels.

The Components of Commodity Futures Excess Returns

- The excess return of a commodity futures contract has two components
 - Roll return and
 - Spot return
- The roll return comes from maintaining a commodity futures position must sell an expiring futures contract and buy a yet to expire contract
 - must sell an expiring futures contract and buy a yet to expire contract
- The spot return comes from the change in the price of the nearby futures contract
- The key driver of the roll return is the term structure of futures prices
 - Similar to the concept of "rolling down the yield curve"
- The key driver of the spot return might be something like inflation

What Drives Commodity Futures Returns? The Term Structure of Commodity Prices

- Backwardation refers to futures prices that decline with time to maturity
- Contango refers to futures prices that rise with time to maturity



What Drives Commodity Futures Returns? The Roll Return and the Term Structure

- The term structure can produce a "roll return"
- The roll return is a return from the passage of time,
 - assuming the term structure does not change
- The greater the slope of the term structure, the greater the roll return



If the term structure remains unchanged between two dates. the roll return Is a passage of time return

Roll return should be positive if the term structure is downward sloping. Negative if upward sloping

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The 'Theory' of Normal Backwardation

- Normal backwardation is the most commonly accepted "driver" of commodity future returns
- "Normal backwardation" is a long-only risk premium "explanation" for futures returns
 - Keynes coined the term in 1923
 - It provides the justification for long-only commodity futures indices

• Keynes on Normal Backwardation

"If supply and demand are balanced, <u>the spot price must exceed the forward price by the amount which</u> <u>the producer is ready to sacrifice in order to "hedge" himself</u>, i.e., to avoid the risk of price fluctuations during his production period. Thus in normal conditions the spot price exceeds the forward price, i.e., there is a backwardation. In other words, the normal supply price on the spot includes remuneration for the risk of price fluctuations during the period of production, whilst the forward price excludes this."

A Treatise on Money: Volume II, page 143

The 'Theory' of Normal Backwardation

- What normal backwardation says
 - Commodity futures provide "hedgers" with price insurance, risk transfer
 - "Hedgers" are net long commodities and net short futures
 - Futures trade at a discount to expected future spot prices
 - <u>A long futures position should have a positive expected excess return</u>
- How does normal backwardation tie into the term structure of commodity futures prices?
- What is the empirical evidence for normal backwardation and positive risk premia?

The 'Theory' of Normal Backwardation

- Normal backwardation says commodity futures prices are downward biased forecasts of <u>expected</u> future spot prices
- Unfortunately, expected future spot prices are unobservable. Nevertheless, the theory implies that commodity futures <u>excess returns should be positive</u>



Evidence on Normal Backwardation

- Positive "energy" excess returns are often taken as "proof" of normal backwardation
- How robust is this "evidence"?



Evidence on Normal Backwardation

- As we saw earlier, the gold term structure sloped upward
- Normal backwardation says
 - The excess return from gold futures should be positive
 - Expected future spot prices should be above the futures prices



Note: commodity price term structure as of May 30th, 2004

Evidence on Normal Backwardation

• But gold futures excess returns have been negative



Evidence on Normal Backwardation December 1982 to May 2004

- Normal backwardation asserts that commodity futures excess returns should be positive ۲
- Historically, many commodity futures have had negative excess returns ٠
 - This is not consistent with the prediction of normal backwardation _
 - "Normal backwardation is not normal"*



Annualized Standard Deivation Of Return

What Drives Commodity Futures Returns? The Roll Return and the Term Structure (December 1982 to May 2004)

- A "visible" term structure drives roll returns, and roll returns have driven excess returns
- An "invisible" futures price/expected spot price "discount" drives normal backwardation
- What about spot returns?
 - Changes in the level of prices, have been relatively modest
 - Under what circumstances might spot returns be high or low?



Return T-Statistics December 1982 to May 2004

- Roll return t-stats have been much higher than excess return or spot return t-stats
 - Average absolute value of roll return t-stat: 3.5
 - Average absolute value of spot return t-stat: 0.25
 - Average absolute value of excess return t-stat: 0.91



What Drives Commodity Futures Returns? Pulling It All Together

• The excess return of a commodity future has two components

Excess Return = Roll Return + Spot Return

• If spot returns average zero, we are then left with a rule-of-thumb

Excess Return ~ Roll Return

• The expected future excess return, then, is the expected future roll return

Are Commodity Futures an Inflation Hedge?

- What does the question mean?
 - Are "commodity futures" correlated with inflation?
 - Do all commodities futures have the same inflation sensitivity?
- Do commodity futures hedge unexpected or expected inflation?
- Are commodities an inflation hedge if the real price declines
 - Even though excess returns might be correlated with inflation?

Are Commodity Futures an Inflation Hedge?

- We will look at the correlation of commodity futures excess returns with the Consumer Price Index
- Yet the CPI is just a portfolio of price indices
 - The CPI correlation is just a weighted average of sub-component correlations



Expected or Unexpected Inflation Correlation? 1969 to 2003

- An inflation hedge should, therefore, be correlated with unexpected inflation
- Historically, the GSCI has been highly correlated with unexpected inflation
- However, the GSCI is just a portfolio of individual commodity futures
 - Do all commodity futures have the same unexpected inflation sensitivity?



Year-over-Year Change In Inflation Rate

Note: in this example the actual year-over-year change in the rate of inflation is the measure of unexpected inflation

Expected or Unexpected Inflation Correlation? Annual Observations, 1982 to 2003

	Intercept	Inflation	Inflation	Δ Inflation Δ	Inflation	Adjusted
	T-Stat	Coefficient	T-Stat	Coefficient	T-Stat	R Square
GSCI	-0.38	3.92	0.93	10.88	2.98	28.0%
Non-Energy	-0.64	1.84	0.71	3.94	1.77	6.0%
Energy	-0.36	7.50	0.97	18.80	2.81	24.5%
Livestock	-1.15	4.73	1.49	6.88	2.51	17.6%
Agriculture	-0.67	1.68	0.48	1.06	0.35	-9.6%
Industrial Metals	0.26	1.20	0.15	17.44	2.59	26.7%
Precious Metals	2.36	-8.02	-2.95	-2.78	-1.19	26.2%
Heating Oil	-0.26	6.07	0.81	17.76	2.73	23.9%
Cattle	-0.75	4.00	1.38	7.19	2.87	24.0%
Hog	-1.23	6.32	1.24	6.47	1.48	2.0%
Wheat	-0.87	3.09	0.67	-2.58	-0.64	-0.1%
Corn	-1.37	5.91	1.15	4.44	1.00	-2.6%
Soybeans	1.17	-5.95	-1.11	-1.10	-0.24	-2.8%
Sugar	0.06	-0.06	-0.01	3.56	0.61	-7.7%
Coffee	0.11	-0.81	-0.07	0.24	0.02	-11.0%
Cotton	0.31	-0.51	-0.08	0.30	0.05	-11.0%
Gold	2.02	-7.50	-2.58	-2.38	-0.95	20.3%
Silver	2.16	-10.18	-2.89	-4.45	-1.46	24.3%
Copper	0.27	1.43	0.18	17.08	2.45	23.8%
EW 12 Commodities	0.14	0.15	0.06	3.88	1.74	10.3%

No R-Squared higher than 30% That means the "tracking error" of commodity futures relative to inflation is close to the own standard deviation of each commodity future.

