CAN METAL MARKETS HELP PREDICT STOCK MARKET RETURNS?

by

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ABSTRACT

The metals and mining sector is driving the world economy like never before. Concentration of industry at a particular level of the global value chain decides how an economy will be affected by rising metal prices seen recently. Stock markets are bound to reflect the broader effect on an economy.

This leads to the question – are stock markets and metal markets correlated, and can metal markets be used to predict stock markets? Taking the LME as a proxy for metal markets and the S&P 500 as a representative stock market, stock market returns are regressed onto notional returns on metal markets and convenience yields in metal prices.

Metal markets are only found to be able to predict the Metals and Mining sub-index of the S&P 500 very weakly. Overall, no conclusions may be drawn pending more rigorous testing and/or use of other explanatory variables, possibly across markets and commodities.

DEDICATION

This project is dedicated to my elders and all my teachers, whose expectations I hope to rise to in charting a career for myself upon completion of this program.

Most importantly though, this project, like everything else I do, is for my wife Anandita, who has never stopped believing in me, and has always been at my side to spur me on to greater achievements. Here is hoping I will be able to give you all of what you so thoroughly deserve.

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I also wish to thank Dr. Richard Heaney – Professor of Finance at RMIT University, Melbourne, Australia, who was kind enough to provide me insights into some of the pre-existing scholarly work on commodity markets, and on industries'/companies' exposure to commodity markets.

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GLOSSARY

Term	Definition/Contextual Reference
15-month futures contract	A contract for the delivery of the contracted amount of a metal 15 months after the date of contract
3-month futures contract	A contract for the delivery of the contracted amount of a metal three months after the date of contract
Base metal[1]	An informal term used in chemistry to broadly refer to any metal that oxidizes/corrodes with relative ease, and reacts with hydrochloric acid to release hydrogen gas, e.g. nickel, lead, zinc, iron, and copper
CRSP	The Center for Research in Security Prices, at the University of Chicago, Graduate School of Business
Cash contract[2]	A contract for immediate delivery of the contracted amount of a metal/commodity
LME	London Metal Exchange
MatLab®	A numerical computing environment and programming language
.METAL	A custom-ticker on Bloomberg® ticker created to represent all stocks listed on the S&P 500 index, other than those forming a part of the Metals and Mining sub-index within it
Non-ferrous metal[1]	A group of metals that do not contain iron, e.g. aluminium, copper, tin, and zinc – also includes alloys e.g. brass, and precious metals e.g. gold, silver, and platinum
S&P 500	The index maintained by Standard and Poor's of the stocks of 500 corporations, all of which trade on the major US stock exchanges
S5METL	The Bloomberg® ticker for the Metals and Mining sub-index within the S&P 500 index

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[1] The terms "base metals" and "non-ferrous metals" are used interchangeably in this project to refer to a group of metals that includes all of aluminium, copper, lead, nickel, tin, and zinc, in line with common industry usage.

[2] The terms "cash contract" and "spot price/contract" are used interchangeably in this project to refer to a price quotation/contract for immediate delivery of the contracted amount of a metal/commodity.

Spot price/ contract[2]	A price quotation/contract for immediate delivery of the contracted amount of a metal/commodity
SPX	The Bloomberg® ticker for the S&P 500 index
TVW	A reference to a notional index of metal prices drawn up on a trade volume-weighted basis, or to returns on such an index
VW	A reference to a notional index of metal prices drawn up on a value-weighted basis, or to returns on such an index

1 INTRODUCTION

The resource sector, encompassing the metals and mining as well as the oil and gas industries, has been growing at a rapid pace recently – all over the world, and especially in North America,. Supply- as well as demand-side factors for metals, oil and gas, among other resources, are driving development at a continuously increasing pace in these industries. Though metals such as copper and lead are known to have been mined by some of the earth's oldest civilizations, it was the onset of the Industrial Revolution in the late 18th century that marked the increasingly widespread and progressively more varied usage of non-ferrous metals. As technology for more efficient coal production evolved, increased supplies of this crucial input (even more so at the time) for the reduction of many ores meant that metals could be extracted from the earth's crust on a mass scale not imagined before.

With increased exploitation of ore-bearing resources all over the world, fears over the ever-growing demand for metals soon outstripping their known supplies are increasing everyday. It is now predicted that Hubbert's peak will be reached for the major base metals – copper, aluminium, lead, tin, and zinc, within the next few decades, and almost certainly before the end of the 21st century. In their pure state as well as in alloyed forms, the major base metals have diverse usage:

1. Aluminium: Vehicle bodies, construction, packaging, consumer durables, machinery, high-tension wiring, etc.
2. Copper: Cables and wires, electrical conductors, circuits, coinage, electromagnets, etc.
3. Lead: Batteries, munitions, radiation shielding, glass, paints, etc.

4. Nickel: Stainless steel production, electrolysis, coinage, catalysts, plating, etc.
5. Tin: Plating, superconductors, electromagnets, steel/other alloys, glass manufacture, etc.
6. Zinc: Galvanized steel, batteries, paints, biochemical catalysts, etc.

The above listing is only an indicator of the all-pervasiveness of base metals in modern human existence. The (known) availability of base metal ore reserves in only selected areas around the world, combined with steadily increasing demand for them has meant that their value has increased manifold over the past 100 years. Over time, base metals have evolved from being simply publicly traded commodities to having specialized markets and career professionals engaged in trading in and/or studying them.

Since its formal inception in 1877, the London Metal Exchange (LME) has grown to become the world's primary market for base metals today – it currently has an annual turnover of over US$4,500 billion[3]. Watkins and McAleer (2004)[4] cite Gilbert (1996) in saying that

> "The London Metal Exchange (LME) is the major international market for the main industrially used non-ferrous metals, namely aluminium, aluminium alloy, copper, lead, nickel, tin, zinc and silver... The LME is used worldwide by producers and consumers of non-ferrous metals as a centre for spot, futures and options trading in these metals. Three primary functions are performed by the non-ferrous metal markets on the LME. First, the exchange provides a market where non-ferrous metal industry participants can hedge against risks arising from price fluctuations in world metal markets. Second, settlement prices determined on the LME are used internationally as reference prices for the valuation of activities relating to non-ferrous metals. Third, the LME also provides appropriately located storage facilities to enable market participants to take or make

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[3] http://www.lme.co.uk/who.asp

[4] Watkins, C. and M. McAleer (2004) Econometric modelling of non-ferrous metal prices. Journal of Economic Surveys, 18 (5): 651 – 701.

