A Global Cornucopia

Accessing commodities in a long-term portfolio

GLOBAL STRATEGIC RESEARCH

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J.P.Morgan Asset Management

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This publication was edited, designed and produced by the Institutional Americas marketing group at J.P. Morgan Asset Management.

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AUTHORS

Rumi Masih, Ph.D.
Global Head
Strategic Investment
Advisory Group (SIAG)

Alexandre Christie
Strategic Advisor
Strategic Investment
Advisory Group (SIAG)

CONTRIBUTORS

Highbridge Capital Management —Global Macro Group

Sassan Alizadeh, Ph.D.
Senior Portfolio Manager

Mark Nodelman, CFA
Portfolio Manager

Vinayak Tripathi, Ph.D.
Manager of Research

In the aftermath of the 2008 credit crisis, investment fundamentals have been reassessed as never before. The role of non-correlated asset classes has been elevated as a critical factor for institutions. The dynamics of the global economy have tilted in a market that emphasises new factors. In particular, central banks around the world are becoming more actively involved in asset markets, injecting vast amounts of liquidity and making full use of their policy arsenal in an attempt to reignite faster economic growth and keep deflationary pricing at bay.

Meanwhile, most emerging markets have resumed their robust growth trajectories and have to contend with higher rates of inflation. Against this macroeconomic backdrop, demand for commodities has picked up in the emerging world and remains latent in the developed world. Even if demand from the developed world does not recover any time soon, the structural shift towards emerging economies coupled with stagnant production levels of commodities could significantly impact the global demand and supply balance. All of which is not to say, of course, that individual commodities prices will be spared the volatility that has become a defining characteristic of the asset class.

Amid this rapidly evolving landscape for investors, we believe that some elements of portfolio composition should be reconsidered—in particular, the potential role of commodities in an institutional investor's long-term portfolio. Many investors think of commodities as mainly gold and oil. Yet an investment in commodities can be considerably more complex than such a view would suggest.

Over the past few years, a number of papers have been published in both business and academic circles that investigate what sets commodities-oriented investments apart from other financial instruments. Most refer to the changing balance of economic power in China and India, or provide a review of return and volatility over time. These are important and valid areas of research. But we would respectfully assert that there is much more to commodities as an investment than merely return and volatility.

What follows is an advanced analysis[1] of risks and opportunities that attempts to explain the basic dynamics of the market for commodities and to show empirically how commodities may affect the long-run downside risk of a portfolio in times of extreme market stress.
As explored in a number of recent J.P. Morgan Asset Management Global Strategic Insight papers, today's market uncertainties require institutional investors to look beyond volatility and recognize that downside risk is more pervasive than was previously thought to be the case. We also apply econometric and programming techniques to explore whether active managers have genuine arbitrage opportunities to exploit in this market.

We believe this paper offers a qualitatively and quantitatively different approach from other research publications and one that will provide insight to help institutional investors make more informed decisions about the potential role for commodities in their portfolios.

[1] Details of the analytical techniques and tools utilised are described in **Appendix III**.

INTRODUCTION

Commodities are the oldest asset class known to man but perhaps one of the least understood today. For thousands of years, commodities have been traded in bulk or in the form of promissory notes at a standardised quantity for a given price. The word itself is derived from the Latin term *commoditas*, meaning something that is "apt" or "in due measure."

Dating from time immemorial, farmers and merchants have used futures contracts to alleviate some of the uncertainty involved in bringing the annual harvest to market. One of the first investors known to profit from a commodity-related transaction was the pre-Socratic Greek philosopher Thales who, as Aristotle recalls, invested in oil presses near the ancient Ionian cities of Chios and Miletus early in the growing season one year and thus reaped the benefits of a bumper crop of olives.[2]

For the modern investor, most commodities are traded on highly regulated exchanges and cash settlement is the norm (as opposed to physical delivery). The wide spectrum of traded goods ranges from grains and livestock to industrial materials such as iron ore and precious metals like gold and rhodium. One of the primary advantages commodities provide is a measure of global exposure that crosses the divide between developed and emerging economies. Other attractive aspects include the relatively low level of historical correlation with other asset classes. Empirical evidence shows their potential for use in downside risk management. But perhaps the most alluring aspect for the long-term institutional investor—and a focus of this paper—is their relevance to inflationary and deflationary price signals since commodity returns are a function of global pricing trends.

Indeed, one of the most topical questions for investors today is whether inflation or deflation presents the greatest near-term threat to their portfolios. Signals are mixed in this respect. On the one hand, looser monetary policies in the developed world and limits on natural resource supplies in emerging economies are inflationary tinder. At the same time, a global supply glut due to excess production capacity and rising interest rates in some emerging economies may tip the scales in favor of deflationary expectations. As a result of these dynamics, there may be a growing global disconnect in pricing trends between the first and third worlds.

[2] Source: Kirk, G.S., J.E. Raven and M. Schofield; *The Presocratic Philosophers,* Cambridge University Press (London), 1957, 1983 (2nd edition); pp. 80–81.

Amid all this uncertainty, **we believe that commodities may be the most relevant asset class for investors to consider as a refuge from extreme price movements—up or down.** In this paper, we consider the case for commodities as a tactical and strategic investment in the context of post-2008 financial crisis risk management. As part of that assessment, we attempt to illustrate to what degree commodities provide protection to portfolios from higher inflationary and deflationary risk scenarios. Consideration is also given to how commodity investment returns may change under different portfolio management constraints.

More specifically, we focus on four questions:

1. In the wake of the global economic crisis, are there imbalances between the demand for commodities and the supply of them and, in particular, how will the rise of China as an economic power impact prices in the mid- to long-term?
2. How does the "non-normality" of commodity returns affect the return and risk profile of an overall investment portfolio?
3. In what ways do commodities offer protection against inflation, deflation and cyclical macroeconomic downturns?
4. Is there scope for active management by exploiting linkages between commodities and index-based market inefficiencies?

Our overall conclusion is that the risk/return case for including commodities as one component of a diversified portfolio has become stronger in the wake of the 2008 financial crisis and amid the economic ascendancy of China. In particular, this paper attempts to show that there are significant supply constraints on commodities amid burgeoning demand for them, not only among developed nations and China but also from a broader swath of the developing world. This includes emerging economies in places as far afield as Africa, Asia and South America, many of which, up until recently, have been characterised as commodity exporters as opposed to commodity consumers. We also provide empirical research indicating that commodities may offer protection in moderately inflationary as well as in deflationary[3] environments as we illustrate the way in which commodities behave across the business cycle. Finally, we detail an analysis of the linkages between and among commodities that could potentially be exploited by an active manager with a flexible approach so as to outperform an index-based strategy tied to a fixed basket of commodities.

A PRIMER ON COMMODITIES

For the purpose of investors, commodities are low (or no) value-added and unbranded raw materials measured in standard units. They are, by definition, indistinguishable from one another based on their identical composition. For example, a metric ton of copper from one mine is not substantively discernible from a metric ton produced at any other location. As a result, the global price is uniform, all other things remaining equal (although accessibility and distance to market come into play as distinguishing factors). The types of commodities traded range from agricultural commodities such as corn and pork bellies, to industrial commodities, including molybdenum and nickel, to energy commodities like oil and natural gas. In this paper, we consider broad categories of commodities such as industrial commodities and agricultural commodities. However, we do not focus on individual commodities per se, as their unique properties fall beyond the scope of this paper.

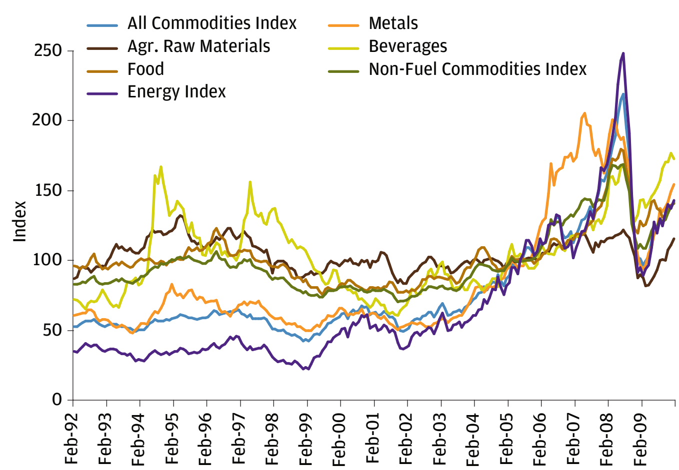
[3] Through actively managed shorting strategies.