If the average commodity future own standard deviation is about 25%, it is hard to call this a good statistical hedge.

Annualized Excess Return and Inflation Changes Annual Observations, 1982 to 2003

A positive inflation beta does not necessarily mean commodity future's excess • return is positive when inflation rises

		Excess Return		Roll Return				
	When Inflation Rises	When Inflation Falls	Difference	When Inflation Rises	When Inflation Falls	Difference		
GSCI	22.2%	-8.2%	30.5%	6.6%	-0.3%	6.9%		
Non-Energy	1.7%	-2.3%	4.0%	-0.8%	-0.8%	0.0%		
Energy	41.0%	-14.2%	55.1%	14.7%	0.0%	14.7%		
Livestock	8.8%	-3.9%	12.7%	0.9%	1.8%	-0.9%		
Agriculture	-5.7%	-1.8%	-3.9%	-5.5%	-3.0%	-2.5%		
Industrial Metals	15.2%	-4.3%	19.6%	9.3%	-4.1%	13.3%		
Precious Metals	-7.2%	-3.6%	-3.5%	-5.0%	-4.2%	-0.9%		
Heating Oil	36.9%	-14.4%	51.3%	10.1%	0.4%	9.6%		
Cattle	10.8%	-0.9%	11.7%	2.9%	2.8%	0.1%		
Hogs	5.5%	-10.2%	15.7%	-6.0%	-1.6%	-4.4%		
Wheat	-10.6%	-1.1%	-9.5%	-8.8%	-5.3%	-3.5%		
Corn	-6.6%	-7.3%	0.7%	-9.1%	-8.0%	-1.1%		
Soybeans	-3.7%	1.8%	-5.5%	-3.6%	-1.9%	-1.7%		
Sugar	-2.7%	-4.8%	2.2%	-1.4%	-6.6%	5.2%		
Coffee	-10.8%	-6.0%	-4.8%	-5.7%	-3.8%	-1.9%		
Cotton	1.8%	1.6%	0.2%	-4.8%	3.1%	-7.8%		
Gold	-7.1%	-4.0%	-3.1%	-5.5%	-4.4%	-1.1%		
Silver	-13.8%	-4.4%	-9.4%	-5.9%	-5.2%	-0.7%		
Copper	15.3%	-2.6%	17.9%	10.2%	-1.8%	12.0%		
Avg. Inflation Change	0.9%	-0.9%		0.9%	-0.9%			
Erb-Harvey (2005)		- 10 10			- // / *	36		
Unexpected Inflation Betas and Roll Returns December 1982 to December 2003

• Commodity futures with the highest roll returns have had the highest unexpected inflation betas



Erb-Harvey (2005)

Commodity Prices and Inflation 1959 to 2003

- The only long-term evidence is for commodity <u>prices</u>, not commodity <u>futures</u>
- In the long-run, the average commodity trails inflation



Correlation of Commodity Prices and Inflation 1959 to 2003

- The challenge for investors is that
 - Commodities might be correlated with inflation, to varying degrees, but
 - The longer-the time horizon the greater the expected real price decline



The Economist Industrial Commodity Price Index 1862 to 1999

- Very long-term data shows that
 - Commodities have had a real annual price decline of 1% per year, and an "inflation beta" of about 1
- Short-run hedge and a long-run charity



Erb-Harvey (2005)

The Economist Industrial Commodity Price Index 1862 to 1999

- The commodities-inflation correlation seems to have declined



Are Commodity Futures A Business Cycle Hedge?

- From December 1982 to May 2004
 - There were 17 recession months and 240 expansion months
- In this very short sample of history, commodity futures had <u>poor</u> recession returns

	<u>-</u>	LACCSS INCLU	<u>111</u>		<u>spor Retur</u>	<u>11</u>	<u>Kon Ketunn</u>				
_	Overall	Expansion	Contraction	Overall	Expansion	Contraction	Overall	Expansion	Contracti		
GSCI	4.49%	5.93%	-13.87%	1.89%	3.48%	-18.11%	2.59%	2.45%	4.23%		
Non-Energy	-0.12%	0.66%	-10.59%	0.67%	1.28%	-7.54%	-0.80%	-0.62%	-3.05%		
Energy	7.06%	8.82%	-14.98%	1.69%	3.85%	-24.38%	5.37%	4.97%	9.40%		
Livestock	2.45%	2.83%	-2.72%	1.20%	1.94%	-8.61%	1.25%	0.89%	5.88%		
Agriculture	-3.13%	-2.02%	-17.54%	0.64%	1.08%	-5.43%	-3.77%	-3.10%	-12.11%		
Industrial Metals	4.00%	5.34%	-13.10%	3.17%	4.76%	-16.92%	0.83%	0.57%	3.82%		
Precious Metals	-5.42%	-5.06%	-10.38%	-0.84%	-0.36%	-7.31%	-4.58%	-4.69%	-3.07%		
Heating Oil	5.53%	6.51%	-7.35%	0.93%	2.65%	-20.45%	4.60%	3.86%	13.10%		
Cattle	5.07%	5.85%	-5.35%	1.97%	2.99%	-11.42%	3.10%	2.86%	6.07%		
Hogs	-2.75%	-3.19%	3.78%	0.26%	0.60%	-4.45%	-3.01%	-3.80%	8.23%		
Wheat	-5.39%	-4.44%	-17.85%	0.57%	0.41%	2.85%	-5.96%	-4.85%	-20.719		
Corn	-5.63%	-4.67%	-18.21%	1.57%	1.87%	-2.67%	-7.19%	-6.54%	-15.55%		
Soybeans	-0.35%	0.35%	-9.76%	1.80%	2.36%	-5.79%	-2.15%	-2.01%	-3.96%		
Sugar	-3.12%	-2.03%	-17.27%	0.30%	2.23%	-23.39%	-3.42%	-4.26%	6.12%		
Coffee	-6.36%	-3.51%	-38.66%	-1.24%	0.40%	-21.65%	-5.12%	-3.91%	-17.029		
Cotton	0.10%	1.89%	-22.12%	-0.62%	0.25%	-12.14%	0.72%	1.65%	-9.98%		
Gold	-5.68%	-5.72%	-5.15%	-0.79%	-0.71%	-1.92%	-4.90%	-5.01%	-3.23%		
Silver	-8.09%	-6.82%	-24.29%	-2.54%	-1.23%	-19.26%	-5.55%	-5.59%	-5.03%		
Copper	6.17%	7.73%	-13.57%	3.28%	5.02%	-18.44%	2.89%	2.70%	4.86%		
Average _	-1.71%	-0.67%	-14.65%	0.46%	1.40%	-11.56%	-2.17%	-2.07%	-3.09%		
(2005)											

GSCI As An Equity Hedge? December 1969 to May 2004

• No evidence that commodity futures are an equity hedge



S&P 500 Monthly Excess Return

GSCI As A Fixed Income Hedge? December 1969 to May 2004

No evidence that commodity futures are a fixed income hedge ٠



Returns largely uncorrelated ٠

Commodity Futures Strategic Asset Allocation December 1969 to May 2004

- Historically, cash collateralized commodity futures have been a no-brainer
 - Raised the Sharpe ratio of a 60/40 portfolio
- What about the future?
- How stable has the GSCI excess return been over time?