> physical delivery of approved brands of non-ferrous metals. The LME is the most important market for the pricing of non-ferrous metals worldwide. Approximately, 95% of the total world trade in copper futures occurs though the LME, with the bulk of the remaining 5% in the copper market on the Commodity Exchange of New York (COMEX). Smaller regional markets typically participate only in spot trade of non-ferrous metals. One exception is the Shanghai Futures Exchange (SHFE), on which a small volume of futures for aluminium and copper are traded primarily for the Chinese domestic market. The copper settlement price determined on the LME is effectively the world copper price. (page 652)"

The above quote succinctly captures the major factors because of which the LME forms a part of many studies on metal markets – both as an indicator of the international trade in non-ferrous/base metals, and as a reliable source of data. The statistics on copper towards the end of the quote highlight the extent to which the LME is "the world's metal market".

The world's mostly limited metal supply has struggled to keep up with the continuously growing demand, especially that originating in recent times from China, India and other emerging economies. This demand-pull has seen metal prices reach record-breaking levels, exemplified by the spot price of aluminium (i.e. the aluminium cash contract) on the LME more than doubling in the three years between spring/summer 2003 (~ US$1,500 per MT) and spring/summer 2006 (~ US$3,300 per MT), with the other metals also exhibiting similar, if not greater appreciation in value. For companies actively engaged in the primary production of ores (mining) and refined metal concentrates, this price escalation has mostly led to significant increases in their profit margins and windfalls in financial performance. As well, newer and smaller exploration companies have been able to capitalize on the increasingly prevalent sentiment of impending shortages and the need to find new reserves at the earliest, in raising money from the financial markets. This sentiment, along with the evolution of greater technological ability has meant that more remotely located ore deposits can, and must, now be accessed. The increased capital intensity of finding and working newer mines means that companies must now have scale to continue pursuing the economically sustainable development of new deposits. This realization has in turn spawned tremendous merger and acquisition (M&A) activity – even among the largest, most well-established players in the metals and mining industry. To illustrate, as this paper is being written in fall/winter 2006, less than half a year has passed since Barrick Gold Corporation acquired Placer Dome Inc., the Swiss miner Xstrata Plc has recently bought Falconbridge Ltd., the ink is still drying on Brazilian CVRD's (Companhia Vale do Rio Doce's) purchase of Inco Ltd., and Freeport McMoran Copper & Gold Inc. is set to acquire Phelps Dodge Corporation to create the world's largest copper manufacturer.

In view of North America's (especially Canada's) having abundant base metal (and other mineral) deposits, as well as some of the continent's mining companies being among the largest entities in their respective fields, the resource boom described above has been a significant contributor to good stock market performance. Along with the fears over the world's supposedly fast vanishing oil supplies that have increasingly brought Canada's oil-sands deposits into world focus, the growing metals and mining industry has been notable in aiding the stock markets' recovery from the "tech bust" of 2001; Canada's bellwether S&P/TSX Composite Index even crossed 12,600 to set a new record (on November 21, 2006).

The above is a commentary on the evolving metal markets, but what do the underlying developments and trends mean for the average, unsophisticated investor? Can a person aiming to generate regular income from a conventional equity portfolio look to benefit from the resource sector-driven exuberance of the financial markets? Most specifically, do the rising base metal prices on the LME have any correlation with, and/or do they predict stock market behaviour?

2 LITERATURE REVIEW

There is a rich body of literature documenting studies on metal markets as well as derivatives based on underlying metal (and other commodity) contracts. Scholars such as Working (1949), Telser (1958), Brennan (1958), Cox, Ingersoll and Ross (1981), Fama and French (1988), Pindyck (1993, 1994, 2004a, 2004b), and Heaney (1998, 2006) have written on commodity market volatility, the concept of convenience yield, the relationship between economic cycles and metal price behaviour, forward and futures prices, etc. At the same time, a few workers have looked at a lead/lag relationship between stock indices and industry-specific portfolios: Hong, Torous, and Valkanov (2005) is an example of this infrequently used approach. However, little scholarly attention has been paid to exploring any such lead/lag or a possible predictive relationship between metal markets and stock markets directly.

Fama and French (1988)[5] examined the relative variation between spot and future metal prices to test the theory of storage (after Working (1949), Brennan (1958), and Telser (1958)), according to which the marginal convenience yield on inventory falls at a decreasing rate as the level of inventory increases. They acknowledged the problem of accurately defining aggregate inventory faced by many scholars previously, which arose due to the:

1. Lack of clarity regarding treatment of government stocks, as well as inaccuracies in their estimation, and
2. Inability to enumerate total global quantities at a point in time for commodities that are produced, traded and consumed continuously.

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[5] Fama, E.F. and K.R. French (1988) Business cycles and the behaviour of metal prices. The Journal of Finance, 43 (5): 1075 – 1093.

In this paper, Fama and French also discussed the above relation postulated by the theory of storage – between inventory levels and convenience yields. However, they examined its implication for the relative variation of spot and future prices rather than testing the inventory-convenience yield relation directly. Based on the theory of storage, they predicted that future prices are less variable than spot prices when inventory is low, though both would be similarly variable in times of high metal inventories. These predictions were based on their interpretation of the hypothesis of Samuelson (1965), the essence of which is that futures prices vary less than spot prices and that the futures price variation decreases as contract maturity approaches. Fama and French interestingly observed that the theory of storage and the phenomenon of declining marginal convenience yields on inventory, though first developed to explain the seasonal variations in the spot and futures prices for agricultural commodities; was just as applicable to metal prices as well. This is even though predictions of metal price behavior are based on general economic conditions and business sentiment, rather than on seasonality, which drives price behavior for agricultural commodities.

Fama and French's sample data covered the years 1972 through 1983, including the 1979-80 period when silver exhibited inverted behaviour vis-à-vis normal futures-spot price relations. They explained this observation also using the theory of storage: metal production is unable to adjust fast to a positive demand shock experienced at the peak of a business cycle. Their data comprised daily observations of:

1. Spot and three-month forward prices for aluminium, copper, lead, tin, and zinc from the LME, with the series for aluminium prices commencing from 1979;
2. Spot, three-, six-, and twelve-month forward prices for silver from the LME;
3. Twelve-month futures prices for copper and gold from the New York Commodity Exchange (Comex), with the gold price series starting in 1975; and

4. Twelve-month futures prices for platinum from the New York Mercantile Exchange (NYM).

Assuming *F (t, T)* to be the forward (or futures) price at time *t* for delivery of a commodity at time *T*, and *S (t)* to be its spot price, Fama and French started with:

$$F(t,T) - S(t) = S(t)R(t,T) + W(t,T) - C(t,T) \qquad [1]$$

According to the theory of storage, the return from purchasing the commodity at time *t* and selling it for delivery at time *T*, i.e. *F (t, T) – S (t)*, is a sum of the interest foregone during storage: *S (t) R (t, T)*, and the marginal warehousing cost: *W (t, T)*, reduced by the marginal convenience yield: *C (t, T)*. This model provided an intuitive basis for conceptualizing the convenience yield: if the notional holding period return is insufficient to cover the interest and warehousing costs borne, a holder of metal inventory must have another source of positive returns arising on account of its holding inventory, i.e. another incentive to carry stocks of a commodity. This practically translates into a commodity storer having lower output costs per unit when possessing inventory, as opposed to incurring a lump sum cost in having to replenish exhausted stocks. The inventory in hand allows the storer to meet immediate customer requirements.