SUPPLY & DEMAND IMBALANCES

While not all commodity prices move in lock-step, throughout history there have been marked periods of generalised spikes and swoons. In the 1970s, prices of many commodities trended higher, but by the 1990s prices typically weakened.

That decade of weak price signals left a legacy of underinvestment and dwindling supplies. From 2000 onward, however, demand picked up for all types of commodities. A bull market that kicked off in 2006 pushed some prices to record levels. The reasons for this were manifold, but perhaps the chief driving force was a sharp rise in demand from emerging economies. In the wake of the financial crisis in 2008, global demand dropped as a result of negative GDP growth in most of the developed world and lower growth in many developing economies. But prices for many commodities have rebounded over the past two years as demand has recovered, especially in emerging economies (Exhibit 1).

EXHIBIT 1: GLOBAL COMMODITIES PRICES HAVE TRENDED HIGHER, 1992–2010



Source: IMF.

A Rising Tide

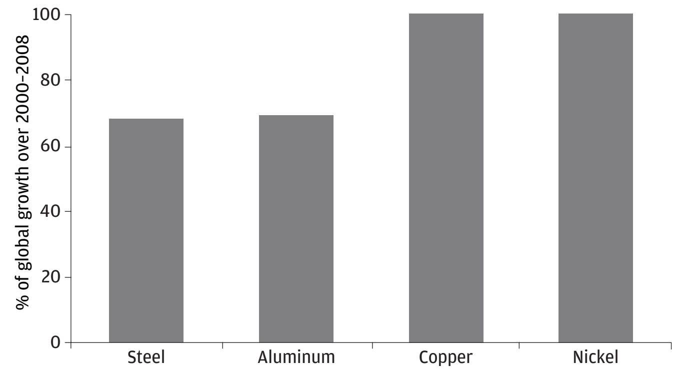
While demand for commodities has been largely a product of short-term cycles in the US, Western Europe and Japan, demand from emerging economies such as China, Brazil and India appears to represent a longer-term structural shift in consumption. Of course, even in these rapidly growing countries demand is not infinite. But to the extent that their inputs remain vastly underutilised—although less so all the time—there is reason to believe that this new aggregate demand represents a “supercycle” which is largely immune to secular swings in demand tied to the business cycle.[4]

[4] By inputs, we refer to primary factors of production such as land, labour and capital.

Consider that while China has long been the world's most highly populated country, the catalysts of wider access to capital and economic liberalisation over the past two decades have sowed the seeds for a revolution of rising expectations. Not only has China become an export platform as the "world's factory," but rapid industrialisation and urbanisation (now approaching 50%) have fostered the development of a consumer market. An increasingly affluent and large middle class is hungry for all manner of consumer goods. As of 2008, most Chinese living in cities owned at least one air conditioner (100.3%), color television (132.9%), refrigerator (93.6%) and mobile phone (172%). While the highest income bracket in China only accounts for about 50 million people, the number of those living below the poverty line has shrunk from 99 million in 2001 to less than 30 million in 2010.[5] In other words, there are more affluent Chinese than poor Chinese today. And no wonder: in the five years leading up to the global downturn in 2008, the Chinese economy grew at an average annual rate of 11%. To fuel the twin engines of domestic consumption and export demand, China's appetite for raw materials has grown exponentially in recent years and shows few signs of slowing down.

To take but one example, the rise in Chinese demand for cars has been a large contributing factor to the increase in demand for some commodities. In 2009, for the first time ever, China displaced the US as the largest single market for vehicle sales with a record 13.6 million units, well above the 10.4 million sold in the US[6] Most vehicles sold in China are produced in local factories, which helps explain the growth in Chinese demand for commodities, especially where industrial metals are concerned. In the period from 2000 to 2008, China accounted for roughly two-thirds of the growth in global demand for aluminum and steel, and nearly all of the growth in demand for copper and nickel (Exhibit 2). By 2008, Chinese demand made up one-third of the world's total use of steel and aluminium and one-quarter of copper and nickel usage.[7]

EXHIBIT 2: CHINA'S GROWING SHARE OF GLOBAL DEMAND FOR METALS



Source: Worldsteel, WBMS, Brook Hunt.

An Ebbing Supply

The supply of commodities has struggled to keep up with greater demand. A peak in commodity prices in the late 1970s and early 1980s was followed by two decades of falling prices, some reaching all-time lows in the 1990s. During this pricing trough, there was little incentive for commodity producers to build out new capacity and production infrastructure. What is more, with no profit motive to increase production, existing facilities were left to deteriorate. For example, even though the demand for metals has been rising, as of 2004 no new mine shafts had been opened in 20 years worldwide. The last iron ore smelter to be built in the US dates back to 1969.[8]

Moreover, taking advantage of the lull in commodity prices, many manufacturers and other industrial commodity users adopted just-in-time inventory practices in order to minimise storage expenses. As consumption started to rise over the past decade, limited inventories have on occasion caused some manufacturing delays due to commodity shortages. This type of disruption may become more common if continued growth in the emerging world strains available supplies of natural resources.

Even today, during one of the worst global economic recessions since the 1930s, oil production capacity utilisation remains near 95%.[9] Moreover, capacity rates are unlikely to decline over the mid-term even if global economic growth is subdued. Additional

[5] Figures shown as a percentage of total population. From 2003–2007, the poverty rate in China fell by two-thirds to just 4% of the population. *OECD Economic Surveys: China 2010,* Organization for Economic Cooperation and Development, February 2010.

[6] China's 13.6 million vehicle sales figures in 2009 included heavy trucks, but after deducting some 650,000 heavy trucks, total Chinese demand still exceeded US light vehicle sales. "China Car Sales Top US," Reuters, January 11, 2010.

[7] Humphreys, David. "The Great Metals Boom: A Retrospective," *Resources Policy,* 2010, Vol. 35, Issue 1.

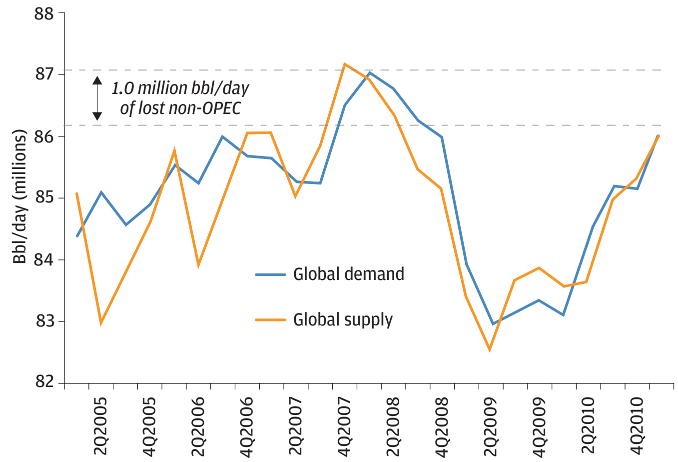
[8] Rogers, Jim. *Hot Commodities: How Anyone Can Invest Profitably in the World's Best Market,* Random House (New York), 2004.

[9] "Commodities: A Solution in Search of a Strategy," Goldman Sachs & Co., January 2010.

capacity requires long lead times because of the tremendous fixed costs and regulatory hurdles typically involved, especially in the market for energy (eg, oil refineries). Commodities also face increased scrutiny about their environmental impact, which could preclude new investment in most developed nations and delay it in many emerging economies. Raw materials production and distribution-related infrastructure investment has historically tended to lag the demand cycle and thereby run the risk of becoming obsolete upon completion. That has made many commodity producers wary of these capital intensive investments, regardless of the longer-term demand dynamic. All of which is to say that global demand and supply may become less balanced than ever before, should use of commodities pick up where it left off in 2007, at least until new production facilities can be brought online—something which may take a decade or two to accomplish.