One-Year Moving-Average GSCI Excess and Roll Returns December 1969 to May 2004

- However, the excess return "trend" seems to be going to wrong direction
 - Excess and roll returns have been trending down
- Is too much capital already chasing too few long-only "insurance" opportunities?
 - No use providing more "risk transfer" than the market needs



So Now What?

- Let's look at four tactical approaches
- Basically this says go long or short commodity futures based on a signal
- Since the term structure seems to drive long-term returns,
 - Use the term structure as a signal
- Since the term structure is correlated with returns,
 - Use momentum as a term structure proxy

1. Using the Information in the Overall GSCI Term Structure for a Tactical Strategy July 1992 to May 2004

• When the price of the nearby GSCI futures contract is greater than the price of the next nearby futures contract (when the GSCI is backwardated), we expect that the long-only excess return should, on average, be positive.

	Compound		
	Annualized	Annualized	
	Excess	Standard	Sharpe
	Return	Deviation	Ratio
GSCI Backwardated	11.25%	18.71%	0.60
GSCI Contangoed	-5.01%	17.57%	-0.29
Long if Back wardated, Short if Contangoed	8.18%	18.12%	0.45
Cash Collateralized GSCI	2.68%	18.23%	0.15

2. Overall GSCI Momentum Returns

December 1982 to May 2004

- Go long the GSCI for one month if the previous one year excess return has been positive or go short the GSCI if the previous one year excess return has been negative.
- Momentum can then been seen as a "term structure proxy"



3. Individual Commodity Term Structure Portfolio December 1982 to May 2004

• Go long the six most backwardated constituents and go short the six least backwardated constituents.



Trading strategy is an equally weighted portfolio of twelve components of the GSCI. The portfolio is rebalanced monthly. The 'Long/Short' portfolio goes long those six components that each month have the highest ratio of nearby future price to next nearby futures price, and the short portfolio goes short those six components that each month have the lowest ratio of nearby futures price to next nearby futures price. 50

4a. Individual Commodity Momentum Portfolios December 1982 to May 2004

 Invest in an equally-weighted portfolio of the four commodity futures with the highest prior twelve-month returns, a portfolio of the worst performing commodity futures, and a long/short portfolio.
 Compound Annualized



Erb-Harvey (2005)

Trading strategy sorts each month the 12 categories of GSCI based on previous 12-month return. We then track the four GSCI components with the highest ('best four') and lowest ('worst four') previous returns. The portfolios are rebalanced monthly.

4b. Individual Commodity Momentum Portfolio Based on the Sign of the Previous Return

December 1982 to May 2004

- Buy commodities that have had a positive return and sell those that have had a negative return over the past 12 months.
- It is possible that in a particular month that all past returns are positive or negative.
- Call this the "providing insurance" portfolio.



Trading strategy is an equally weighted portfolio of twelve components of the GSCI. The portfolio is rebalanced monthly. The 'Providing Insurance' portfolio goes long those components that have had positive returns over the previous 12 months and short those components that had negative Erb-Harvey (2005) returns over the previous period. 52

Conclusions

- The expected future excess return is mainly the expected future roll return
- Sometimes the diversification return is confused with the average excess return
- Standard commodity futures 'faith-based' argument is flawed
 That is, normal backwardation is rejected in the data
- Alternatively, invest in what you actually know
 - The term structure
- Long-only investment only makes sense if all commodities are backwardated
- If the term structure drives returns, long-short seems like the best strategy

Supplementary Exhibits

Ten Year Investment Horizon Stock And Commodity Returns 1862 to 1999

- How high must inflation be for commodities to beat stocks?

Erb-Harvey (2005)

Note: Economist Commodity Index and Nominal Stock Return Index and Bill Index from Jeremey Siegel.com (www.jeremysiegel.com)

Expected Diversification Return Sharpe Ratio

- Assume a universe of uncorrelated securities
- The number of portfolio assets drives the diversification return Sharpe ratio

Number Of Securities In An Equally Weighted Rebalanced Portfolio

56

Note: Diversification return ~ Average Variance / 2, portfolio variance = Average Variance / N, and Sharpe ratio = $((1-1/N)^*$ Average Variance / 2)/ (Average Erb-Harvey (2005) Variance / N)^{1/2} ~ Average Standard Deviation * N^{1/2} / 2

Expected Diversification Returns

- What if, over time, volatility varies between 20% and 30%
- Which has a higher diversification return
 - A portfolio with an average standard deviation of 25%, or
 - A portfolio half the time with a 20% or 30% standard deviation

Number Of Securities In An Equally Weighted Rebalanced Portfolio

Commodity Futures: Diversification Return

- Diversification return calculations require a constant composition asset universe
- When the size of the asset universe changes,
 - the diversification return has to be recalculated

		Annualize	ed Geometric Exce	ess Return	
	Dec. 1959 to	Dec. 1969 to	Dec. 1979 to	Dec. 1989 to	Dec. 1999 to
	Jan. 2005	Jan.2005	Jan. 2005	Jan. 2005	Jan. 2005
Corn	1.22%	1.40%	-1.52%	-1.29%	-0.73%
Soybeans	1.98%	2.12%	-0.87%	-0.65%	2.16%
Wheat	0.79%	1.96%	-1.76%	-2.24%	3.15%
Live Cattle		3.26%	0.98%	1.02%	5.58%
Lean Hogs		2.00%	1.09%	0.77%	6.14%
Gold			-0.99%	0.27%	7.68%
Silver		3.65%	-6.43%	1.71%	4.28%
Copper	3.30%	1.96%	1.25%	2.00%	10.52%
Cocoa	2.06%	1.91%	-2.60%	3.37%	12.53%
Coffee			-2.15%	1.88%	-3.44%
Sugar #11		3.37%	-2.25%	-2.33%	8.40%
Cotton	0.61%	1.52%	-2.08%	-2.98%	-2.87%
Orange Juice		1.87%	-0.60%	-4.54%	-1.53%
Platinum		4.81%	0.93%	3.95%	14.96%
Crude Oil				5.39%	13.26%
Heating Oil			1.91%	1.79%	13.78%
Natural Gas					21.70%
Oats	1.78%	2.79%	0.18%	0.57%	8.74%
Unleaded Gas				4.99%	13.54%
Average Geometric Return	1.67%	2.51%	-0.93%	0.76%	7.25%
Rebalanced EW Portfolio	4.34%	6.64%	3.08%	4.59%	12.83%
Diversification Return	2.66%	4.14%	4.02%	3.83%	5.58%