Fama and French adapted the above model:

$$[F(t,T) - S(t)]/S(t) - R(t,T) = [W(t,T) - C(t,T)]/S(t) \qquad [2]$$

to imply that the interest-adjusted basis (the quantity on the left-hand side) was equal to the difference between the relative warehousing cost *w (t, T) = W (t, T)/S(t)* and the relative convenience yield ; *c (t, T) = C (t, T)/S (t)*, i.e. the quantity on the right. Based on this they developed testable hypotheses regarding the convenience yield and the relative variation between commodity spot and forward prices. They observed *F (t, T)*, *S (t)*, and *R (t, T)*, assuming:

1. Marginal warehousing costs to be constant through the range of inventory covered, and
2. Variation in the convenience yield to dominate that in warehousing costs.

Fama and French's results, especially those for base metals, confirmed their predictions. When metal inventories were high, demand and supply shocks impacted spot prices permanently, with the changed price level being reflected in future prices too. However, spot price changes during periods of low aggregate inventory were not carried forward significantly, since market expectations of demand and supply adjustments with time "normalized" the future prices, causing them to change less. These observations were much weaker for precious metals, and the authors suggested this to be due to gold and silver having lower storage costs. These, and the precious metals' relatively lower aggregate usage meant that sufficient inventories could be maintained to allow convenience yields to be close to zero at almost all times.

The appeal of Fama and French (1988) lies in its use of the convenience yield concept to intuitively explain spot price/future price spreads for metals in high and low inventory situations. As well, they very briefly related the sharp rises and subsequent declines in all metal prices to the concurrent business cycle peaks of 1973-74 and 1979-80, citing that the accompanying positive demand shocks increased the convenience yields and led to negative interest-adjusted bases for these periods. This was seen to be fully consistent with the theory of storage indicated by earlier scholars Even their observations for precious metals relate to observations that gold is often held as an inflation hedge, with market movements for it also being driven to a certain extent by conspicuous consumption demands from southern Asia.

LME lead contracts were used in Heaney (1998)[6] to explore whether stock levels of metals affected the ability of current futures prices in predicting the spot prices observed on

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[6] Heaney, R. (1998) A test of the cost-of-carry relationship using the London Metal Exchange lead contract. The Journal of Futures Markets, 18 (2): 177 – 200.

maturity of the futures contracts. An entity requiring metal in the future can either purchase a futures contract – guaranteeing supply in the future delivered at a contracted price, or purchase the metal at the spot price and store it till the time it is required, and Heaney used this situation to set up his cost-of-carry model:

$$F(t,T) = P(t)e^{[rf(t,T)+s(t,T)+sle(t)]} \qquad [3]$$

Heaney's model assumed continuously compounding rates of return, so that the resulting log-linearity made it amenable to the cointegration testing that he used, and storage costs were proportional to spot prices. With *F (t, T)* and *P (t)* being the futures and spot prices respectively, *rf (t, T)*, *s (t, T)*, and *sle (t)* represent the risk-free rate of return for the intervening period, storage cost, and stock level effect at the current time *t*, respectively. The term for the continuously compounded risk-free rate of return represents the opportunity cost of a cash purchase of metal at spot rates, held through to the actual time of use, rather than going long a futures contract maturing at the time of use. The above transforms into a linear model on taking the natural logarithm of both sides:

$$\ln[F(t,T)] = \ln[P(t)] + rf(t,T) + s(t,T) + sle(t) \qquad [4]$$

The stock level effect, which aggregated the effects of storage costs and convenience yields, affected currently held physical stocks, but not the futures contract price. Heaney modelled this effect as a linear function of the stock level to arrive at a stock effect with parameters α and γ:

$$sle(t) = \alpha \ln(S(t)) - \gamma \qquad [5]$$

which yielded the final cost of carry model where the convenience yield parameter was adjusted for storage costs (i.e. $\gamma^* = s(t, T) - \gamma$):

$$\ln(F(t,T) = \ln(P(t)) + rf(t,T) + \gamma^* + \alpha \ln(S(t)) \qquad [6]$$

Heaney averred that the cost of carry model represented a long-term equilibrium and arrived at conclusions that were essentially in agreement with those of Fama and French:

> "When stocks are sufficiently low, the convenience yield tends to overwhelm the other storage costs resulting in a futures price less than the spot price. If the stock levels are sufficiently high, this effect is small and the difference between the futures price and spot price is essentially the cost of storage plus any risk premium effect. (page 187)".

This was because adjustments in the other variables from amongst spot and futures prices, and inventory levels would quickly eliminate arbitrage opportunities arising out of a change in any single variable due to an external demand/supply shock. A major attraction of Heaney's paper is in his recognition of the LME as a prime data source for studies involving spot and/or futures prices for metals. While the stock level only looks at metal stocks held in LME warehouses around the world and is not representative of actual metal stock levels around the world, it does represent the stocks deliverable against trades done through the LME. Therefore, spot and futures contract prices, as well as stock levels are all available from a single source, which is unique.

Heaney (2006)[7] reconciled the two alternative commodity pricing models commonly used: the two-state character of commodity pricing, and the concept of convenience yields, to better explain changes in metal pricing with stock levels. He discussed literature dating back to Keynes (1950), and then Scheinkman and Schechtman (1983) and subsequent work by other scholars, documenting the possible movement of prices between a value state (synonymous with high stock levels) and a consumption state (at low stock levels). The concept of a convenience yield – first proposed by Kaldor (1939), is often still used as an alternative to the two-state theory for better explaining the gaps that arise due to spot/futures price inversions.

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[7] Heaney, R. (2006) An empirical analysis of commodity pricing. The Journal of Futures Markets, 26 (4): 391 – 415.

Heaney (2006) built on the more recent approach advocated by scholars such as Ng and Ruge-Murcia (2000) and Routledge, Seppi and Spatt (2000) in combining the two pricing models, in his 2006 paper. He advocated this richer approach due to its greater explanatory power in modelling commodity prices, since the statistical analysis reported by him supported both:

1. A two-state pricing regime for metals, and
2. Convenience yields that were a non-linearly decreasing function of metal stock levels.

Hong, Torous and Valkanov (2005)[8] ("HTV") investigated the ability of industry-specific stock portfolio returns in predicting movements of the broader stock market as a whole. Their data covered 33 industries having continuous time series between 1946 and 2002, taken from French's website (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/), along with value-weighted REIT index data dating back to 1972 taken from NAREIT's website (www.nareit.com).