The drop in commodity demand during the 2008 financial crisis was matched by a drop in global economic activity, which suggests that as more and more countries emerge from recession, demand for commodities will rise commensurately. In the case of oil, for example, Goldman Sachs estimates that low commodity prices and tighter credit conditions are set to reduce global oil production capacity by more than 1.0 million barrels per day by the end of 2010. But capacity constraints are likely to start to create restrictions on oil demand growth as early as the fourth quarter of 2010 (**Exhibit 3**).[10]

EXHIBIT 3: GROWTH IN OIL DEMAND MAY BE CRIMPED BY CONSTRAINTS ON SUPPLY



Source: IEA and GS Global ECS Research.

A similar story is likely to hold for industrial metals, for which strong emerging market demand growth may quickly absorb excess production capacity. Output of agricultural commodities is also close to 100% due to population growth, declining returns from the so-called green revolution of the 1960s and rising protein consumption among the growing ranks of affluent consumers in the fastest growing emerging economies, such as Brazil, China and India.

[10] "Commodities in Crosshairs—A Commodity Shortage Lies Ahead," Goldman Sachs & Co., August 2009.

RISK/RETURN CONSIDERATIONS

FOR A LONG-TERM PORTFOLIO

The Importance of 'Fat' Left Tails

As the stock market turbulence over the past couple of years has demonstrated, conventionally derived portfolios may carry a higher level of downside risk than many investors realise, or than current portfolio modelling techniques can even identify. There is, therefore, a need to modify risk management frameworks to better capture the long-term downside risk associated with market anomalies which, though rare, occur more frequently than has been assumed in many forward-looking models.

To account for key shortcomings embedded in traditional portfolio modelling techniques, J.P. Morgan Asset Management has developed a novel framework capturing this "non-normality."[11] In short, this new approach focuses on three areas:

- Serial correlation
  Standard risk management models typically ignore the effect of past returns on present returns.

- Negative skewness
  Traditional models have underestimated the probability of extreme negative returns.

- Correlation breakdown
  Correlations have proven apt to converge during periods of market stress, a characteristic not captured by most models.

The non-normal framework represents new dimensions on the risk management frontier that break from reliance on standard deviation as a primary measure of portfolio risk. That is because standard deviation treats desirable upside movements as if they were just as undesirable as downside movements, which is generally inconsistent with investor risk preferences. Further, standard deviation assumes symmetric distributions—which our empirical work contradicts. Because standard deviation defines risk as being only a "one standard deviation event," it fails to capture the potential effect of the "fat" left tails (more akin to two or three standard deviation events) which should inform optimal portfolio selection.

[11] Sheikh, Abdullah and Hongtao Qiao. "The Non-Normality of Market Returns," J.P. Morgan Asset Management (2009).

Instead, we use Conditional Value at Risk ("$CVaR_{95}$"), defined as the average real portfolio loss (or gain) relative to the starting portfolio in the worst five percent of scenarios, based on 10,000 simulations. This is, simply stated, the average real loss (or gain) in the worst 500 (5% of 10,000) scenarios. $CVaR_{95}$ overcomes many of the drawbacks of standard deviation as a risk measure. As it only measures risk on the downside, it primarily captures both the asymmetric risk preferences of investors (the fear of loss being disproportionately greater than the benefits expected from any gain) and the incidence of "fat" left tails induced by skewed return distributions. Plus, given the widespread use by major institutional investors and regulators of its first cousin—Value at Risk—we judge it to be the most appropriate risk measure to incorporate into our framework.

Our results indicate that there is scope for an investor to improve portfolio efficiency even if that investor already holds a well diversified portfolio. But how does that apply to a commodities investment juxtaposed with investments in other asset classes? The following simulation exercise explores how changes to asset allocations can impact portfolio return when using $CVaR_{95}$, or non-normality, as the chief risk measure.

Demonstrating the Potential of 'Non-normality'

In **Exhibit 4**, the first column shows a hypothetical core portfolio with $1 billion invested in 30% bonds, 55% equity (10% international equity, 40% US large cap equity, and 5% emerging market equity) and 15% alternatives, invested equally in hedge funds, private equity and REITs. We also show various statistics for each portfolio such as the arithmetic and compound return, the $CVaR_{95}$ (as defined above), as well as the return per unit of $CVaR_{95}$, which is the arithmetic return minus the risk free rate[12] divided by the $CVaR_{95}$ (with $CVaR_{95}$ expressed as a percentage of the $1 billion starting portfolio value). The subsequent columns show the impact of transferring a portion of the alternatives allocation to commodities. In each case, we compare the resulting portfolio characteristics with those of the core portfolio (ie, Column No. 1 vs. Columns No. 2–No. 5).

[12] The risk free rate is assumed to be 4%, which is consistent with J.P. Morgan Asset Management's' Long-Term Capital Market Return Assumptions.

EXHIBIT 4: DEMONSTRATING 'NON-NORMAL' POTENTIAL—COMMODITIES MAY BOOST RETURN PER UNIT OF RISK

Initial value = $1 billion	1: Current Portfolio (%)	2: 5% from Fund of HFs (%)	3: 5% from Private Equity (%)	4: 5% from REITs (%)	5: 12% from Alternatives (%)
TOTAL BONDS	**30.0**	**30.0**	**30.0**	**30.0**	**30.0**
US Aggregate bonds	30.0	30.0	30.0	30.0	30.0
TOTAL EQUITY	**55.0**	**55.0**	**55.0**	**55.0**	**55.0**
EAFE	10.0	10.0	10.0	10.0	10.0
US Large Cap	40.0	40.0	40.0	40.0	40.0
Emerging markets equity	5.0	5.0	5.0	5.0	5.0
TOTAL ALTERNATIVES	**15.0**	**15.0**	**15.0**	**15.0**	**15.0**
Fund of Hedge Funds	5.0	0.0	5.0	5.0	1.0
Private Equity	5.0	5.0	0.0	5.0	1.0
REITS	5.0	5.0	5.0	0.0	1.0
Commodities	0.0	5.0	5.0	5.0	12.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Expected arithmetic return	7.78	7.86	7.62	7.68	7.64
Expected compound return	7.29	7.35	7.18	7.21	7.18
Volatility	10.38	10.50	9.84	10.10	10.00
Conditional Value at Risk 95 (allowing for non-normality)	$38.54	$38.69	$36.14	$34.70	$35.20
Return per unit of CVaR95	**0.98**	**1.00**	**1.00**	**1.06**	**1.03**
Improvement relative to current portfolio		**0.02**	**0.02**	**0.08**	**0.05**

Source: J.P. Morgan Asset Management.

In Column No. 2, we illustrate the impact of adding a 5% allocation of commodities to the portfolio (through the S&P GSCI index), with a corresponding reduction in the allocation to hedge funds. This raises the compound return of the portfolio from 7.29% to 7.35% and increases the conditional value at risk by $0.15. It also raises the return per unit of $CVaR_{95}$ from 0.98 to 1.00. That means that for any given return there is less risk.[13] In the case of a $1 billion portfolio, for example, it would hypothetically increase the return by $20 million without changing the risk. Column No. 3 shows that if the 5% to commodities had been taken from private equity rather than from a fund-of-hedge funds, the expected portfolio return would be lower than the starting core portfolio but also encompass a lower level of risk. The net effect is that there is no appreciable difference in the return per unit of risk than was the case in Column No. 2's portfolio.[14]

Column No. 4 depicts the result when the 5% is allocated to commodities from REITs rather than from hedge funds or from private equity. Interestingly, in this case the return per unit of $CVaR_{95}$ improves more than in any other, in fact, even more so than for a portfolio with a 15% allocation to commodities. This is comparable to the results of Column No. 5, in which the whole allocation to alternatives is invested in commodities leaving merely a nominal 1% allocation to hedge funds, private equity and REITs. In summary, including commodities in the portfolio appears likely to increase the overall return per unit of $CVaR_{95}$ in all four scenarios illustrated, based on our model and J.P. Morgan Asset Management's Long-Term Capital Market Return Assumptions. Of course, more is not necessarily better. An allocation to commodities above 15%—or even above 5% in some cases—may not result in returns significantly better than those highlighted above because of a vastly greater volatility. Rather, the point of this exercise has been to demonstrate that commodities deserve due consideration within a given investment portfolio's "alternatives" asset allocation bucket.