Estimating The Size Of The Diversification Return Varing Asset Universe Size July 1959 to February 2005

- The CRB commodity futures index is an example of a changing asset mix universe
 - The initial portfolio composition is different from the ending portfolio composition
- A way to calculate the diversification return for an equally weighted portfolio over time
 - Is to create "sub-period constant mix portfolios"
- This makes it possible to calculate sub-period diversification returns

Geomteric Returns	7/59-1/61	1/61-8/63	8/63-11/64	11/64-2/66	2/66-2/67	2/67-3/68	3/68-8/72	8/72-12/74	12/74-11/78	11/78-3/83	3/83-12/84	12/84-3/90	3/90-2/05	7/59-2/05
CRB	-1.32%	0.71%	4.67%	0.16%	-5.98%	-1.09%	3.86%	26.05%	3.13%	1.18%	0.49%	0.12%	1.47%	
Corn	-2.59%	3.43%	-1.67%	-0.49%	13.99%	-12.31%	1.92%	50.57%	-9.94%	7.68%	-8.20%	0.82%	-1.81%	
Soybeans	11.62%	-0.15%	10.29%	-3.18%	3.31%	-4.97%	5.36%	35.38%	-0.70%	-1.43%	-5.94%	1.89%	-0.18%	
Wheat	5.69%	-6.91%	-11.92%	5.26%	8.60%	-14.25%	5.30%	47.05%	-4.80%	-1.09%	-2.00%	1.39%	-0.70%	
Copper	-4.68%	3.50%	75.40%	13.05%	-29.36%	21.95%	-4.14%	2.50%	5.52%	2.99%	-14.44%	14.34%	1.69%	
Cocoa	-21.46%	1.53%	-2.93%	-0.51%	19.28%	6.87%	3.59%	33.23%	31.12%	-17.83%	11.20%	-8.50%	2.00%	
Cotton	-0.19%	1.55%	-4.35%	-10.64%	-22.36%	36.63%	-1.14%	11.64%	16.91%	2.44%	-7.13%	2.05%	-2.55%	
Oats	-4.61%	-1.47%	3.89%	5.48%	1.39%	6.64%	0.43%	37.10%	-6.24%	5.13%	6.95%	-1.62%	-0.15%	
Sugar		33.44%	-44.00%	-17.14%	-18.38%	-0.48%	37.68%	116.31%	-35.49%	-4.05%	-26.26%	28.58%	-4.20%	
Silver			1.64%	-1.70%	0.58%	70.09%	-5.95%	43.83%	10.81%	16.87%	-30.43%	-4.10%	2.49%	
Cattle				17.22%	-12.99%	7.07%	5.21%	6.90%	9.79%	5.05%	-3.22%	1.71%	1.21%	
Hogs					-19.53%	-5.62%	8.73%	18.86%	5.93%	-1.74%	5.35%	3.21%	-0.93%	
OJ						51.72%	0.97%	-3.39%	22.48%	0.49%	20.93%	3.60%	-5.57%	
Platinum							-8.07%	1.37%	19.62%	4.70%	-16.28%	9.82%	4.15%	
Coffee								3.92%	24.75%	-3.18%	8.55%	-7.80%	1.74%	
Gold									1.27%	19.36%	-15.51%	3.47%	1.11%	
Heating Oil										12.98%	-1.74%	-4.53%	6.76%	
Crude Oil										0.00%	-5.74%	-6.42%	7.17%	
Unleaded Gas												-2.35%	5.05%	
Natural Gas													10.33%	
EW Portfolio Geometric Return	-2.06%	5.95%	1.76%	4.76%	-3.93%	15.79%	6.83%	34.88%	8.97%	8.04%	-2.59%	7.07%	5.83%	7.13%
Average Geometric Return	-2.32%	4.37%	2.93%	0.73%	-5.04%	13.61%	3.84%	28.95%	6.07%	3.02%	-4.94%	1.98%	1.45%	3.44%
Diversification Return	0.25%	1.58%	-1.17%	4.03%	1.12%	2.18%	2.99%	5.93%	2.91%	5.02%	2.34%	5.09%	4.38%	3.68%
EW Portfolio Variance	0.40%	0.99%	1.70%	1.43%	0.58%	1.36%	0.64%	4.75%	1.84%	2.22%	1.45%	1.39%	1.07%	1.44%
Average Variance	1.93%	5.15%	7.09%	11.62%	5.75%	10.93%	7.66%	20.06%	10.34%	13.32%	9.15%	12.75%	9.92%	10.25%
Time Span(Years)	1.50	2.58	1.25	1.25	1.00	1.08	4.42	2.33	3.92	4.33	1.75	5.33	14.83	45.58

Erb-Harvey (2005) Note: Commodity Research Bureau data, www.crbtrader.com/crbindex/

Estimating The Size Of The Diversification Return Guessing Portfolio Average Variance July 1959 to February 2005

- Say that we only know each asset's variance for the time period after it enters the asset universe
 - For instance, corn's annualized variance from July 1959 to February 2005 was 5.41%
 - The March 1990 to February 2005 annualized variance for natural gas was 32.86%
- We can calculate the time-weighted average of asset variances
- The time-weighted average of "since inception" asset variances provides an approximation
 - of the time-weighted average of "sub-period" asset variances