In their study, CRSP's value-weighted index returns represented those of the broad market portfolio, while time series for other economic indicators such as inflation, default spread, industrial production level, market dividend yield, and market volatility were sourced from the DRI and CRSP databases. HTV also obtained time series on the Stock and Watson coincident index of economic activity (a weighted average of industrial production, real personal income, real manufacturing and trade sales, and total non-agricultural employee hours) from Watson's website (http://www.princeton.edu/~mwatson/sw/SW2e_data.html).

HTV found that 14 of the 34 industries they studied (including commercial real estate, petroleum, metal, retail, financial and services) could predict market movements a month ahead of time, while a subset of these 14 could even predict the market's movement two months ahead. Furthermore, the predictive ability of portfolios for these 14 industry groups remained statistically

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[8] Hong, H.G., W.N. Torous, and R.I. Valkanov (2002) Do industries lead stock markets? Journal of Financial Economics, forthcoming (First draft: July 31, 2002, Draft used: December 05, 2005). Available at http://rady.ucsd.edu/faculty/directory/valkanov/docs/industries.pdf.

significant even after the authors introduced several recognized measures of risk and liquidity as well as lagged market returns into their basic time-series regression model. That 14 or more industries predicted market movement with statistical significance in 0.04% of their simulations for the entire sample period indicated that their observations were not just chance phenomena. As well, five industries on an average were able to predict the market at a 10% level of significance.

In addition to the above, HTV substantiated the economic and statistical significance of their findings by:

1. Comparing the predictive ability of the 34 industry portfolios chosen by them with other recognized economic indicators, e.g. inflation and dividend yield, to find comparable predictive ability.
2. Showing that a portfolio constructed and managed on the basis of information contained in industry returns from preceding time periods could (under certain conditions) lead to a higher Sharpe ratio than just investing in the market portfolio.
3. Extending their analysis to eight of the world's largest stock markets outside USA, to find that similar inferences could be drawn from the results for those other markets.

HTV's study was driven by contemporary work into the effect of market participants' limited information processing capacity for asset prices. They cited the work of Shiller (2000) and Sims (2001) among others into investors' bounded rationality, saying that no one could follow all sources of information together to be able to understand their impact on the asset prices of their interest. Indeed, the statement guiding their work on industries leading stock markets was "... that the gradual diffusion of information across asset markets leads to cross-asset return predictability." Practically, generalist "market holders" receive information pertaining to specific industries after a time lag, and so industry portfolios that include information on macroeconomic fundamentals lead the total market portfolio. This includes industries with their returns innately tied to economic indicators (particularly leading indicators) like real estate (housing starts, etc.), and metals and mining (commodity prices). HTV elucidated the two assumptions underlying cross-asset return predictability – that information diffuses slowly across markets (industry-specific, geographic, etc.), and that not all investors may be able to extract all relevant information from asset prices, especially from those that they do not specialize in. The second assumption links to Merton (1987) and later literature on segmented markets and limited market participation, and the authors state that:

> "… limited participation is a pervasive feature of financial markets and may be another rationale for why investors in one market may be slow to adjust to information emanating from another. (page 3)"

For the US as well as for seven of the eight non-US countries for which they analyzed monthly returns obtained from Datastream, HTV were able to prove their hypothesis that the predictive ability of a particular industry portfolio was highly correlated with "its propensity to forecast market fundamentals such as industrial production growth or other measures of economic activity." They expanded on this further:

> "Indeed, industry returns that are positively (negatively) cross-serially correlated with the market are also positively (negatively) cross-serially correlated with future economic activity. (page 3)",

and proceeded to illustrate this with the fact that high returns for certain industries, e.g. retail have a very different implication for future economic activity, than those for certain other industries, e.g. petroleum.

HTV concluded by suggesting that their hypothesis could be tested in settings other than those involving industry portfolios vis-à-vis the broad market index, and even cited papers written after their own first draft of 2002. Specifically, the findings of:

- Menzly and Ozbas (2004) about industry returns leading/lagging each other as per their place in the value chain, and
- Pan and Poteshman (2004) about option volumes predicting stock price movements on account of options markets leading stock markets,

were cited as yielding confirmatory findings.

Reference to HTV's article was the starting point of this project: a study of the relationship as well as a lead/lag between industries and stock markets would serve to identify any phenomena underlying the links between markets. This project develops HTV's approach by exploring the relationship between the non-ferrous/base metals market and the stock market.

Chang, Chen and Chen (1990)[9] and Hill, Moore and Pruitt (1991)[10] provided reinforcement to the idea of using notional returns on an index of metals in order to facilitate the study of any predictive lead/lag relationship with stock market returns. In the absence of a precedent directly analyzing correlation between stock markets and metal markets, the idea of constructing an index of metal prices was appealing on account of its intuitive simplicity. The two papers use index construction to achieve very different objectives, but this only serves to highlight the applicability of such an approach in a wide variety of contexts.

Chang, Chen and Chen (1990) ("CCC") analyzed the risk-return profile of copper, platinum and silver futures vis-à-vis common stocks within the framework of Sharpe and

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[9] Chang, E.C., C. Chen, and S.N. Chen (1990) Risk and return in copper, platinum, and silver futures. The Journal of Futures Markets, 10 (1): 29 – 39.

[10] Hill, S.R., N.H. Moore, and S.W. Pruitt (1991) Cold fusion – Hot metal: An analysis of the metals futures market reactions to the cold fusion announcement. The Journal of Futures Markets, 11 (3): 385 – 397.

Lintner's Capital Asset Pricing Model (CAPM). For this, the proxy used for the market portfolio comprised:

1. Returns on the value-weighted CRSP stock index, to the tune of 90%, and
2. Returns on the Dow Jones Cash Commodity Index, to the extent of the balance 10%.

CCC's paper was based on the intuition that the market only compensates investors for the non-diversifiable (i.e. systematic) risk assumed, which is estimated as:

$$R_{it} - R_{ft} = a_i + b_i(R_{mt} - R_{ft}) + \varepsilon_{it} \qquad [7]$$

However, as CCC ran time-series regressions of returns on commodity futures contracts, which are mostly traded on margin, they assumed that the traders in these were not seeking compensation for deferring consumption. The regression model used by them consequently substituted raw returns for the excess returns on the left hand-side of [7] above:

$$R_{it} = a_i + b_i(R_{mt} - R_{ft}) + \varepsilon_{it} \qquad [8]$$

The returns, standard deviations and Sharpe ratios obtained as above for silver, copper and platinum were compared with those for CRSP's value-weighted stock index, 30-day Treasury bills, and an index of Treasury bonds over the period January 1964 to December 1983. based on their regression coefficients, CCC concluded that the futures traders did in fact bear a higher amount of risk than conventional investors, and that the market compensation to them was not commensurate with this higher risk. Generally, silver futures were most volatile while copper futures were least volatile, though the former also yielded the highest returns as copper earnt the lowest.