[13] It should, however, be noted that in modelling hedge funds, we chose a fund-of-hedge funds, which figures in relatively low returns and correspondingly low levels of risk. Investing in directional hedge funds might offer the potential of much higher returns, but at a higher risk.

[14] Of course, private equity is an asset class which traditionally displays large performance differences between the top and bottom quartile manager. In this analysis, we rely on J.P. Morgan's Long-Term Capital Market Return Assumptions, which assume the return of a median private equity manager and the volatility of the DJ US Microcap Total Stock Market Index. If our hypothetical portfolio were invested with a top quartile manager, we would expect the returns to be 400-500 bps higher.

COMMODITIES AND MACRO HEADWINDS

In the wake of the 2008 credit crisis and subsequent unprecedented injections of liquidity into world markets, a major concern for many investors is the prospect for higher rates of inflation in the future. At the same time, with growth in developed economies still well below trend, *de*flation is also a significant concern as it may be a more immediate threat.

Both pricing regimes—inflation and deflation—present challenges to investors seeking to maximise the purchasing power of their portfolio assets over the mid-to-long term. While real assets such as commercial real estate have historically tended to perform best during periods of high inflation and fixed income investments have been a safe harbour amid deflation, the role of commodities in these pricing environments is perhaps less well understood. Can a strategic allocation to commodities act as a hedge in either case—or both?

The Upside of Inflation

In order to understand the relationship between inflation and asset returns, including commodity returns, we conducted an empirical analysis in which we sought to isolate the impact of inflation on various asset prices, taking into account the fact that asset returns are also driven by other factors such as prospects for economic growth, interest rates, capital flows, currency valuation, financial regulation, government policy (including taxes) and changes to investor risk appetite, to name but a few variables. Our model is based on a trio of indicators illustrating the vitality of the overall economy: the real US GDP growth rate, the US unemployment rate and the trade weighted US dollar exchange rate. These inputs define economic aspects that are not necessarily captured by inflation alone. For example, real GDP growth indicates the health of the economy in terms of output; the unemployment rate indicates the likely direction of central bank policy in terms of interest rates and the strength of the dollar indicates the likely impact on imports/exports and commodity prices. In addition, given the complexity of isolating inflation's impact on asset returns, it is important to consider inter-relationships among these three economic indicators, investment returns and the rate of inflation.

While accepting that there are several ways to approach the problem, we consider the question within the context of a so-called factor analysis. We believe such analyses best capture the dynamic inter-play between inflation and asset returns,

EXHIBIT 5: IMPACT OF INFLATION, GDP AND UNEMPLOYMENT ON ASSET CLASS RETURNS (Q1 1983–Q4 2008)

Asset class	Higher inflation	Higher real GDP growth	Higher unemployment rate	Higher foreign exchange rate
Equity	Significantly negative	Significantly positive	*Not significant*	*Not significant*
US Treasuries	*Not significant*	Significantly negative	Significantly positive	*Not significant*
Investment Grade Corporate Bonds	*Not significant*	*Not significant*	Significantly positive	*Not significant*
Commodities	Very significantly positive	*Not significant*	*Not significant*	*Not significant*

Source: J.P. Morgan Asset Management.

Note: Significance is determined at the 5% level using an F-test of significance; for illustrative purposes only.

contingent upon different conditions of the economy. In testing the impact of inflation we consider a simple multi-factor analysis including the variables listed above. Inference is conducted by tests of statistical significance indicating which way (negative or positive) and how important (weak or strong) an impact these types of inflation have on returns (Exhibit 5).

The results of our analysis suggest that inflation detracts from equity performance, as profit margins are depressed and both higher variable input costs as well as labour costs tend to impede earnings growth. Fixed income (in the form of government-issued securities), meanwhile, is negatively affected by strong GDP growth as well as by a higher unemployment rate. Corporate bonds, which have both equity[15] and fixed income qualities, suffer in a high inflationary environment because that is when their fixed income characteristics tend to dominate. Long positions in commodities are perhaps the closest thing to a pure "inflation hedge" relative to the other liquid asset classes considered in this analysis. That is because, as our results show, unlike equities or fixed income, commodities exhibit a significant positive return in inflationary environments. In other words, inflation and commodity returns have strong positive correlations.[16]

Deflation: Danger or Opportunity?

Given the current slack in economies around the world, investors are also concerned about the potential for deflation. In this section, we define deflation as a decrease in the general price level of goods and services. Deflation occurs when the annual inflation rate becomes negative, resulting in an increase in the real value of money. The analysis of the impact of deflation is not as straightforward as that for inflation because history does not provide us with as much prior experience. We therefore are required to build a slightly more elaborate and dynamic factor analysis, known as a vector autoregressive, or VAR, analysis. VAR analysis allows us to capture feedback dynamics from fluctuations permeating across all factor sets. As a tool, this also allows us to simulate shocks (sudden rises or declines) in a particular factor and thereby provide a window into what the impact would be. This, of course, is conditional on certain assumptions. But in the absence of an extensive historical track record, VAR analysis may be seen as an insightful alternative. Exhibit 6 outlines the results of our analysis.

EXHIBIT 6: IMPACT OF DEFLATION ON ASSET RETURNS (Q1 1970–Q2 2009)

Asset class	Immediate impact	Longer-term impact (3 years)
Equity	Negative	Positive
Fixed Income	Positive	Dissipates
Credit	Positive	Positive
Commodities	Negative	Negative

Source: J.P. Morgan Asset Management.

Note: Based on VAR analysis; for illustrative purposes only.

What we found is that the immediate impact of deflation on equities is to depress prices, but that moderates over a three-year time frame. As for fixed income, it reacts positively in deflationary cycles, but this effect dissipates over time. Credit, however, benefits in both short-and mid-term deflationary scenarios. Commodities, on the other hand, display an unambiguously negative response to deflation. But that is not necessarily a disincentive for an investor because that strong correlation

[15] Corporate bond yield spreads tend to be highly correlated with equity prices.

[16] It should be noted that between 1970 and 1982, during which unusually high inflation prevailed as a result of unexpected inflation, all our factors—including inflation—detracted from commodity returns. This does not mean that commodities were not a good hedge during this period, but rather that other factors dominated return behavior when inflation was unexpected.

may provide lucrative opportunities to short commodities positions. Indeed, of the four asset classes considered, commodities display the strongest hedging opportunity when shorting against deflation over the period examined.

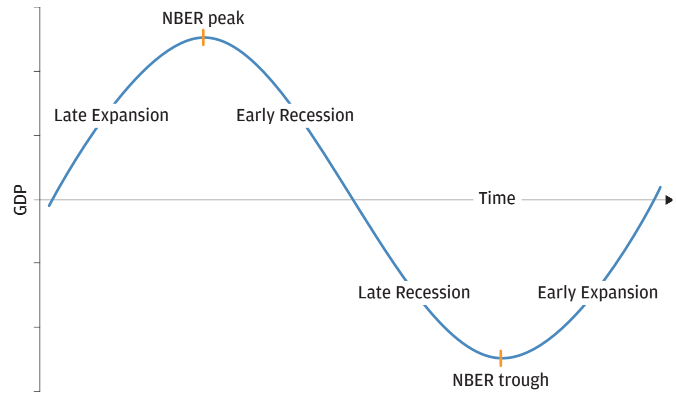
It should not be surprising that commodities present a potentially attractive investment opportunity amid both inflation and deflation as their prices typically mirror global pricing trends. As demand for goods and services increases, so does the price of these goods and services, and the price of the commodities which are used to produce those goods and services rises in kind. Similarly, as the price of goods and services falls in a deflationary environment, the price of the commodities which are used in their production also falls. By way of contrast with that outcome, our research confirms the widespread notion that stocks and bonds tend to perform better when the rate of inflation is stable or slowing. Faster inflation lowers the value of future cash flows paid by stocks and bonds because those future dollars will be able to buy fewer goods and services than they would today. The inverse of this was exemplified during the 1980s and 1990s, when inflation fell and stocks and bonds experienced bull markets.

