

ECO-6004B Economics of Alternative Investments

Lecture 04: Commodities: Applications and Evidence.

Dr. Andrea Calef

2019 – 2020

School of Economics
University of East Anglia

The Road-map of the module

- **Week 01:** An introduction to Alternative Investments.
- **Week 02:** Measures of Risk and Performance.
- **Weeks 03–04: Managed futures portfolio trading strategies.**
- **Weeks 05–06:** Real Estate.
- **Week 07:** Hedge Fund Investment Program.
- **Week 08:** Private Equity.
- **Week 09:** Investment in Structured Products.
- **Week 10:** Dynamic Portfolio Management.
- **Week 11:** Module Review.

Readings for Lecture 04

- Alternative Investments - CAIA Level I.

Chapter 12: Commodities: Applications and Evidence.

- Handbook of Alternative Assets.

Chapter 12: Introduction to Commodities.

Chapter 13: Investing in Commodity Futures.

Chapter 14: Commodity futures in a Portfolio Context.

Chapter 15: Managed Futures.

Outline of Lecture 04

- Recap on Portfolio Theory.
- Commodity Investing for Diversification.
- Commodity Investing for Return Enhancement.
- Investing in Commodities without Futures.
- Commodity Exposure Through Futures Contracts.
- Commodity Risks and Returns.

Recap on Portfolio Theory

- By spreading investment over more than 1 security, portfolio's expected return is the weighted average return of the securities held in the portfolio.
- There is a change of losing all the capital, if it is all invested in just one type of security.
- By combining securities with less than perfect correlation, investors can reduce the risk of the portfolio through diversification.

Recap on Portfolio Theory

- The effectiveness of this reduction will depend on the **degree of correlation** between the movements of the security returns.
 - ✓ If two securities' returns are perfectly positively correlated, they move up and down together in proportion. If they were combined in a portfolio, the investor would not get any risk reduction.
 - ✓ If two securities' returns are perfectly negatively correlated, then they move up and down in exact opposition and in proportion. If the investor was to combine two such securities in a portfolio, he/she would eliminate risk entirely!

In practice, negative correlation or low correlated assets are not easy to find. Presuming less than perfect correlation, diversification reduces risk.

Recap on Portfolio Theory

- We can now consider the formula for computing the risk of a portfolio (variance) that invests in N assets.
- The variance of a portfolio is the weighted average of the individual variances (ω_i^2), where the weights ω_i are squared, plus the weighted covariances ($\sigma_{i,j}$) between all the pairs of individual assets in the portfolio.

$$Var(R_P) = \sigma_P^2 = \sum_{i=1}^N \omega_i^2 \sigma_i^2 + \sum_{i \neq j=1}^N \omega_i \omega_j \sigma_{i,j}$$

or

$$\sigma_P^2 = \sum_{i,j=1}^N \omega_i \omega_j \sigma_{i,j} = \sum_{i,j=1}^N \omega_i \omega_j \rho_{i,j} \sigma_i \sigma_j$$

where $\rho_{i,j}$ is the correlation coefficient between the returns of assets i and j .

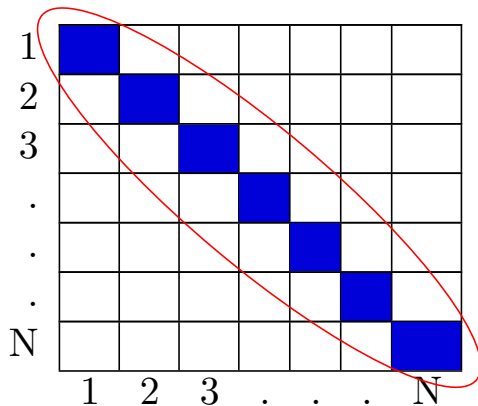
Recap on Portfolio Theory

The risk of a 2-assets portfolio (variance of portfolio) is the sum of all the elements of the following matrix:

	Stock 1	Stock 2
Stock 1	$\omega_1^2 \sigma_1^2$	$\omega_1 \omega_2 \sigma_{1,2} = \omega_1 \omega_2 \rho_{1,2} \sigma_1 \sigma_2$
Stock 2	$\omega_2 \omega_1 \sigma_{2,1} = \omega_2 \omega_1 \rho_{2,1} \sigma_2 \sigma_1$	$\omega_2^2 \sigma_2^2$

where ω_i is portfolio weight in asset i , σ_i is standard deviation of the return on asset i , $\sigma_{i,j}$ is covariance of the returns of assets i and j , and $\rho_{i,j}$ is the correlation of the returns of assets i and j .