Hill, Moore and Pruitt (1991) examined the efficiency of futures markets for metals in the light of the cold fusion announcement of March 23, 1989, by studying the statistical significance of the observed changes in the price, volatility and trading volumes for palladium in the period immediately following the event. Historical returns for each of four metals – gold, silver, aluminium, copper were combined period-by-period into an equally weighted index that served as a market proxy for studying general commodity price change behaviour independent of the announcement. As Pons and Fleischmann – the two scientists who "discovered" cold fusion used both platinum and palladium, the price change behaviour for each of these two metals was studied in isolation vis-à-vis the market proxy. As well,

> "In addition to the created metal index, the CRB commodity index was also employed as a market proxy to assess the robustness of the study. No substantive differences were observed between the two sets of results. (footnote 4 on page 389)"

Thus, index construction was seen to be a sufficiently rigorous if not oft-used tool employed for conducting studies into unique topics that had no documented precedent available.

Fama and French (1992)[11] found that the CAPM, which they referred to as the Sharpe-Lintner-Black (SLB) model, presented a simplistic positive relation between the average return on a stock and its market beta that did not hold for NYSE-listed stocks over the period 1963-1990. They cited firm size, leverage, the earnings/price (E/P) multiple, and the book-to-market equity ratio (BE/ME) as factors significantly related to stock returns, following from work by Banz (1981), Bhandari (1988), Basu (1983), Stattman (1980), Rosenberg, Reid, and Lanstein (1985), and Chan, Hamao, and Lakonishok (1992) among others. All four of these variables are derivatives of the stock price itself, but the effects of leverage and E/P were said to be to be redundant in explaining stock returns. Fama and French (1992) postulated that:

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[11] Fama, E.F. and K.R. French (1992) The cross-section of expected stock returns. The Journal of Finance, 47 (2): 427 – 465.

> "... for the 1963-1990 period, size and book-to-market equity capture the cross-sectional variation in average stock returns... (page 450)"

From the point of view of this project, the most interesting part of Fama and French (1992) is the table (Table III on page 439) showing the average coefficients (along with t-statistics) of the month-wise regressions of the stock returns onto market beta, size, BE/ME, leverage, and E/P. The table is an instructive study into the method of regressing a dependent variable onto various combinations of multiple independent variables, and served as the basis for drawing up regressions on the two independent variables identified for this project, for each of the six metals.

However, the time-series nature of this study makes it more akin to the time-series methodology seen in Fama and French (1995)[12], than to the cross-sectional approach of Fama and French (1992). The latter was more exploratory in nature, seeking to narrow down on variables that captured the full range of variation in the cross-section of stock returns. The latter was an attempt to identify the impact of these same factors (market returns, size, and BE/ME ratio), identified for returns in the 1992 paper, on earnings, and to see whether these were reflected in returns. In Fama and French's own words regarding the later paper:

> "Our long-term goal is to provide an economic foundation for the empirical relations between average stock return and size, and average return and book-to-market equity, observed in Fama and French (1992). Our work to date is guided by two hypotheses. If the average-return relations are due to rational pricing, then (i) there must be common risk factors in returns associated with size and BE/ME, and (ii) the size and book-to-market patterns in returns must be explained by the behavior of earnings. (page 153)"

Their findings were in their own words, inconclusive at best:

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[12] Fama, E.F. and K.R. French (1995) Size and book-to-market factors in earnings and returns. The Journal of Finance, 50 (1): 131 – 155.

> "Our efforts to document that the common variation in returns is driven by the common factors in earnings are, however, not entirely successful. We do find that the market and size factors in earnings help explain the market and size factors in returns. But we find no evidence that returns respond to the book-to-market factor in earnings. (page 154)"

The wisdom distilled from the papers documented above was utilized in a manner deemed most appropriate for the purpose of this project.

3 INTUITIVE RATIONALE

Commodity prices and stock markets are both leading indicators for an economy. Continued positive stock price growth is assumed to be a precursor to a period of economic stability/prosperity. On the other hand, rising commodity prices are generally seen as precursors to an approaching economic slowdown on account of a squeeze on corporate profits and more expensive goods and services. Of course, the exact effect of rising commodity prices on a particular economy is a function of which particular industries act as its major growth drivers. An economy that is dependent on manufacturing, services, and/or other tertiary industry, but that does not have much of a natural resource base is more likely to experience an economic downturn, while a majorly natural resource-driven economy is more likely to undergo a boom when commodity prices rise, *ceteris paribus*. In the same breath, it must be mentioned that in today's world of globalization and convergence, it is very hard to classify the economies of most countries as belonging to one category as opposed to the other.

To the extent that stock market performance is an indicator of at least short-term economic activity in a country, stock markets may perform well or poorly, based to a large extent on where in the global value chain a country's economy is placed, or more appropriately, concentrated. Therefore, the correlation between commodity prices (specifically metal prices with regard to this study) and stock prices may intuitively range from a high positive value to a high negative value. As well, structural and other factors unique to an economy may mean that the impact of changing commodity prices may affect the rest of the economy, and therefore the stock market, with at least some delay. This is why stock returns were correlated to returns on a notional index of metals trading on the LME, with a lag ranging from zero to eight quarters.

At the same time, industrial growth and rapid economic progress, as manifested in a rising stock market (possibly driven by other, non-resource-based industries, at least initially) may create demand-pull for metals, especially in view of the wide-ranging usage of the six non-ferrous metals covered here. This could theoretically lead to a scenario where stock returns drove notional returns on metal markets. Needless to say, for the metal markets to be led by stock return behaviour, the latter would have to be a phenomenon observed on a global scale. However, it may be said that this is what has been happening in world equity markets over the recent past leading up to the present. To take an example, the BSE Sensex – the benchmark stock market index comprising India's 30 largest stocks, has grown from a level of around 6,000 at the turn of the millennium to cross a level of 13,000 as this project is being written in late 2006. The current infrastructural expansion and industrial development at a pace never seen before in India, as well as in China and other emerging markets, are at the heart of such phenomenal stock market appreciation. This rapid industrialization has spawned an ever-increasing demand for base metals, especially from these countries, and this demand has been a large reason for metal prices (on the LME and elsewhere) currently being at historic highs. In this project, correlations having stock returns leading metal market returns were formulated based on this observation.

Regressions of stock market returns onto notional metal market returns, as well as onto a proxy for the convenience yield on various metals, were an attempt to combine the findings of any significant correlations detected above, with the intuition of Fama and French (1988) and Heaney (1998). A consumption state in the economy would be indicated by backwardation, i.e. spot metal prices being greater than futures prices – generally referred to as a futures/spot price inversion. Would the regression of stock returns onto returns on a notional index of metals, and onto the presence of convenience yields, be statistically significant? The lack of pre-existing scholarly research / literature on a link between stock markets and base metal (or any other commodity) markets necessitated this study's mostly being exploratory in nature.