The Correlation Corollary

According to modern financial theory as it was pioneered by Harry Markowitz in 1952, the risk associated with asset returns is divided into two components: the asset-specific risk and the market risk. In theory, it is not possible to avoid market risk by portfolio diversification, as only asset-specific risk may be reduced in this way. For example, because commodity returns and equity returns are negatively correlated, holding both these asset classes can reduce the asset-specific risk taken by sharing it between the two assets. The market risk, however, is undiversifiable.

If we take into account the cyclical nature of economic growth, however, we find that an investment in commodities can, in fact, help reduce the systematic, market risk taken by a portfolio. Indeed, if we can identify patterns between asset class returns and economic cycles, an investor employing sophisticated hedging techniques may be able to exploit them.

EXHIBIT 7: CLASSIC BUSINESS "PEAK TO TROUGH" CYCLE



Source: Yale International Center for Finance.

In particular, commodities tend to perform well in the early stages of a recession, a time when stock returns generally deteriorate. In later stages of recessions, commodity returns also start to deteriorate, but this is typically when equities begin to outperform. An investor employing sophisticated hedging techniques may therefore be able to take advantage of this apparent pattern in asset class returns and economic cycles.

Exhibit 7 depicts a classic business cycle in stylized form identifying the peak and trough—as determined by the US National Bureau of Economic Research (NBER). The corresponding cycles are divided into phases, which are calculated by dividing the number of months from peak-to-trough (or trough-to-peak) into equal halves to indicate Early Recession and Late Recession (and then Early Expansion and Late Expansion). In this way, the Early and Late Expansion phases correspond to an economic expansion, while the Early and Late Recession phases correspond to an economic contraction.

Each of the four stages in the exhibit have been defined as a combination of the level of the output gap (i.e., the difference between actual output and potential output) and the rate of economic growth. In Stage No. 1, the economy is in a late expansionary phase characterized by fast growth and above-trend output, so capacity constraints begin to come into play and commodity prices rise. In Stage No. 2, labeled Early Recession in the diagram, output is still above-trend but it starts to slow as capacity constraints lead to a rise in unemployment. Eventually, output drops below its trend average and the

EXHIBIT 8: AVERAGE RETURNS AND (VOLATILITY) FOR MAJOR ASSET CLASSES DURING A CLASSIC CYCLE, 1970–2006

Asset class	Late expansion	Early recession	Late recession	Early expansion
Equities	7.84 (5.23)	4.05 (7.21)	18.28 (4.66)	7.84 (5.30)
Government bonds	6.07 (3.07)	9.34 (5.65)	12.96 (3.18)	4.45 (3.09)
Treasury bills	6.55 (0.44)	7.81 (0.47)	5.05 (0.39)	4.45 (0.35)
Commodities	19.97 (4.62)	9.53 (10.59)	5.63 (5.00)	8.48 (6.05)

Source: GS Commodity research.

Note: Each entry in the table represents the annualised quarterly return between 1970 and 2006, followed by the quarterly standard deviation around the average return.

economy enters a Late Recession phase. Thus, in Stage No. 3, output continues to decline, unemployment levels peak and capacity utilisation bottoms out. Finally, in Stage No. 4, the Early Expansion, the economy emerges from recession with rising, but still below trend, output and moderating unemployment levels.

The obvious question for the long-term investor is: How well do major asset classes perform across each of the four stages of an economic cycle? To answer that, we looked at average annualised quarterly returns and volatility (via standard deviation) for four major asset classes during the four stages of a complete cycle (Exhibit 8).

From this simple analysis, we can see that commodities tend to perform better than the other three asset classes when the economy is in a late expansionary phase, with average returns of 19.97% and relatively low volatility. As the economy enters recession, this analysis shows that commodity returns are still higher than the returns to the other asset classes, but that bonds and bills are on the rise and equities underperform. In the latter part of a recession, we have determined that equities and bonds seem to outperform, while in an early expansion, commodities regain the upper hand. In this respect, historically speaking, a tactical allocation to equity investments would have been optimal just when the economy was at its worst, while an opportunistic allocation to commodities would seem to have been most logical just as an economic recovery got underway.

It should be emphasised that these results are purely descriptive and are not meant to imply a trading strategy since the business cycles used are dated ex-post facto. However, one key takeaway that emerges from this analysis is that equities, bonds, and treasuries display similar risk characteristics relative to the economic cycle. Commodities, in contrast, behave very differently from other asset classes, offering potential for lowly correlated macroeconomic diversification within an investment portfolio.

EXPLOITING LINKAGES BETWEEN COMMODITIES

The analysis in the previous section made the assumption that an investment in commodities usually is made via an index, such as the S&P GSCI or the Dow Jones UBS index. In most of the literature that we know of, any analysis of commodities makes the assumption that the investment is transacted via an index of commodities, in which the weightings of each are determined by the owner of the index.

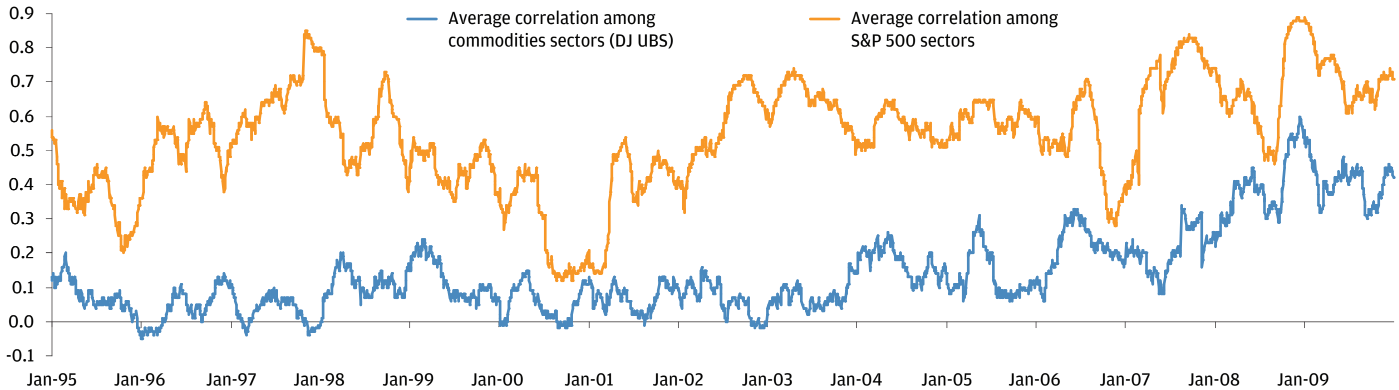
So, while investors may purchase an index, they have no influence on allocation to various commodities or commodity-linked sectors. In this section, we attempt to ascertain opportunity costs involved with gaining exposure to commodities through indices. And we explore potential opportunities from investing in commodities via actively managed vehicles such as long-only and hedge funds.

The Limits to Index-Based Investing

In theory, commodity indices create a uniform standard of a broad-based indicator representative of commodity price movement. But in practice, portfolio weightings, construction, and calculation methodology vary from one index to another. (Some of the most prominent differences in commonly referenced commodity indices are highlighted in Appendix I and Appendix II.) The high level of historical volatility in commodity prices takes on particular importance when one considers that markets in individual commodities often move far more independently of each other than do the components of many other financial markets. Consider, for example, the average correlation among commodity sectors as measured by the Dow Jones UBS index compared to the average correlation among S&P 500 sectors (Exhibit 9). The performance of each commodity sector tends to be determined by its own unique supply and demand dynamics, while equity prices overall have typically been influenced more by general market conditions than sector-specific considerations.