Variances	7/59-1/61	1/61-8/63	8/63-11/64	11/64-2/66	2/66-2/67	2/67-3/68	3/68-8/72	8/72-12/74	12/74-11/78	11/78-3/83	3/83-12/84	12/84-3/90	3/90-2/05	7/59-2/05
CRB	1.15%	1.15%	1.15%	1.15%	1.15%	1.15%	1.15%	1.15%	1.15%	1.15%	1.15%	1.15%	1.15%	
Corn	5.41%	5.41%	5.41%	5.41%	5.41%	5.41%	5.41%	5.41%	5.41%	5.41%	5.41%	5.41%	5.41%	
Soybeans	7.17%	7.17%	7.17%	7.17%	7.17%	7.17%	7.17%	7.17%	7.17%	7.17%	7.17%	7.17%	7.17%	
Wheat	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	
Copper	7.26%	7.26%	7.26%	7.26%	7.26%	7.26%	7.26%	7.26%	7.26%	7.26%	7.26%	7.26%	7.26%	
Сосоа	10.33%	10.33%	10.33%	10.33%	10.33%	10.33%	10.33%	10.33%	10.33%	10.33%	10.33%	10.33%	10.33%	
Cotton	7.01%	7.01%	7.01%	7.01%	7.01%	7.01%	7.01%	7.01%	7.01%	7.01%	7.01%	7.01%	7.01%	
Oats	9.89%	9.89%	9.89%	9.89%	9.89%	9.89%	9.89%	9.89%	9.89%	9.89%	9.89%	9.89%	9.89%	
Sugar		25.93%	25.93%	25.93%	25.93%	25.93%	25.93%	25.93%	25.93%	25.93%	25.93%	25.93%	25.93%	
Silver			9.32%	9.32%	9.32%	9.32%	9.32%	9.32%	9.32%	9.32%	9.32%	9.32%	9.32%	
Cattle				3.89%	3.89%	3.89%	3.89%	3.89%	3.89%	3.89%	3.89%	3.89%	3.89%	
Hogs					10.77%	10.77%	10.77%	10.77%	10.77%	10.77%	10.77%	10.77%	10.77%	
OJ						12.37%	12.37%	12.37%	12.37%	12.37%	12.37%	12.37%	12.37%	
Platinum							8.15%	8.15%	8.15%	8.15%	8.15%	8.15%	8.15%	
Coffee								16.48%	16.48%	16.48%	16.48%	16.48%	16.48%	
Gold									3.79%	3.79%	3.79%	3.79%	3.79%	
Heating Oil										15.73%	15.73%	15.73%	15.73%	
Crude Oil											11.39%	11.39%	11.39%	
Unleaded Gas												16.71%	16.71%	
Natural Gas													32.86%	
EW Portfolio Geometric Return	-2.06%	5.95%	1.76%	4.76%	-3.93%	15.79%	6.83%	34.88%	8.97%	8.04%	-2.59%	7.07%	5.83%	7.13%
Average Geometric Return	-2.32%	4.37%	2.93%	0.73%	-5.04%	13.61%	3.84%	28.95%	6.07%	3.02%	-4.94%	1.98%	1.45%	3.44%
Diversification Return	0.25%	1.58%	-1.17%	4.03%	1.12%	2.18%	2.99%	5.93%	2.91%	5.02%	2.34%	5.09%	4.38%	3.68%
EW Portfolio Variance	0.40%	0.99%	1.70%	1.43%	0.58%	1.36%	0.64%	4.75%	1.84%	2.22%	1.45%	1.39%	1.07%	1.44%
Estimated Average Variance	7.61%	9.90%	9.84%	9.24%	9.38%	9.63%	9.52%	10.01%	9.60%	9.98%	10.06%	10.43%	11.61%	10.36%
Actual Average Variance	1.93%	5.15%	7.09%	11.62%	5.75%	10.93%	7.66%	20.06%	10.34%	13.32%	9.15%	12.75%	9.92%	10.25%
Time Span(Years)	1.50	2.58	1.25	1.25	1.00	1.08	4.42	2.33	3.92	4.33	1.75	5.33	14.83	45.58

Erb-Harvey (2005) Note: Commodity Research Bureau data, www.crbtrader.com/crbindex/

Estimating The Average Variance Of The Bodie-Rosansky Commodity Portfolio 1949 to 1976

- Assume, for convenience, that variances are constant over time
- Diversification return = (Average Variance Portfolio Varaince)/2

=(25.5% - 5.0)/2 = 10.2%

					Soybean	Soybean										Pork		Orange						
	Wheat	Corn	Oats	Soybeans	Oil	Meal	Potatoes	Wool	Cotton	Egg	Cocoa	Copper	Sugar	Silver	Cattle	Bellies	Platinum	Juice	Hogs	Broilers	Propane	Lumber	Plyw ood	Average
	27	27	27	27	27	27	27	27	27	27	23	23	23	13	12	12	11	10	10	8	8	7	6	0
Std.	30.75%	26.31%	19.49%	32.32%	57.67%	35.60%	42.11%	36.96%	36.24%	27.90%	54.63%	47.21%	116.22%	25.62%	21.61%	39.32%	25.19%	31.77%	36.62%	39.20%	202.09%	34.67%	39.96%	
Variance	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%	15.37%	408.40%	12.02%	15.97%	
27	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%														12.89%
26	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%														12.89%
25	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%														12.89%
24	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%														12.89%
23	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%											24.31%
22	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%											24.31%
21	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%											24.31%
20	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%											24.31%
19	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%											24.31%
18	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%											24.31%
17	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%											24.31%
16	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%											24.31%
15	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%											24.31%
14	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%											24.31%
13	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%										23.04%
12	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%								21.42%
11	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%							20.53%
10	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%					19.61%
9	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%					19.61%
8	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%	15.37%	408.40%			37.92%
7	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%	15.37%	408.40%	12.02%		36.74%
6	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%	15.37%	408.40%	12.02%	15.97%	35.84%
5	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%	15.37%	408.40%	12.02%	15.97%	35.84%
4	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%	15.37%	408.40%	12.02%	15.97%	35.84%
3	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%	15.37%	408.40%	12.02%	15.97%	35.84%
2	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%	15.37%	408.40%	12.02%	15.97%	35.84%
1	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%	15.37%	408.40%	12.02%	15.97%	35.84%
Average	9.45%	6.92%	3.80%	10.44%	33.26%	12.67%	17.73%	13.66%	13.13%	7.78%	29.84%	22.28%	135.06%	6.56%	4.67%	15.46%	6.34%	10.09%	13.41%	15.37%	408.40%	12.02%	15.97%	25.50%

Expected Diversification Returns Bodie and Rosansky (1949 to 1976)

- Assume a universe of securities with average variances of 25%
- What are the expected diversification returns
 - If the asset correlations average 0, 0.1, 0.2 and 0.3?

Number Of Securities In An Equally Weighted Rebalanced Portfolio

When Fantasies Become Facts Bodie and Rosansky (1949 to 1976) 1973 Excluded

• Bodie and Rosansky noted that 1973 was a volatile high return year

- So, they recalculated their portfolio results excluding 1973
- Excluding 1973, the Bodie and Rosansky equally weighted portfolio
 - Had a geometric excess return of 6.15% and a diversification return of 8.73%
- Bodie and Rosansky <u>mistook a diversification return for a risk premium</u>