4 DATA

To achieve the aims of this project, the S&P 500 was chosen as a representative stock market, while the LME was chosen as the proxy for the metal market in view of most of the world's metal trade being done based on prices set on it. Though this project is being written in Canada, the S&P 500's being a more representative, broad-based stock index having more evenly distributed industry weightings translated into its being deemed a better option for the purpose of this exploratory study.

Historical month-end prices for the S&P 500 as well as for the Metals and Mining sub-index within it were obtained from Bloomberg® (tickers SPX Index and S5METL Index, respectively). Time series data ranging back to September 1989 were used as the S&P 500's Metals and Mining sub-index was instituted in that month. A notional sub-index of the S&P 500, comprising all listed stocks except for those on the Metals and Mining sub-index and represented by a custom ticker (.METAL Index), was also set up on Bloomberg. This third index was primarily meant to be a control variable that would capture any effect of metal price movements on the rest of the stock market. In practice, other industries such as infrastructure, machinery and capital goods, though well removed from metals and mining, are innately connected to it by actually lying further down the metals value-chain, and they would be expected to be affected by metal price variation. The .METAL sub-index was formulated to capture any such effect, as reflected in the variation of stock returns.

Metal price time series were downloaded from historical data available on Bloomberg® for the six base metals traded on the LME. Apart from the cash contract, futures contracts that involve delivery three, 15, 27, and 63 months respectively after the date of contract inception are also traded on the LME. While the cash, 3-month, and 15-month contracts are priced for all six metals, the 27-month contract does not exist for lead and tin, while the 63-month contract is only traded for aluminium and copper. As this project aims to look at LME non-ferrous metal prices movements on a broad base, the 27- and 63-month futures contracts were not considered. Consequently, historical month-end price data for the following tickers was obtained from Bloomberg®:

1. LMAHDY Comdty, LMAHDS03 Comdty, and LMAHDS15 Comdty (for the spot, 3-month, and 15-month futures prices for aluminium)
2. LMCADY Comdty, LMCADS03 Comdty, and LMCADS15 Comdty (for copper)
3. LMPBDY Comdty, LMPBDS03 Comdty, and LMPBDS15 Comdty (for lead)
4. LMNIDY Comdty, LMNIDS03 Comdty, and LMNIDS15 Comdty (for nickel)
5. LMSNDY Comdty, LMSNDS03 Comdty, and LMSNDS15 Comdty (for tin)
6. LMZSDY Comdty, LMZSDS03 Comdty, and LMZSDS15 Comdty (for zinc)

The time series for the tin contracts listed above was only available from June 1989 onwards – the first full month after their institution on the LME. This conveniently facilitated the synchronization of the metal price data with stock price data (available from September 1989 onwards only). All time series were obtained up to the end of August 2006, with the 17-year coverage of the data yielding a maximum of 204 monthly price observations. As the earliest data point in the time series for prices was lost in the calculation for monthly returns, all time series for returns actually go back to October 1989 only, leading to the coverage of 203 months only rather than 204 (for cases where no lag was considered between metal market and stock market prices/returns). In other words, the data covers one month short of the full 17-year period.

Contemporaneous data on the US Consumer Price Index (Bloomberg ticker: CPI INDX Index) was also obtained to adjust all return calculations (both on the stock market indices, as well as for the notional metal indices) for the effect of inflation. The use of the GDP deflator would intuitively have been more appropriate in this situation because of its being more broad-based and more indicative of price changes throughout the economy – at the level of the consumer as well as the producer. However, the GDP deflator time series is only updated on a quarterly basis, while the stock market and metal market prices were all obtained on a monthly basis. Therefore, usage of the US CPI time series was persisted with for this study, in spite of its being a cruder estimator of inflation.

5 EMPIRICAL METHOD

The aim of this project is to explore the existence and basic nature of the relationship between metal markets and stock markets. In keeping with this aim, historical (monthly) price data for a representative stock market (the S&P 500 Index) as well as a globally recognized and followed market for base metals (the LME – London Metal Exchange) were obtained using Bloomberg®, as detailed above.

5.1 Index construction and preliminary correlations

In order to construct a notional index for the metal market, a variable was sought that could be used to weight the prices of the six individual metals in a practical manner, e.g. trade volumes (in terms of traded money values or metal tonnage), or open interest / stock levels. But since no historical time series was publicly available for any such variable pertaining to the LME, the following were the only two variables usable for weighting the six metals' prices:

- Daily opening stocks at the LME's warehouses around the world (physical stocks in MT, for each day from January 01, 2006 onwards), or
- Monthly traded volumes on the LME of all futures and options for the six metals (in lots, from January 2006 till August 2006, and for the corresponding months in 2005),

It was decided to use the monthly traded volumes for weighting the month-end prices, and two indices were constructed using:

1. Value weights for the price levels of the six metals at the end of each month under consideration – implying equally weighted prices, and

2. Trade volume weights, arrived at by weighting the prices with the monthly traded futures and options volumes for the periods January to August 2005 and January to August 2006. The former was assigned a weight of 1/3, while the latter was assigned a weight of 2/3.

In the absence of a variable that pertained to each corresponding interval (month) for the entire period under study, it was thought prudent to use weights pertaining to the current and previous years in constructing a trade volume-weighted index. This is because any pricing or trade-related phenomena in the more recent past would be more likely to drive/be affected by any correlation between the metal and stock markets than those dating longer back in time. In addition, current trade volumes of physical metal stocks would be more difficult to estimate for the world as a whole, as Fama and French had identified, but metal futures and options traded on the LME are much more representative of forthcoming global trade volumes. This relates to why the LME was chosen as a proxy for the metal market for this study in the first place.

Value-weighted (VW) and trade volume-weighted (TVW) indices were constructed in the manner specified here for the cash, 3-month and 15-month futures LME contracts using time series of prices for the six metals. It must be mentioned here that the time series used in this study for the LME's 15-month futures contract for tin is discontinuous. This is because this particular contract was not priced/traded on the exchange in February 1993, and again during the period between (and including) January and July 1995. Both the value-weighted and the trade volume-weighted notional indices constructed ignore tin for these 2 small sub-periods. An index contract (LMEX) based on the six primary metals is traded on the LME nowadays, but as it was only instituted in April 2000, the lack of sufficient historical data precluded its use for this study. The construction of the notional indices discussed above was therefore necessitated.