Our research shows that correlations among commodities tend to be low due to highly specific supply-side factors and demand elasticity. It is because of these low correlations that active rotation among commodity sectors may allow for more consistent returns than are possible by simply investing in a broad basket of commodities through an index. Despite the expectation commodity prices may continue to rise due to supply and demand imbalances seemingly inherent to global growth, individual commodity prices may spike or plummet within a multi-commodity index environment. For this reason, passive exposure to commodities may potentially come at a greater

EXHIBIT 9: AVERAGE CORRELATION AMONG COMMODITY SECTORS VS. AVERAGE CORRELATION AMONG S&P 500 SECTORS



Source: Bloomberg.
Note: Data through December 31, 2009.

cost than with index exposure to other asset classes, as interim moves of individual commodities against even a prolonged overall trend may be more frequent and more severe.

Foreseeable tactical opportunities for actively managed strategies to deal with this issue include those related to cyclicality, seasonality, cross-correlation and weather premiums all present scenarios that, by definition, cannot be fully exploited—or avoided—by a broad basket of commodities such as those in an index. Agricultural commodities, for example, are heavily influenced by seasonal factors, as well as by specific supply and demand factors. Another characteristic of commodity indices involves the rolling of futures contracts. To explain the roll yield advantages and disadvantage of an index, it is important to grasp two key concepts: *backwardation* (a by-product of scarcity) and *contango* (a by-product of over-supply).

In order to avoid ever having to take physical delivery of a commodity, and to maintain a long position, index providers sell the front, or expiring, futures contract month and buy a back month. This is known in industry parlance as a "roll" because these contracts are rolled forward, theoretically in perpetuity. Backwardation refers to a situation in which futures prices rise as the delivery time frame shortens. In other words, spot prices exceed futures prices. If a given "discounted" futures position is rolled forward before expiration, then it can earn a "positive carry" (where returns exceed initial investment costs) as the contract "rolls up," or converges, to the higher spot price. The opposite of this phenomenon is called contango and it describes a condition in which futures prices fall as the delivery time frame shortens. In other words, futures prices exceed spot prices. If a given "premium" futures position is rolled forward before expiration, then it can encounter a "negative carry" (where initial investment costs exceed returns) as the contract "rolls down," or converges, to a lower spot price. A savvy active manager could potentially take advantage of these pricing patterns. For instance, buying future contracts for a commodity market experiencing backwardation would position an investor to benefit from appreciation as delivery nears and the futures price converges with the higher spot price. Similarly, shorting future contracts for a commodity market experiencing contango positions an investor to benefit from depreciation as delivery nears and the futures converge with the lower spot price.

Of course, market conditions can change rapidly, especially where commodities prices are concerned. In late 2004, for example, some energy-related commodity futures contracts which had been in backwardation for many months suddenly switched to being in contango, resulting in severe roll losses for some investors locked in to their long positions. As a consequence of that major shift, the S&P GSCI Excess Return Index, which includes spot and roll yield, returned +21.6% in 2005, which was less than the S&P GSCI Spot Index return of +39.1%. A negative roll yield of this magnitude is not uncommon where energy prices are concerned, and since energy represents a large proportion of index weightings, it may continue to have significant effects on commodity index returns. That is because in conditions of contango, commodity indices seem to be predisposed to lower returns to the extent that they are exposed to the full brunt of "negative carry."

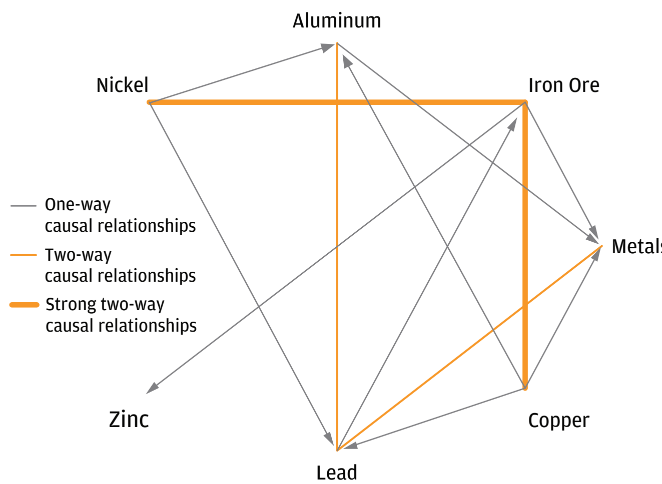
Exploiting Linkages: A Metals Case Study

To illustrate the potential for active management in commodity investments, we developed a case study focusing on links between individual metals and a determination as to whether or not any such links could be exploited on a systematic basis. If some metal prices lag other metal prices, then it stands to reason that an active manager who is looking for trading opportunities could theoretically exploit this knowledge ahead of the broader market (i.e., indices). To test this hypothesis, we used what is known as multivariate Granger causality, which is widely considered to be a technique that goes beyond "mere" correlation by revealing aspects of causality. According to this method, a commodity X_1 may "Granger cause" a commodity X_2 if it can be demonstrated (through a series of F-tests on lagged values for X_1) that those values provide statistically relevant information about the value of X_2. In other words, X_1 historical data may provide a better forecasting metric than is possible when considering only the track record of X_2. It should be noted that identifying Granger causality is not the same thing as identifying actual causation. It merely indicates that some linkages are likely to exist between one or more variables (e.g., commodities) which could, in theory, be exploited by a manager in the long term.[17]

For our purposes, we systematically tested the relationship of individual metals' to a broader metals index.[18] This yielded some interesting results, which are illustrated in **Exhibit 10**.

The gray lines in **Exhibit 10** represent Granger causal relationships between the metals index, labeled "Metals," and the individual metals depicted. For example, the arrow from "Iron Ore" to "Metals" indicates that knowledge of the pricing history of iron ore contains meaningful information for predicting the future value of the index. Or consider the arrow connecting "Nickel" to "Aluminium," which appears to show that historical prices of nickel could help inform an investor about the likely price of aluminium. It is conceivable that this apparent close relationship stems from the fact that nickel, which has corrosion-resistant properties, is commonly used in aluminium-based and other alloys. That may also help explain the orange line between "Iron Ore" and "Nickel." The orange lines in the diagram depict causal relationships going in *both* directions—and the thickness of the lines indicates the magnitude of the relationship. So our diagram implies that iron ore's price history helps inform the directionality of nickel prices and vice-versa. In this respect, it would be advisable for a portfolio manager to be aware of how many arrows *originate* from each point and how many *arrive* at each point. The results are detailed in **Exhibit 11**.

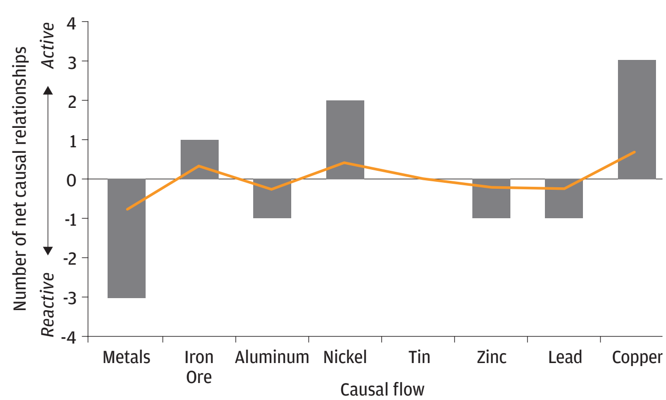
EXHIBIT 10: CAUSAL RELATIONSHIPS AMONG MAJOR METALS



Source: Anil Seth, Granger Causal Connectivity Analysis Toolbox; J.P. Morgan Asset Management.

Commodity sources: Iron Ore: Brazil (N.Sea.Ports); Aluminum: Canada/U.K.; Nickel: Canada, Can/Ports; Tin: All origins (London); Zinc: U.K. (London); Lead: U.K. (London); Copper: U.K. (London).