	Arithmetic	Geometric		Average	Number of		Arithmetic	Geometric		Average	Number of
	Excess Return	Excess Return	Variance	Correlation	Years		Excess Return	Excess Return	Variance	Correlation	Years
1 Wheat	-1.04%	21.96%	4.82%	0.28	26	19 Hogs	7.66%	33.96%	11.53%	0.30	9
2 Corn	-1.70%	17.58%	3.09%	0.34	26	20 Broilers	7.06%	38.16%	14.56%	0.22	7
3 Oats	1.25%	19.74%	3.90%	0.25	26	21 Propane	-1.88%	41.67%	17.36%	0.07	7
4 Soybeans	9.04%	22.53%	5.08%	0.28	26	22 Lumber	5.63%	31.26%	9.77%	0.19	6
5 Soybean Oil	18.66%	44.83%	20.10%	0.25	26	23 Plywood	25.37%	39.82%	15.86%	0.17	5
6 Soybean Meal	8.41%	31.34%	9.82%	0.20	26						
7 Potatoes	2.36%	38.56%	14.87%	0.18	26						
8 Wool	5.25%	35.86%	12.86%	0.19	26						
9 Cotton	3.00%	19.40%	3.76%	0.20	26						
10 Egg	-4.69%	28.45%	8.09%	0.11	26						
11 Cocoa	12.38%	53.47%	28.59%	0.06	22						
12 Copper	14.77%	41.57%	17.28%	0.12	22						
13 Sugar	24.59%	118.88%	141.32%	0.15	22						
14 Silver	0.05%	23.22%	5.39%	0.23	12						
15 Cattle	7.94%	22.57%	5.09%	0.17	11						
16 Pork Bellies	13.84%	40.42%	16.34%	0.25	11						
17 Platinum	0.67%	26.55%	7.05%	0.21	10						
18 Orange Juice	0.71%	33.15%	10.99%	0.07	9						

Note: Zvi Bodie and Victor Rosansky, "Risk and Return In Commodity Futures", Financial Analysts Journal, May June 1980, pages 27-39. This study covered 23 commodity futures over the period 1949 to 1976.

Portfolio Geometric Return	9.64%	
T-Bill Return	3.49%	
Excess Return	6.15%	
Diversification Return	7.73%	(Average Variance-Portfolio Varaince)/2
"Risk Premium"	-1.58%	

Estimating The Average Variance Of The Bodie-Rosansky Portfolio 1949 to 1976 Excludes 1973

- Bodie and Rosansky also calculated return and risk excluding 1973
 - A year of very high volatility
- Diversification return = (Average Variance Portfolio Varaince)/2

=(17.5% - 2.0%)/2

= 7.7%

Std. Variance	Wheat 26 21.96% 4.82%	Corn 26 17.58% 3.09%	Oats 26 19.74% 3.90%	Soybeans 26 22.53% 5.08%	Soybean Oil 26 44.83% 20.10%	Soybean Meal 26 31.34% 9.82%	Potatoes 26 38.56% 14.87%	Wool 26 35.86% 12.86%	Cotton 26 19.40% 3.76%	Egg 26 28.45% 8.09%	Cocoa 22 53.47% 28.59%	Copper 22 41.57% 17.28%	Sugar 22 118.88% 141.32%	Silver 12 23.22% 5.39%	Cattle 11 22.57% 5.09%	Pork Bellies 11 40.42% 16.34%	Platinum 10 26.55% 7.05%	Orange Juice 9 33.15% 10.99%	Hogs 9 33.96% 11.53%	Broilers 7 38.16% 14.56%	Propane 7 41.67% 17.36%	Lumber 6 31.26% 9.77%	Plyw ood 5 39.82% 15.86%	Average
26	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%														8.64%
25	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%														8.64%
24	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%														8.64%
23	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%														8.64%
22	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%											21.05%
21	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%											21.05%
20	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%											21.05%
19	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%											21.05%
18	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%											21.05%
17	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%											21.05%
16	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%											21.05%
15	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%											21.05%
14	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%											21.05%
13	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%											21.05%
12	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%										19.93%
11	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%								18.78%
10	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%	7.05%							18.09%
9	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%	7.05%	10.99%	11.53%					17.37%
8	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%	7.05%	10.99%	11.53%					17.37%
7	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%	7.05%	10.99%	11.53%	14.56%	17.36%			17.23%
6	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%	7.05%	10.99%	11.53%	14.56%	17.36%	9.77%		16.89%
5	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%	7.05%	10.99%	11.53%	14.56%	17.36%	9.77%	15.86%	16.85%
4	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%	7.05%	10.99%	11.53%	14.56%	17.36%	9.77%	15.86%	16.85%
3	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%	7.05%	10.99%	11.53%	14.56%	17.36%	9.77%	15.86%	16.85%
2	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%	7.05%	10.99%	11.53%	14.56%	17.36%	9.77%	15.86%	16.85%
1	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%	7.05%	10.99%	11.53%	14.56%	17.36%	9.77%	15.86%	16.85%
Average	4.82%	3.09%	3.90%	5.08%	20.10%	9.82%	14.87%	12.86%	3.76%	8.09%	28.59%	17.28%	141.32%	5.39%	5.09%	16.34%	7.05%	10.99%	11.53%	14.56%	17.36%	9.77%	15.86%	17.50%

Expected Diversification Returns Bodie and Rosansky (1949 to 1976, Ex-1973)

- Assume a universe of securities with average variances of 17%
- What are the expected diversification returns
 - If the asset correlations average 0, 0.1, 0.2 and 0.3?

Number Of Securities In An Equally Weighted Rebalanced Portfolio

Expected Diversification Returns Gorton and Rouwenhorst (1959 to 2004)

- Assume a universe of securities with average variances of 10%
- What are the expected diversification returns
 - If the asset correlations average 0, 0.1, 0.2 and 0.3?

Number Of Securities In An Equally Weighted Rebalanced Portfolio

Data Source

- We use Goldman Sachs total returns, excess returns and spot returns
- Why?
- These returns underlie the most prominent long-only commodity futures index
 - A seemingly objective source of information for researchers
- The returns are available and explained in a 200+ page document
- Most studies of commodity futures returns rely on other data sources
 - Sources that might be less accurate and comprehensive

Financial Archaeology, Selection Bias and Survivor Bias Bodie-Rosanksy and Gorton-Rouwenhorst

- Bodie and Rosansky start their analysis in 1949
- Gorton and Rouwenhorst start their analysis in 1959
- How similar are their 1959 portfolios?
- The Bodie and Rosansky 1959 portfolio consists of 13 commodity futures
- The Gorton and Rouwenhorst 1959 portfolio consists of 9 commodity futures
- What happened?
- Did Bodie and Rosansky make up data?
- Did Gorton and Rouwenhorst lose data?
- It is always interesting when to portfolios that supposedly represent the "market"
 - Do not have the same composition
- Is this selection bias, survivor bias or some other bias?

Portfolio Composition 1959

Bodie-RosanskyWheat CornOatsSoybeansSoybean OilSoybean MealPotatoesWoolCottonEggsCocoaCopperSugarGorton-RouwenhorstWheat CornOatsSoybeansSoybean OilSoybean MealCocoaCopperCotton

What Drives Commodity Futures Returns? Normal Backwardation The Standard Commodity Futures Risk Premium Argument Keynesian Hagiography

- Normal backwardation is the most commonly accepted "driver" of commodity future returns
- "Normal backwardation" is a long-only risk premium "explanation" for futures returns
 - Keynes coined the term in 1923
 - It provides the marketing justification for long-only commodity futures indices
- <u>Keynes on Normal Backwardation</u>

"If supply and demand are balanced, <u>the spot price must exceed the forward price by the</u> <u>amount which the producer is ready to sacrifice in order to "hedge" himself</u>, i.e., to avoid the risk of price fluctuations during his production period. Thus in normal conditions the spot price exceeds the forward price, i.e., there is a backwardation. In other words, the normal supply price on the spot includes remuneration for the risk of price fluctuations during the period of production, whilst the forward price excludes this."