Recap on Portfolio Theory



To calculate portfolio variance sum the values in the cells.

The shaded cells contain variances, while the remainder contains covariances.

Recap on Portfolio Theory

Number of assets	Number of variances	Number of covariances	Assume an equal amount in each asset
2	2	2	1/2
3	3	6	1/3
4	4	12	1/4
10	10	90	1/10
100	100	9900	1/100
N	N	$N^2 - N$	1/N

The importance of covariances

- Total variance of a portfolio of N assets, when N is large is equal to the average covariance between the N assets that make up the portfolio.
- A very important conclusion is that when we are dealing with large portfolios, the risk (variance) of an individual asset i we are thinking of adding to the portfolio is not important.
- What is truly important is the covariance between it and the assets already in the portfolio.

Portfolio Construction

How do investors construct portfolios?

There are many ways, but two types of portfolios need to be considered:

- i. Minimum Variance portfolio;
- ii. Maximum Sharpe Ratio portfolio.

Minimum Variance Portfolio

- One particular portfolio of interest is the portfolio with the lowest risk – the minimum variance portfolio.
- Subject to the assumption of total investment of the capital, i.e. $\omega_1 + \omega_2 = 1$, we have

$$\sigma_P^2 = \omega_1^2 \sigma_1^2 + (1 - \omega_1)^2 \sigma_2^2 + 2\omega_1(1 - \omega_1)\sigma_{1,2}$$

- Differentiate both sides with respect to ω_1 to obtain:

$$\begin{aligned}\frac{\partial \sigma_P^2}{\partial \omega_1} &= 2\omega_1 \sigma_1^2 - 2(1 - \omega_1) \sigma_2^2 + 2(1 - 2\omega_1) \sigma_{1,2} \\ &= 2\omega_1 (\sigma_1^2 + \sigma_2^2) - 2\sigma_2^2 + 2\sigma_{1,2} - 4\omega_1 \sigma_{1,2} \\ &= 2\omega_1 [\sigma_1^2 + \sigma_2^2 - 2\sigma_{1,2}] - 2\sigma_2^2 + 2\sigma_{1,2}\end{aligned}$$

Minimum Variance Portfolio

- The first order condition for finding the minimum is to set the derivative to zero, i.e.

$$\frac{\partial \sigma_P^2}{\partial \omega_1} = 0$$

- This yields the following equation for ω_1^* , where the ‘*’ denotes an optimal value:

$$\omega_2^* = \frac{\sigma_2^2 - \sigma_{1,2}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_{1,2}}$$

Maximum Sharpe Ratio Portfolio

- To find the Maximum Sharpe Ratio Portfolio, we need to assume that there is a risk-free asset available.
- Then we solve the following optimization problem:

$$\max_{\omega_1, \omega_2} \theta = \frac{\mu_P - r_F}{\sigma_P},$$

subject to

$$\omega_1 + \omega_2 = 1,$$

where μ_P is the expected return of the optimal portfolio, r_F is the risk-free rate, and σ_P is the standard deviation of the portfolio returns.