EXHIBIT 11: CAUSAL FLOW—COPPER AND NICKEL APPEAR TO PROVIDE PRICING CUES



Source: Anil Seth, Granger Causal Connectivity Analysis Toolbox; J.P. Morgan Asset Management

[17] Seth, Anil K. "Granger, Causal Connectivity Analysis," *Journal of Neuroscience Methods*, Vol. 172, No. 1 (July 2008); Granger, C.W.J. "Investigating causal relations by econometric models and cross-spectral methods," *Econometrica*, Vol. 37, No. 3 (August 1969).

[18] All data and index definitions are from the International Monetary Fund.

We can conclude that the index (denoted by the label "Metals") is the most passive variable because most of the other variables seem to predicate the direction of the index. This is to be expected since, in principle, one would assume that most of the individual metals contribute to the value of a broader basket, or index. Interestingly, we found that "Copper" originates the most causal relationships. In other words, an investor might theoretically be able to leverage knowledge of copper price directionality to determine the possible pricing outcomes for other metals and the index. In this way, we can rank the metals in order of the embedded information value contained in their prices, with copper at the top. Of course, the linkages which are evidenced by this analysis may arise for a variety of reasons. For one, the metals used in this analysis form part of various production processes which draw on these metals in a certain order, as alluded to above. But in any case, this exercise shows that there does appear to be ample opportunity for a portfolio manager to identify and potentially exploit linkages between and among individual commodities, thereby gaining higher returns than would otherwise be possible by investing in a passive index.

This analysis is merely one tool of many available to exploit such links between metals as part of an overall trading strategy. Other potential components in a sophisticated portfolio manager's tool kit could include volatility-oriented trades using options, calendar spreads, drawing on fundamentals such as inventory and demand forecasts, momentum/trending/mean-reversion related to expected economic substitutions, mispricing due to temporary dislocations in product spreads, and many others. However, describing each of these methods and techniques is beyond the scope of this paper.

The Active Management Tool Kit

Investing in commodities via a passive index only enables an investor to access commodity futures which are traded on regulated exchanges. Since not all commodities are available on exchanges, passive indices are limited in the commodity markets they can reach. In contrast, active management enables an investor to access a wider variety of commodities, including those traded on equity markets and other exchanges. Exhibit 12 shows some of the chief commodity exposures offered by active and passive strategies respectively.

EXHIBIT 12: TYPES OF COMMODITIES EXPOSURE—HOW ACTIVE AND PASSIVE STRATEGIES COMPARE

Active	Passive
• Energies	• Energies
• Agriculture & Softs	• Agriculture & Softs
• Metals	• Metals
• Water	
• Power	
• Electricity	
• Paper & Forestry	
• Shipping/transport	
• Chemicals & building materials	
• Peripheral base metals	
• Coal & other alternative energy	
• Emissions	

Source: Cole Partners.

EXHIBIT 13: ACCESSING COMMODITIES TRADING STRATEGIES—HOW ACTIVE AND PASSIVE STRATEGIES COMPARE

Active	Passive
• Long futures	• Long futures
• Short futures	
• Options	
• Over-the-counter derivatives	
• Calendar spreads	
• Basis trading	
• Long/short equity	
• Arbitrage	
• Market making	
• Physicals	

Source: Cole Partners.

What is more, as noted in the preceding segments, active commodity management is not constrained to long-only strategies. Indeed, active managers can draw on a number of different strategies in an attempt to generate returns over and above the benchmark index, such as seasonal factors in agricultural and energy commodity markets. Exhibit 13 provides some examples of the variety—or lack thereof—in the trading strategies available to active and passive management.

Investors who wish to benefit solely from the beta of an exposure to commodities may be satisfied by investing via a passive index alone. Although an index can exhibit higher volatility and larger draw downs than an actively managed portfolio, these investors may be best poised to fully benefit from a classic bull market in the major commodities. However, correlations between active and passive strategies tend to be very low. So some investors may find it beneficial to invest partly in a passive index and partly in an actively managed strategy, thereby profiting from diversification within a commodities allocation.

A Reasonable Doubt

One of the most common issues for an investor in commodities involves timing. While historical data does seem to show that relatively short periods of strong returns can be followed by longer periods of flat performance, our research indicates that this applies more to passive indices than to some forms of active management due to an expanded tool kit (e.g., shorting, etc.) Whether or not the current supply and demand imbalances described previously continue to put upward pressure on commodity prices, the most adept active managers will seek to exploit volatility and inefficiencies, which are usually plentiful in the market for commodities. One often aired concern involves the higher fees that are typical for actively managed funds relative to their passive rivals. In addition, track records of some actively managed funds may be too short to gauge their long-term viability. Moreover, the number of active commodity managers is low relative to other hedge fund areas so choice may be limited. This could derive from lower interest levels among portfolio managers compared to other (and less volatile) asset classes in recent years, limited trading capacity in certain commodity markets and a relative lack of focus by major banks and asset managers who have been slow to nurture—but anxious to retain—top talent.

In sum, the question of whether to invest in commodities via a passive index or through active management amounts to whether investors want access to the additional markets and strategies which are the preserve of active management. Investing passively enables investors to access the beta returns of the commodities market, taking advantage of supply and demand imbalances and market shocks. Investing actively, on the other hand, enables investors to exploit volatility and inefficiencies, leading to potentially higher returns. For while volatility is higher in the commodities market than in many others, we believe that it is precisely this quality that allows the most competent active managers to display their comparative advantages vis-à-vis their benchmarks.

CONCLUSION

Amid persistent uncertainty in the global marketplace, we believe that an allocation to commodities may help better protect investors' portfolios from a wide spectrum of macroeconomic risks.

In this paper, we have discussed the prospects for demand to exceed supply for many commodities in the coming years. In our view, this is a likely result of continued demand from China superimposed upon the growth trends of other emerging markets, given current supply constraints. We therefore believe that the time is right to consider an allocation to commodities as part of a well-diversified long-term portfolio.

We have also attempted to show that an investment in commodities may lead to an increased return per unit of risk by relaxing some of the assumptions normally made in portfolio analysis. Our empirical analysis also demonstrated that commodities may offer protection against inflation and provide other diversification benefits across the business cycle. Even in a deflationary environment, for example, investors could be poised to benefit from short positions. Finally, we outlined the prospects for achieving higher returns through active management.

Commodities present a combination of challenges and opportunities unlike any other asset class and therefore must be assessed differently from more traditional investment options such as equity and fixed income. It is our belief, however, that an allocation to commodities as part of a balanced portfolio may help diversify and potentially bolster performance in a number of different macroeconomic environments—especially if top quartile actively managed strategies are considered. To be sure, commodities involve higher risk profiles and may be best utilised to complement larger allocations to other asset classes. However, in our view, they do deserve a place in the pantheon of portfolio choices.

APPENDICES

Appendix I: How to Invest in Commodities?

We list here five ways in which investors can gain exposure to commodities, describing some of the benefits as well as potential risks and costs in each case. Exhibit 14 summarises the pros and cons of these various investment vehicles.

The most direct way to invest in commodities is to purchase physical commodities directly. The main advantage of this approach is that direct physical ownership gives an investor the most control over the asset. By definition, this strategy also provides the best opportunity to maximise spot performance. On the other hand, taking delivery of commodities entails storage as well as transportation costs. Also, it is usually not easy to sell these commodities on short notice without incurring extra costs, so direct ownership is a very illiquid way of gaining exposure to the asset class. Moreover, purchasing commodities directly is not always possible for every type of investor.

A common alternative to direct physical ownership is an investment in commodity futures. A commodities futures contract is an agreement to buy or sell a set amount of a commodity at a predetermined price and date. Buyers purchase such contracts to avoid the risks of commodity price fluctuations, and sellers use them to set prices for their products. Futures are highly liquid, unlike physical ownership of the underlying commodities. The main risk to investors is that even a very small move in the price of a commodity could result in large gains or losses. Unlike options, futures imply an obligation to buy and sell the underlying commodities at the set price. If the contract is not rolled over, investors face the risk of having to take delivery of the underlying commodities, which entails storage and transportation costs.