A Treatise on Money: Volume II, page 143

Where Did The Idea Of Normal Backwardation Come From? Keynes's "Logical" Probability And Normal Backwardation

- Where did normal backwardation come from?
 - Keynes made it up because the idea made sense to him
 - Not driven by an analysis of data
- Keynes believed in "logical" probability
 - Probability as a logical relation between evidence and a hypothesis
 - Some have called this "objective Bayesianism"
 - Keynes called it "justifiable induction"
 - "A statement of probability always has reference to the available evidence and cannot be refuted or confirmed by subsequent events"(???)
- Keynes was fond of (his own) logic, not of empiricism
 - "It seems to me that economics is a branch of logic, a way of thinking..."
 - Long running "black magic" harangue of Tinbergen's early econometric work
 - "Experience can teach us what happened but it cannot teach us what will happen"
 - "Too large a proportion of recent "mathematical" economics are mere concoctions, as imprecise as the initial assumptions they rest on, which allow the author to lose sight of the complexities and interdependencies of the real world in a maze of pretentious and unhelpful symbols"

Why Not Normal Contango? The Hedging Pressure Hypothesis

- Some fans of Keynesian normal backwardation could not figure out
 - why hedgers could only be short commodity futures contracts
- In order to plug the holes in the normal backwardation story they suggested
 - Hedgers could be short or long commodity futures
 - Just as there could be normal backwardation, so there could be normal contango
- The "hedging pressure" story changes the prescription for investors
 - Go long futures when "hedgers" are net short
 - Go short futures when "hedgers" are net long
 - Makes the "insurance" story symmetric
- The "right" portfolio choice is a long/short portfolio of commodity futures
 - "hedging pressure" does not support a long only portfolio construct
- How do you know if "hedgers" are short or long?
 - No, the CFTC Commitment of Traders report is not the answer
 - Never really know the "normal" relationship ("normal discount" is invisible)
 - Never really know the real hedging pressure

Keynes And The Empirical Failure Of Normal Backwardation Keynesian Hagiography

• Keynes might be amused that so many have "anchored" on his idea for so many years

"<u>The ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly believed. Indeed, the world is ruled by little else</u>. Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler of a few years back. I am sure that the power of vested interests is vastly exaggerated compared with the gradual encroachment of ideas. Soon or late, it is ideas, not vested interests, which are dangerous for good or evil."

The General Theory of Employment, Interest and Money, page 343

• Keynes might have been less dogmatic than some supporters of normal backwardation

"When the facts change, I change my mind - what do you do, sir?"² Quoted in The Economist, 24 October 1998, p. 57.
What Drives Commodity Futures Returns? Spot Returns and Excess Returns December 1982 to May 2004

- Excess return is the sum of the spot return and the roll return
- The roll return "explained" 92% of the cross-section of futures returns
- The spot return "explained" 52% of the cross-section of futures returns



Compound Annualized Spot Return

What Drives Commodity Futures Returns? Roll Returns and Spot Returns December 1982 to May 2004

- "Higher" roll return commodity futures have "higher" spot returns
- "Lower" roll return commodity futures have "lower" spot returns
- The term structure drives the roll return
 - You can "see" today's term structure today
- Absent term structure information, who knows what spot returns will be



What Drives Commodity Futures Returns? Pulling It All Together

- The excess return of a commodity future has two components
 - Excess Return = Roll Return + Spot Return
- When two independent variables are highly correlated with one another
 - It is possible to choose the variable with the greatest explanatory value
 - If one believes valuable information is not being lost
 - In this case, the variable with the greatest explanatory value is "observable"
- If spot returns average zero, we are then left with a rule-of-thumb
 - Excess Return ~ Roll Return
- The expected future excess return, then, is the expected future roll return

Unexpected Inflation Betas and Roll Returns December 1982 to December 2003

- Commodity futures with the highest roll returns have
 - Had the highest unexpected inflation betas
- Surely there has to be longer-term evidence that commodity futures
 - Are an inflation hedge



Erb-Harvey (2005)

GSCI, Sector and Individual Commodity Stock and Bond Correlations December 1982 to May 2004 Monthly Observations, Excess Returns

- No real evidence that commodity futures zig when stocks or bonds zag
- Returns largely uncorrelated



The Past Has Not Been Prologue And Forecasting Long Term Excess Return Persistence December 1982 to May 2004

- The long-only "trend is your friend" story is an energy and metals story
- One way to think about long-term returns is to forecast roll returns
- This requires observing today's term structure
 - and correctly forecasting the term structure over one's investment time horizon



Inflation And Commodity Spot Returns

- Realized inflation can be spilt into two components
 - Realized Inflation = Expected Inflation + Unexpected Inflation
- Since no one knows what expected inflation is, use a proxy
 - Realized Inflation = Prior Inflation + Actual Change In Inflation
- There is no compelling reason why prior inflation should drive spot commodity returns
- Spot commodity return might be correlated with the actual change in inflation
 - And this could drive a correlation with realized inflation

Trailing Inflation And GSCI Spot Returns December 1969 to May 2004

- A naïve measure of expected inflation
 - is to use recent inflation as a forecast of future inflation
- Commodity spot prices, not surprisingly, are largely uncorrelated with this inflation measure



Previous Twelve Month Annual Inflation

Contemporaneous Inflation And GSCI Spot Returns December 1969 to May 2004

- Even if you had the ability to correctly forecast inflation over the next twelve months
 - A perfect inflation forecast would translate into a noisy spot forecast



Contemporaneous Twelve Month Annual Inflation

Contemporaneous Inflation And GSCI Spot Returns December 1969 to May 2004

- Inflation "surprises" seem to be correlated with spot returns
- All you have to do is correctly forecast unexpected inflation
- Historically, what has been the average value of unexpected inflation?