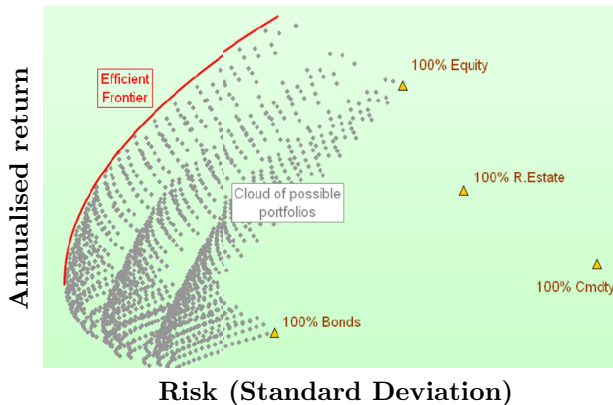
A Technique for Finding the Efficient Frontier

- We need identify 2 **frontier portfolios**, and then find convex combinations of them.
- To find the initial two portfolios, we can maximise the Sharpe Ratio, assuming each time a different risk-free rate.
- A simple combination rule to find other points of the efficient frontier is the following:
 - Given any two weight vectors $\mathbf{x} = [x_1 \dots x_n]$ and $\mathbf{y} = [y_1 \dots y_n]$, all frontier portfolios are formed as convex combinations of \mathbf{x} and \mathbf{y} .
 - In other words, a third portfolio \mathbf{z} has weights given by

$$\mathbf{z} = [\alpha x_1 + (1 - \alpha)y_1 \dots \alpha x_n + (1 - \alpha)y_n],$$

where α is an arbitrary constant.

Example of a Efficient Frontier



The **efficient frontier** represents the set of optimal portfolios that offer the highest expected return for a defined level of risk or the lowest level of risk for a given level of expected return.

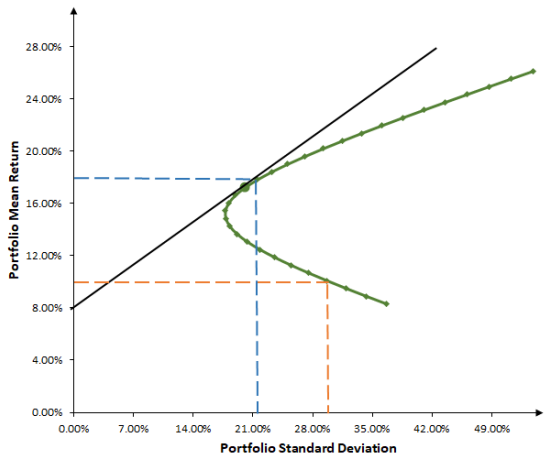
Recap on Portfolio Theory



Stocks offer an expected rate of return of 18%, with a standard deviation of 22%. Gold offers an expected return of 10% with a standard deviation of 30%. For simplicity, assume the covariance to be equal to zero.

In light of the apparent inferiority of gold with respect to both return and risk, would anyone hold gold?

Recap on Portfolio Theory



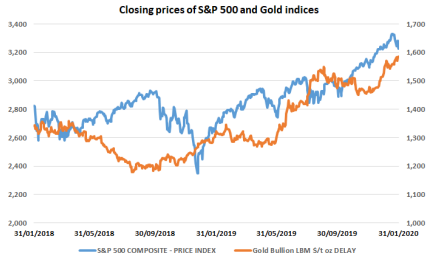
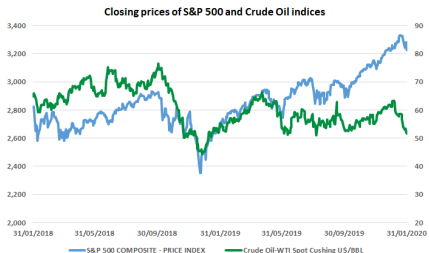
Even though it seems that gold is dominated by stocks, gold might still be an attractive asset to hold as a part of a portfolio if the correlation between gold and stocks is sufficiently low.

Commodity Investing for Diversification

Commodity returns may have low correlation with traditional assets (stocks and bonds):

- Commodity prices are not directly determined by the discount value of future cash flows, but driven by forecasts of supply and demand.
- Nominal commodity prices are positively correlated with inflation while prices of stock and bonds tend to be negatively correlated with inflation because inflation raises the discount rates.
- Commodity prices react differently at different parts of business cycle and depend on current economic conditions and factors relating to short term supply and demand.
- Commodities represent a major cost of some corporate producers, hence negatively correlating with corporate profits.