An alternative is to invest in a commodity index, such as the S&P GSCI or the Dow Jones Commodity Index. An index tracks the performance of a basket of commodities. These indices are often traded on exchanges, allowing investors to gain easier access to commodities without having to enter the futures market. The value of these indices depends on the commodities which constitute the index, and this value can be traded on an exchange in a similar fashion to stock index futures. An advantage of trading a commodity index is that, unlike trading the commodities directly, it is a very liquid investment. It is also accessible to many investors by virtue of being traded on an exchange. On the other hand, it

EXHIBIT 14: PROS AND CONS OF VARIOUS INVESTMENT VEHICLES FOR ACCESSING COMMODITIES

	Potential benefits	Potential risks and costs
Commodity-Related Equities	• Liquidity • Dividends • Tax efficiency	• Primary risk is equity risk • Stock-specific risk
Commodity Indices	• Liquidity • Accessible to most investors	• No alpha generation • Often carry is negative
Commodity Futures	• Liquidity • Leverage	• Physical settlement unless contracts rolled • Inaccessible to many investors
Physical Ownership	• Direct control of asset • Best spot performance tracking strategy	• Storage and transportation costs • Poor liquidity • Inaccessible to many investors
Pooled Commodities Funds[19]		
CTAs (Commodity Trading Advisors)	• Typically trade liquid futures • Active management	• Primary trend-followers • Often not a pure play on commodities; may invest in other financial instruments (e.g., FX)
Commodity-specialist hedge funds	• Deep experience in trading of specific commodities	• Less diversified exposure across commodity sectors • Risk management is critical

Source: J.P. Morgan Asset Management.

Note: Opinions and analysis herein constitute Highbridge Capital Management's judgment and are subject to change without notice.

[19] Does not describe any particular fund or manager.

is by definition a passive investment, so any returns will be purely beta driven. What is more, the "carry" on an index is often negative. (We describe the mechanism and potential risks of investing via an index in some detail in our previous explanation of backwardation and contango.)

Another, though more indirect way, to invest in commodities is by investing in commodity producing companies' equity. Of course, this is by nature more of an equity investment than a commodities investment, at least in terms of asset class allocations. Their main advantages include the fact that they are highly liquid as publicly traded investments and that they may offer dividends. On the other hand, stocks of commodities' companies carry equity risk, and as with any equity investment, also incorporate stock-specific risk.

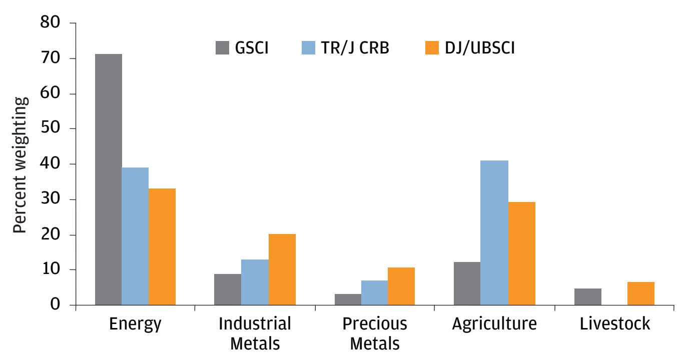
Alternatives to these investment vehicles involve entering into the realm of actively managed investments. One example of this involves a Commodity Trading Advisor, or CTA, which is either a person or a firm paid to provide specialised advice on the trading of commodity-related investments. A CTA will typically trade liquid commodity futures and bring all the benefits of active management to the investment. Investors should be aware, however, that CTAs tend to base their trading strategies on trends, and their bets are not necessarily confined to commodities: their decisions can typically also involve other investments, such as foreign exchange positions.

Commodity specialist hedge funds are another way to gain actively managed exposure to commodities. Their experience is specific to individual commodities or groups of commodities. While their expertise can bring higher returns for individual commodity investments, they are typically less diversified across commodity sectors.

Appendix II: Three Main Commodity Indices

Today there are three main commodity indices—the Goldman Sachs Commodity Index (S&P GSCI), the Dow Jones UBS Commodity Index (DJ/UBSCI), and the Thomson Reuters/Jeffries CRB Index (TR/J CRB) (see **Exhibit 15**). Each is divided into four or five main sectors. It is important to note that each index weights each sector differently. The S&P GSCI, for instance, heavily overweights energies relative to metals, agriculture and livestock. In addition, each index uses different weightings and components to comprise their respective four or five sectors. These breakdowns are illustrated in **Exhibits 16, 17** and **18**.

EXHIBIT 15: SECTOR BREAKDOWN OF KEY COMMODITY INDICES



Source: Goldman Sachs Commodity Index (S&P GSCI), the Thomson Reuters/Jeffries CRB Index (TR/J CRB) and the Dow Jones UBS Commodity Index (DJ/UBSCI).

EXHIBIT 16: S&P GSCI SECTOR WEIGHTINGS BREAKDOWN

Energy (%)	71.04	Industrial Metals (%)	8.76	Precious Metals (%)	31.0	Agriculture (%)	12.27	Livestock (%)	4.83
Crude Oil	37.20	Aluminum	2.73	Gold	2.76	Wheat	2.68	Live Cattle	2.61
Brent Crude Oil	15.18	Copper	3.77	Silver	0.34	Red Wheat	0.54	Feeder Cattle	0.47
RBOB Gas	4.72	Lead	0.49			Corn	2.90	Lean Hogs	1.75
Heating Oil	4.60	Nickel	1.03			Soybeans	2.22		
GasOil	5.85	Zinc	0.74			Cotton	1.20		
Natural Gas	3.49					Sugar	1.73		
						Coffee	0.66		
						Cocoa	0.34		

Source: Goldman Sachs.

Appendix II: Three Main Commodity Indices (cont'd.)

EXHIBIT 17: DJ/UBSCI SECTOR WEIGHTINGS BREAKDOWN

Energy (%)	33.0	Industrial Metals (%)	20.3	Precious Metals (%)	10.8	Agriculture (%)	29.6	Livestock (%)	6.7
Crude Oil	13.8	Aluminum	7.0	Gold	7.9	Coffee	3.0	Live Cattle	4.3
Gasoline	3.7	Copper	7.3	Silver	2.9	Wheat	4.8	Lean Hogs	2.4
Heating Oil	3.6	Nickel	2.9			Corn	5.7		
Natural Gas	11.9	Zinc	3.1			Soybeans	7.6		
						Soybean Oil	2.9		
						Sugar	3.0		
						Cotton	2.3		
						Cocoa	0.3		

Source: Dow Jones-UBS.

EXHIBIT 18: TR/J CRBI SECTOR WEIGHTINGS BREAKDOWN

Energy (%)	39.0	Industrial Metals (%)	13.0	Precious Metals (%)	7.0	Agriculture (%)	41.0
Crude Oil	23.0	Aluminum	6.0	Gold	6.0	Wheat	1.0
Heating Oil	5.0	Copper	6.0	Silver	1.0	Cocoa	5.0
Natural Gas	6.0	Nickel	1.0			Coffee	5.0
Unleaded Gas	5.0					Corn	6.0
						Cotton	5.0
						Lean Hogs	1.0
						Live Cattle	6.0
						Orange Juice	1.0
						Soybeans	6.0
						Sugar	5.0

Source: Thomson Reuters.

Appendix III: Granger Causality Analysis

Granger causality, as described in the main text, is a means of identifying directional connectivity within data using linear regression analysis. For a detailed treatment of this approach, see Granger (1969).

The innovation of the approach taken in this paper, in which we follow the approach pioneered by Seth (2009), is that we adopt a multivariate approach combining Granger causality with network connectivity analysis, which enables us to identify Granger causal networks between two variables while taking account of the effect of all other variables considered. Formally, according to Seth, "a variable X_2 Granger-causes another variable X_1 if knowing X_2 reduces the variance of X_1's prediction error when all other variables $X_3,\ldots,X_n$ are also included in the regression model."

In order for this approach to be statistically valid, we ensure that the underlying regressions are properly specified. This is achieved via a series of multivariate autoregressive models, specifying the optimal lag as it is determined by the Akaike Information criterion. We test the statistical significance of our Granger causal links, and the strength of these links as defined by their respective p-values.

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