Year-Over-Year Change In Inflation

Unexpected Inflation and Expected Spot Returns

- Seemingly, the average value of unexpected inflation has been zero
- If spot returns are correlated with unexpected inflation,
 - Then the expected spot return should be about zero



The Mathematics of the Diversification Return

• Stand alone asset geometric return

= Average Return – Variance/2 = $R_i - \sigma_i^2/2$

• Asset geometric return in a portfolio context

= Average Return – Covariance/2 = $R_i - \beta_i \sigma^2_{Portfolio} / 2$

• Stand alone asset diversification return

= (Average Return – Covariance/2) – (Average Return – Variance/2) = $(R_i - \beta_i \sigma_{Portfolio}^2 / 2) - (R_i - \sigma_i^2 / 2)$ = $\sigma_i^2 / 2 - \beta_i \sigma_{Portfolio}^2 / 2$ = $(\sigma_i^2 - \beta_i \sigma_{Portfolio}^2) / 2$ = Residual Variance/2

Portfolio diversification return

= (Weighted Average Asset Variance – Weighted Average Asset Covariance)/2

= (Weighted Average Asset Variance – Portfolio Variance)/2

An Analytical Approach to the Diversification Return

• The variance of an equally weighted portfolio is Portfolio Variance = Average Variance/N + (1-1/N) Average Covariance

= Average Variance/N + (1-1/N) Average Correlation * Average Variance

• Equally weighted portfolio diversification return = (Weighted Average Asset Variance – Portfolio Variance)/2

= (Average Variance – (Average Variance/N + (1-1/N) Average Covariance))/2

= (1-1/N) *(Average Variance - Average Covariance)/2

= ((1-1/N) *(Average Variance) - (1-1/N) Average Correlation * Average Variance)/2

• As the number of securities, N, becomes large, this reduces to = (Average Variance – Average Correlation * Average Variance)/2

What are "Average" Commodity Futures **Correlations? Excess Return Correlations** Monthly observations, December 1982 to May 2004

Historically, commodity futures excess return correlations have been low •

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Non-Energy	0.36																		
Energy	0.91	0.06																	
Livestock	0.20	0.63	0.01																
Agriculture	0.24	0.78	0.01	0.12															
Industrial Metals	0.13	0.31	0.03	-0.02	0.17														
Precious Metals	0.19	0.20	0.14	0.03	0.08	0.20													
Heating Oil	0.87	0.08	0.94	0.04	0.00	0.05	0.13												
Cattle	0.12	0.50	-0.03	0.84	0.07	0.03	0.01	(0.00										
Hogs	0.21	0.52	0.06	0.81	0.13	-0.06	0.05	(0.06	0.37									
Wheat	0.25	0.66	0.06	0.18	0.79	0.05	0.06	(0.06	0.12	0.17								
Corn	0.14	0.58	-0.03	0.10	0.78	0.12	-0.01	-(0.04	0.05	0.11	0.52							
Soybeans	0.20	0.58	0.02	0.11	0.72	0.18	0.14	(0.05	0.03	0.14	0.43	0.70						
Sugar	0.03	0.21	-0.06	-0.05	0.35	0.14	0.05	-(0.04	0.02	-0.10	0.11	0.12	0.09					
Coffee	-0.01	0.15	-0.04	-0.07	0.23	0.07	0.01	-(0.07	-0.06	-0.06	0.00	0.03	0.07	-0.01				
Cotton	0.11	0.25	0.06	0.00	0.27	0.17	0.04	(0.05	-0.06	0.06	0.05	0.11	0.18	-0.02	-0.01			
Gold	0.20	0.16	0.16	0.01	0.07	0.18	0.97	(0.15	-0.02	0.04	0.07	-0.01	0.14	0.02	0.00	0.03		
Silver	0.08	0.19	0.02	0.02	0.10	0.19	0.77	(0.02	-0.01	0.05	0.03	0.09	0.13	0.07	0.04	0.04	0.66	
Copper	0.15	0.36	0.04	0.01	0.22	0.94	0.20	(0.07	0.03	-0.02	0.08	0.16	0.23	0.14	0.11	0.19	0.18	0.21

Average Correlations

GSCI v. commodity sectors	0.33
GSCI v. individual commodities	0.13
Heating oil v. other commodities	0.03
Individual commodities	0.09

Expected Diversification Returns

- Assume a universe of uncorrelated securities
- The size of the diversification return grows with the number of portfolio assets
 - Two securities capture 50% of the maximum diversification return
 - Nine securities capture 90% of the maximum diversification return



Number Of Securities In An Equally Weighted Rebalanced Portfolio

Four Ways to Calculate the Diversification Return December 1982 to May 2004

- There are at least four ways to calculate the diversification return
 - Difference of weighted average and portfolio geometric returns
 - One half the difference of weighted average and portfolio variances
 - One half the residual variance
 - The "average correlation" method

	e	Fixed Portfolio	Geometric		Residual	Average
<u>(</u>	<u>Commodity</u>	Weights	Excess Return	Variance	<u>Variance</u>	Correlation
H	Heating Oil	8.33%	5.53%	10.59%	9.65%	0.03
(Cattle	8.33%	5.07%	1.95%	1.88%	0.04
H	Hogs	8.33%	-2.75%	5.86%	5.33%	0.07
V	Vheat	8.33%	-5.39%	4.43%	3.38%	0.15
(Com	8.33%	-5.63%	5.13%	3.66%	0.17
S	Soybeans	8.33%	-0.35%	4.62%	2.92%	0.20
S	Sugar	8.33%	-3.12%	14.94%	12.70%	0.04
(Coffee	8.33%	-6.36%	15.76%	14.03%	0.00
(Cotton	8.33%	0.10%	5.12%	4.64%	0.06
(Gold	8.33%	-5.68%	2.06%	1.76%	0.11
S	Silver	8.33%	-8.09%	6.27%	5.09%	0.12
(Copper	8.33%	6.17%	6.60%	4.99%	0.13
I	Equally Weighted Average					
(Of The Individual Commodity Futures		-1.71%	6.94%	5.84%	0.09
I	Equally Weighted Portfolio		1.01%	1.01%	0.00%	
I	Diversification Return					
	1) EW Portfolio Geometric Return - EW Average of Geometric	Return				
	-) - · · · · · · · · · · · · · · · · · ·		2.72%			
	2) (EW Average Variance - EW Portfolio Variance)/2			2.97%		
	3) Residual Variance/2				2.92%	
Erb-Harvey (2005)	4) (1-1/N)* Average Variance *(1 - Average Correlation)/2					2.89%

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Asset Mix Changes and the Diversification Return

- The diversification return shows the benefit of mechanical portfolio rebalancing
- Easiest to calculate for a fixed universe of securities
 - The beginning number of securities has to equal the ending number of securities
- Say that the universe of securities consists of
 - Five securities for an initial period of five years, and
 - Ten securities for a subsequent period of five years
- In this example, when the size of the universe of securities varies over time
 - Calculate the five security diversification return for the first five years, then
 - Calculate the ten security diversification return for the next five years

Variation of the Diversification Return Over Time July 1959 to February 2005

• In general, the diversification return has increased over time for an equally weighted portfolio of commodity futures



Erb-Harvey (2005)

Note: Commodity Research Bureau data, <u>www.crbtrader.com/crbindex/</u>. This is for a universe that starts with 7 contracts and ends with 19.

The Diversification Return and the Number of Investable Assets July 1959 to February 2005

- In general, the diversification return increases with the number of assets
 - For an equally weighted portfolio of commodity futures



This is for a universe that starts with 7 contracts and ends with 19.