Commodity Investing for Diversification



	S&P 500	Gold	Crude Oil	MSCI EM
S&P 500	1.0000			
Gold	-0.0952	1.0000		
Crude Oil	0.2306	0.0422	1.0000	
MSCI EM	0.4458	-0.0104	0.2368	1.0000

Commodity as Diversifier in Perfect Market Equilibrium

- In a perfect market equilibrium, the perfectly diversified portfolio is the market portfolio that contains exposure to all assets.
- The percentage of the total market portfolio attribute to each asset is known as market weight.
- The market weight of an asset is equal to the percentage of total global value of that asset relative to the total global value of all assets.
- For example, if copper represents 4.6% of total wealth of the world, then a perfect diversified portfolio of risky assets should have an 4.6% weight in copper.
- Commodities are a substantial part of total wealth, but the issue is to determine the weight of that commodity.

Commodity as Diversifier in the Presence of Market Imperfections

- In practice, market is imperfect and may remain out of equilibrium for extended period of time (e.g. shortages or oversupplies may last a longer time).
- Investors seek to hold commodities in the proportion that provides the highest return-to-risk ratio based on their existing portfolios rather than market weight.
- Empirical evidence can be a tool for ascertaining the benefits of diversification for each commodity to each investor.

Commodity Investing for Return Enhancement

Return Enhancement: Alpha

- Market participants speculate on idiosyncratic movements in the underlying commodity prices.
- Investors use technical and fundamental analysis to forecast commodity prices and to identify trades with superior risk-adjusted returns.
- Example: managed futures funds use technical analysis to forecast trends in natural gas prices resulting from trading activity or seasonal patterns.

Commodity Investing for Return Enhancement

Return Enhancement: Beta

- In perfect equilibrium, expected returns from assets depend solely on the amount of systematic risk.
- Commodities do not enhance expected returns when they are efficiently priced and when their systematic risk (betas) are low.
- Return enhancement from beta must be attributable to market inefficiencies or markets in disequilibrium.

Investing in Commodities without Futures

- Investing in Physical Commodities.
- Investing in Commodity-Related Equities.
- Exchanged-Traded Funds (ETF).
- Commodity-Link Notes (CLN) .

Investing in Physical Commodities

- Investors can purchase and physically hold an underlying commodity to gain economic exposure to commodity return.
- Physical ownership of commodities offers benefits of convenience yield but also costs of storage and transportation.
- Examples: Gold are hold as “safe-haven”, natural gas inventory buildup for production because of its seasonal nature.

Investing in Commodity-Related Equities

- Investors can own the securities of a firm that derives a substantial part of its revenues from the sale of physical commodities such as natural resource company.
- Not potential for diversification purpose because:
 - Most firms have revenue related to a variety of commodities.
 - High correlation between stock price and commodity price assumes that the firm has not hedged its exposure in forward or futures contract.
 - Commodity equities have two betas: one relates to commodity market and a second to the equity market.
 - Financial and operating leverage may vary and affect return of an investment in the way that is uncorrelated with commodity prices.

Exchanged-Traded Funds (ETF)

- ETF is one of the easiest ways to invest in a basket of commodities or in some individual commodities (gold, silver, oil, ...).
- Commodity ETFs may either hold the actual commodity, or purchase futures contracts, or invest in the equity securities of commodity-producing firms.
- Popular commodity ETFs: United States Oil Fund (USO), SPDR Gold Trust (GLD), PowerShares DB Commodity Index Tracking Fund (DBC), GSG—the iShares S&P GSCI Commodity-Indexed Trust ETF, ...

Commodity-Linked Notes (CLN)

- A Commodity-Linked Note is an intermediate term debt instrument whose value at maturity is a function of the value of an underlying commodity or basket of commodity.
- A gold-mining firm can issue a Commodity-Linked Note that has coupon or principal payments directly linked to the price of gold.
- Commodity-Linked Notes are closely linked to commodity prices as well as idiosyncratic default of issued firms.
- Commodity-Linked Notes are attractive for investors with restrictions on direct position in futures contract.

Commodity Exposure Through Futures Contracts

The Return on a Futures Contract Differs from Spot Return due to basis risk.