The return over each month (r_t) was calculated from the respective price time series using the price for that particular month (P_t) and for the month preceding it (P_{t-1}) as follows:

$$r_t = \frac{P_t - P_{t-1}}{P_{t-1}} \tag{A}$$

This return was then adjusted for inflation during that month (i_t) by deducting the change in the US CPI from the nominal return calculated above, where:

$$i_t = \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}} \tag{B}$$

to get the real return on the index (r_t*) during the month:

$$r_t{}^* = r_t - i_t \tag{C}$$

This process was followed for each of the three stock market indices used:

1. SPX: Representing all stocks listed on the S&P 500,
2. S5METL: Representing stocks within the broader S&P 500 belonging to the Metals and Mining industry sub-index, and
3. .METAL: Representing all stocks listed on the S&P 500 (i.e. included in SPX) but not included in S5METL,

as well as for the two indices (value-weighted and trade volume-weighted) constructed using each of the cash, 3-month and 15-month LME futures contracts.

As a prelude to testing the price and return time series for correlation and the metal market's ability to predict the stock market, the following correlations were run between the time series within each market:

1. Return correlations between the three stock indices used (SPX, S5METL, and .METAL) – shown in Figure 5.1,
2. Return correlations between the value-weighted (VW) and trade volume-weighted (TVW) notional indices for the various metal contracts considered (cash, 3-month futures and 15-month futures) – shown in Figure 5.2, and
3. Pair-wise return correlations between the three metal market contracts, when these are drawn into both value-weighted (VW) as well as trade volume-weighted (TVW) notional indices – shown in Figure 5.3.

This was done essentially to check for any major inconsistencies in the time series. These preliminary correlations were run for the entire 17-year period of study (October 1989 – August 2006), as well as for:

- The earliest and the most recent 10-year sub-periods (October 1989 – August 1999 and September 1996 – August 2006, respectively),
- Three equally spaced 5-year sub-periods within the total period of study (October 1989 – August 1994, September 1995 – August 2000, and September 2001 – August 2006, respectively), and
- The middle-most 7-year sub-period within the total period of study (September 1994 – August 2001).

Figure 5.1 Return correlations between the three stock indices used

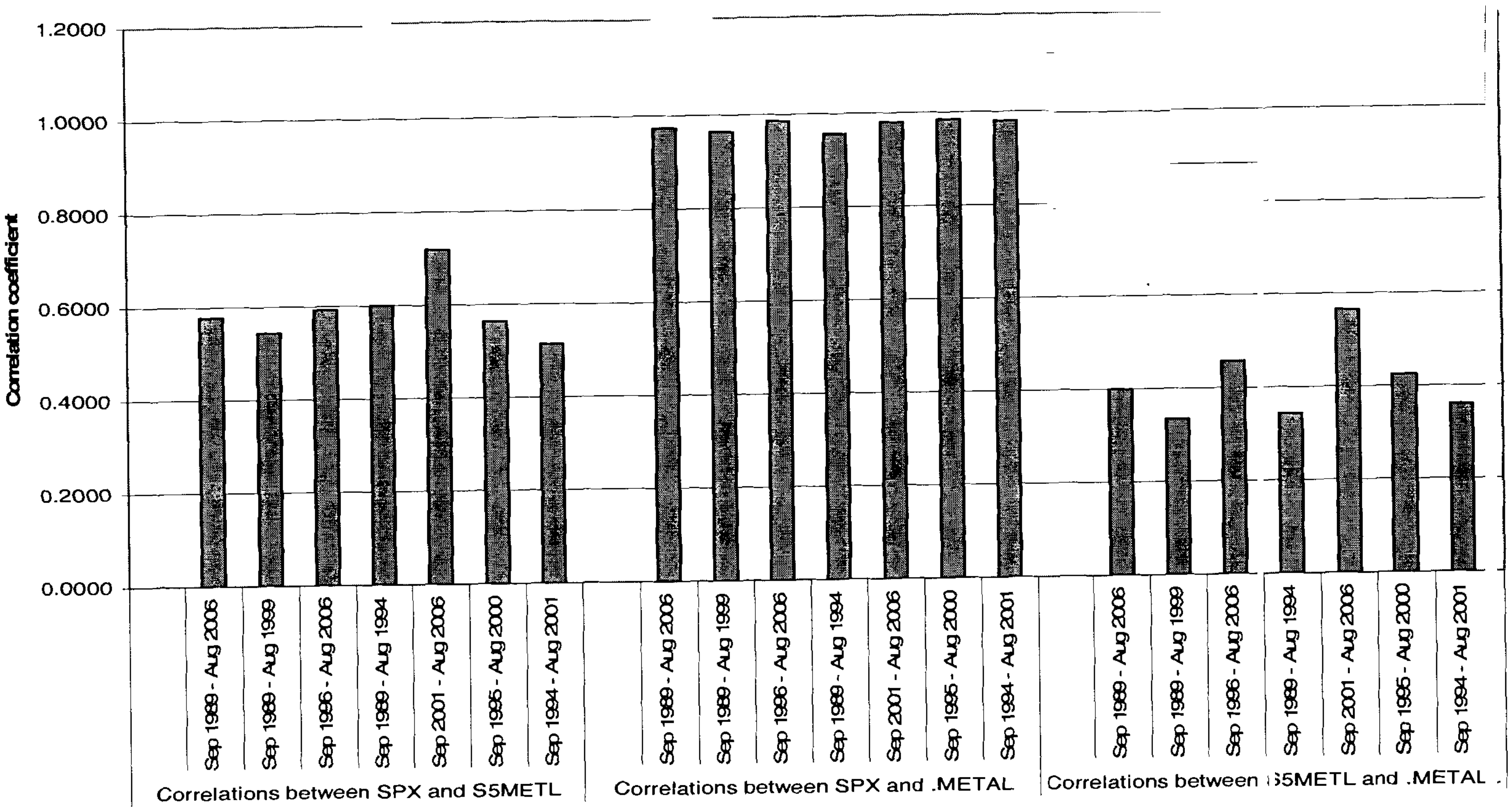


Figure 5.2 Return correlations between the value-weighted (VW) and trade volume-weighted (TVW) notional indices for various metal contracts