The Return on a fully collateralized position in a futures contract is:

$$R_{f\ coll} = \text{Spot Return} + \text{Collateral Yield} + \text{Roll Yield}$$

where the **spot return** is the return on the underlying asset in the spot market, the **collateral yield** is the interest earned from riskless bonds used to collateralize the futures contract, and the **roll yield** is the portion of the return of futures position from the changes in its basis.

Commodity Exposure Through Futures Contracts

We have learned from previous lecture, forward price of a physical asset is given by:

$$F(T) = e^{(r+c-y)T} S$$

where F is forward price, S is spot price, and T denotes the time period of forward contract, r is interest, c is storage cost, y is convenience yield.

Example

Consider a 1-year futures contract on a physical asset that is traded at the spot price of \$25 per unit. The storage cost is 2% per year, annual interest rate is 5% and convenience yield is 1%. This corresponds to $c = 2\%$, $r = 5\%$, $y = 1\%$ and $S = 25$, $T = 1$.

The theoretical futures price should be:

$$F(T) = \$25 \cdot e^{(5\%+2\%-1\%)1} \approx \$26.55$$

How an arbitrageur makes profit:

- (i) if the actual futures price is greater than 26.5459?
- (ii) if the actual futures price is lower than 26.5459?

Scenario (i)

$$F(T) > e^{(r+c-y)T} S$$

If the actual price is greater than 26.5459, an arbitrageur can buy the asset and short 1-year futures contracts to lock in a profit.

As arbitrageurs do so, there will be a tendency for S to increase and F to decrease until $F(T) = e^{(r+c-y)T} S$.

Scenario (ii)

$$F(T) < e^{(r+c-y)T} S$$

If the actual price is less than 26.5459, an investor who already owns the asset can improve the return by selling the asset and buying futures contracts.

Scenario (ii)

$$F(T) < e^{(r+c-y)T} S$$

If the actual price is less than 26.5459, an investor who already owns the asset can improve the return by selling the asset and buying futures contracts.

This strategy may not be applicable for a commodity that is a consumption asset because individuals and companies who own a consumption commodity usually plan to use it in some way. There is therefore nothing to stop such inequality.

Forward price should be expressed thus:

$$F(T) \leq e^{(r+c-y)T} S$$

Other considerations

- The convenience yields and storage costs of market participants may differ and are unobservable.
- If $r + c - y = 0$, futures price equals spot price.
- The term structure of forward price will be upward or downward sloping, depending on the the expected value of these three parameters.
- If the term structure is informationally inefficient, arbitrageurs may use available information to take a long position in under-priced asset and short position in overpriced contract.

Commodity Risks and Returns

There are four main Commodity Market Event Risk Attributes:

- Most global events cause increase in commodity prices due to anticipated decrease in commodity supplies or increases in demand (trade wars, military wars, major weather events, political instability).
- Commodity price increases tend to be larger and more sudden than price decrease, providing long positions in commodities with positively skewed returns.
- Many commodity shocks are likely to be uncorrelated with each other.
- Shocks to commodity markets are generally uncorrelated with financial markets.

Commodity Risks and Returns

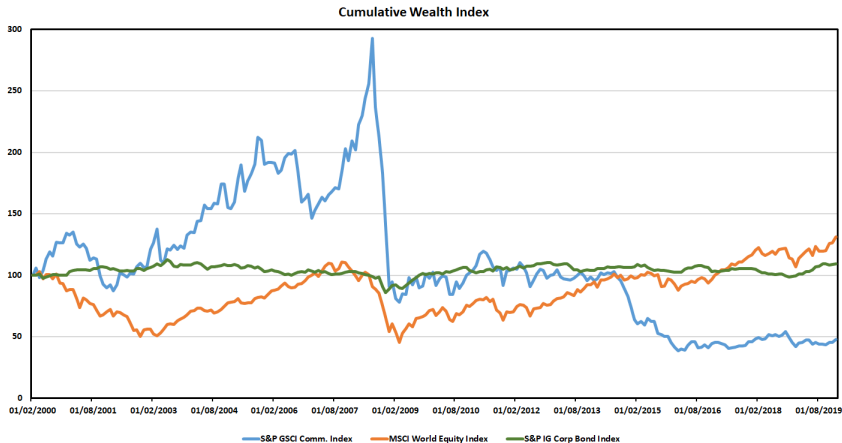
Commodities may be viewed as a defensive investment:

- Traditional assets do not provide downside risk protection: global equity markets have high correlations during period of market stress.
- Most traditional investments do not offer both protection from global turmoil and attractive returns.
- Hedge funds and other skilled-based strategies may provide diversification and having returns protected from market turmoil.

Historical Risks and Returns

Index (Mar.00-Jan.20)	S&P GSCI Comm. Index	MSCI World Equity Index	US T-Bond 10Y Index	S&P IG Corp Bond Index	S&P HY Corp Bond Index	US T-Bond 3M Index
Ann. Mean	-0.746%	2.698%	3.388%	0.171%	25.761%	0.136%
Ann. Std. Dev.	23.572%	16.210%	0.351%	1.219%	3.443%	0.517%
Skewness	-0.974	-0.495	0.276	1.744	2.706	1.509
Kurtosis	3.058	1.943	-0.925	5.016	10.583	-0.019
Range	51.379%	34.496%	0.415%	2.318%	7.270%	0.531%
Minimum	-35.570%	-17.654%	0.122%	-0.579%	0.416%	0.000%
Maximum	15.809%	16.842%	0.536%	1.739%	7.686%	0.531%
Max Drawdown	-81.549%	-56.183%	-0.412%	-4.328%	-12.179%	-0.528%
Sharpe Ratio	-0.029	0.019	1.446	-0.346	2.023	0.000
Alpha	-0.001	-0.001	0.000	-0.003	0.014	0.000
Beta	-0.682	1.265	1.000	1.066	4.012	0.000
Autocorrelation	0.092	-0.005	0.992	0.947	0.994	0.985
N. of Obs.	239	239	239	239	239	239

Historical Risks and Returns



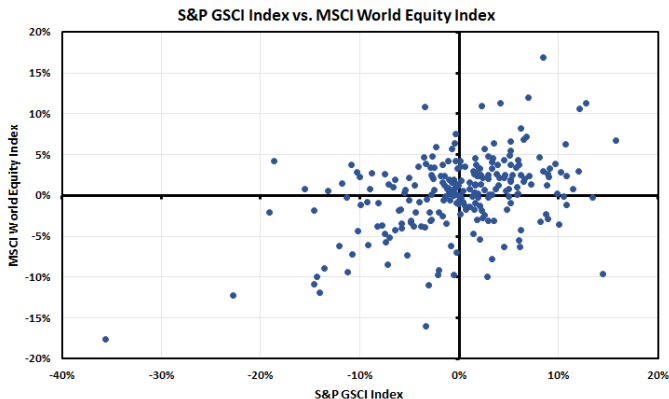
Betas and correlations

Multivariate Betas	MSCI World Equity Index	S&P IG Corp Bond Index	US T-Bond 3M Index	US T-Bond 10Y Index	Intercept	Adj-R ²
S&P GSCI Comm. Index	0.603***	-3.040**	0.319	13.233**	-0.039***	0.216

Univariate Betas	MSCI World Equity Index	S&P IG Corp Bond Index	US T-Bond 3M Index	US T-Bond 10Y Index
S&P GSCI Comm. Index	0.631*	-3.312	4.172	7.366**

Correlation matrix	S&P GSCI Comm. Index	MSCI World Equity Index	S&P IG Corp Bond Index	US T-Bond 3M Index	US T-Bond 10Y Index
S&P GSCI Comm. Index	1.000				
MSCI World Equity Index	0.434***	1.000			
S&P IG Corp Bond Index	-0.171***	-0.222***	1.000		
US T-Bond 3M Index	0.091	-0.054	0.245***	1.000	
US T-Bond 10Y Index	0.110	-0.077	0.387***	0.761***	1.000

Scatter Plot of the Returns



Why investing in commodities can be challenging?

Why investing in commodities can be challenging?