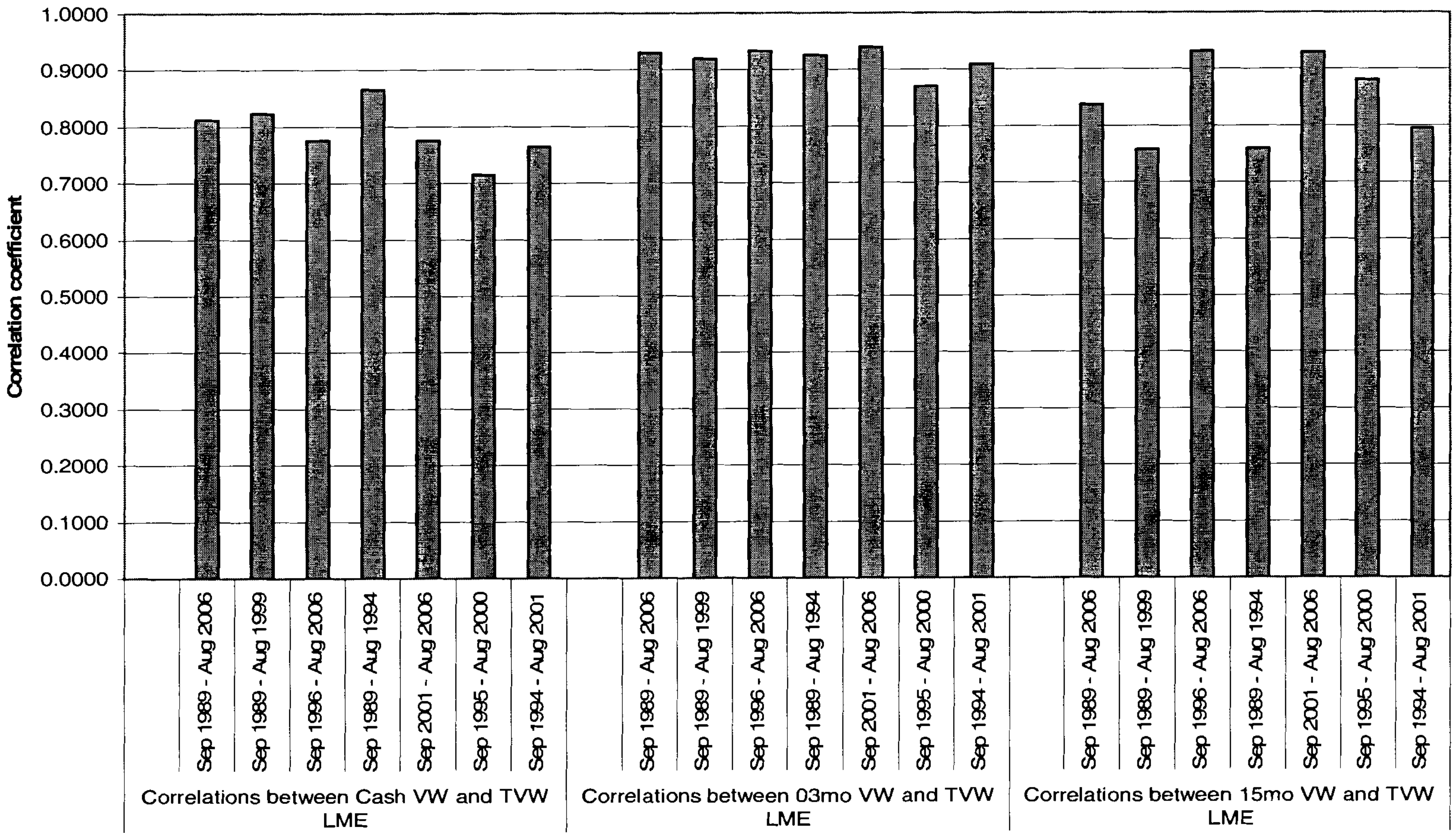
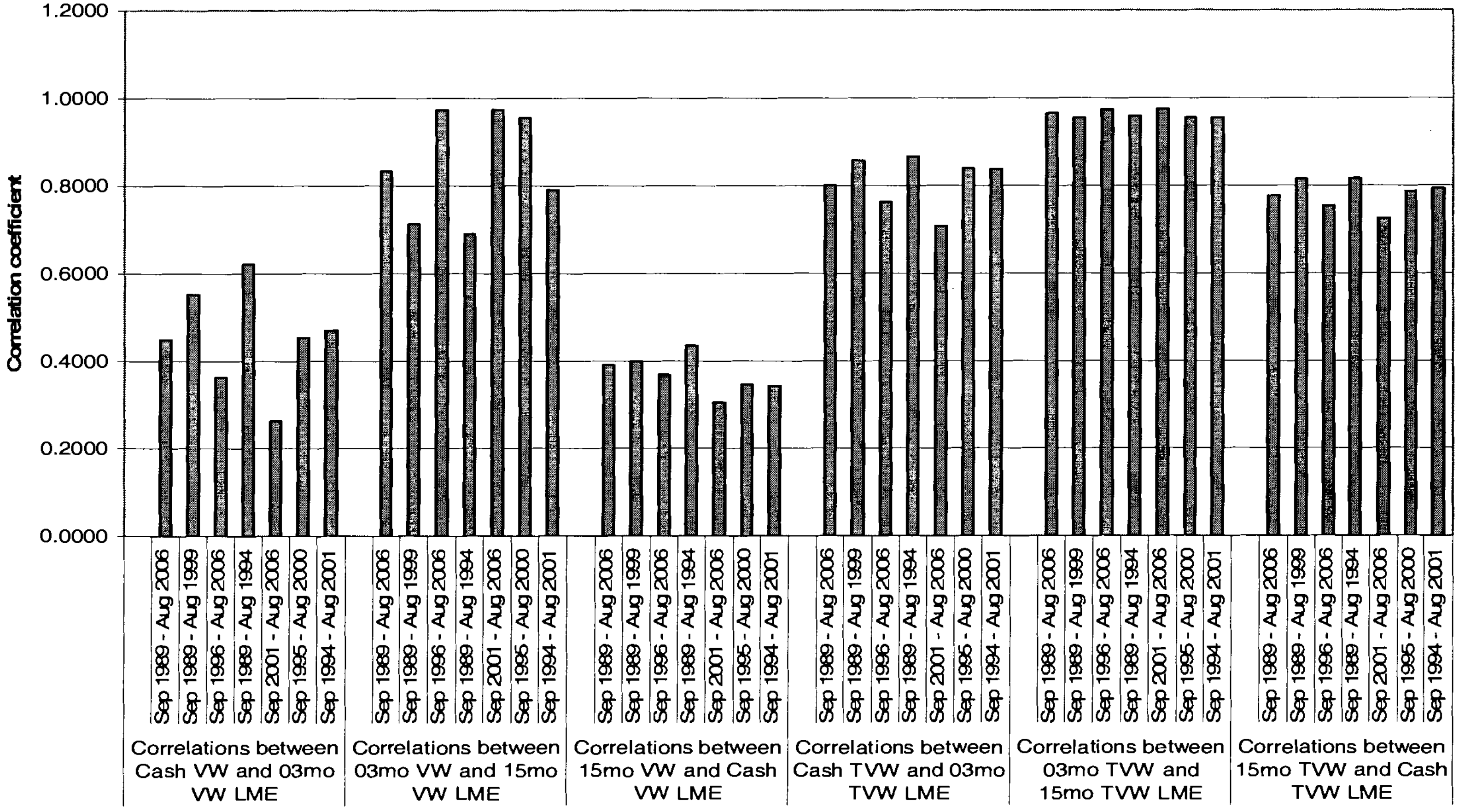


Figure 5.3 Return correlations between various metal market contracts as a part of value-weighted (VW) and trade volume-weighted (TVW) notional indices



5.2 Concurrence in the movement of stock market indices with that of metal prices

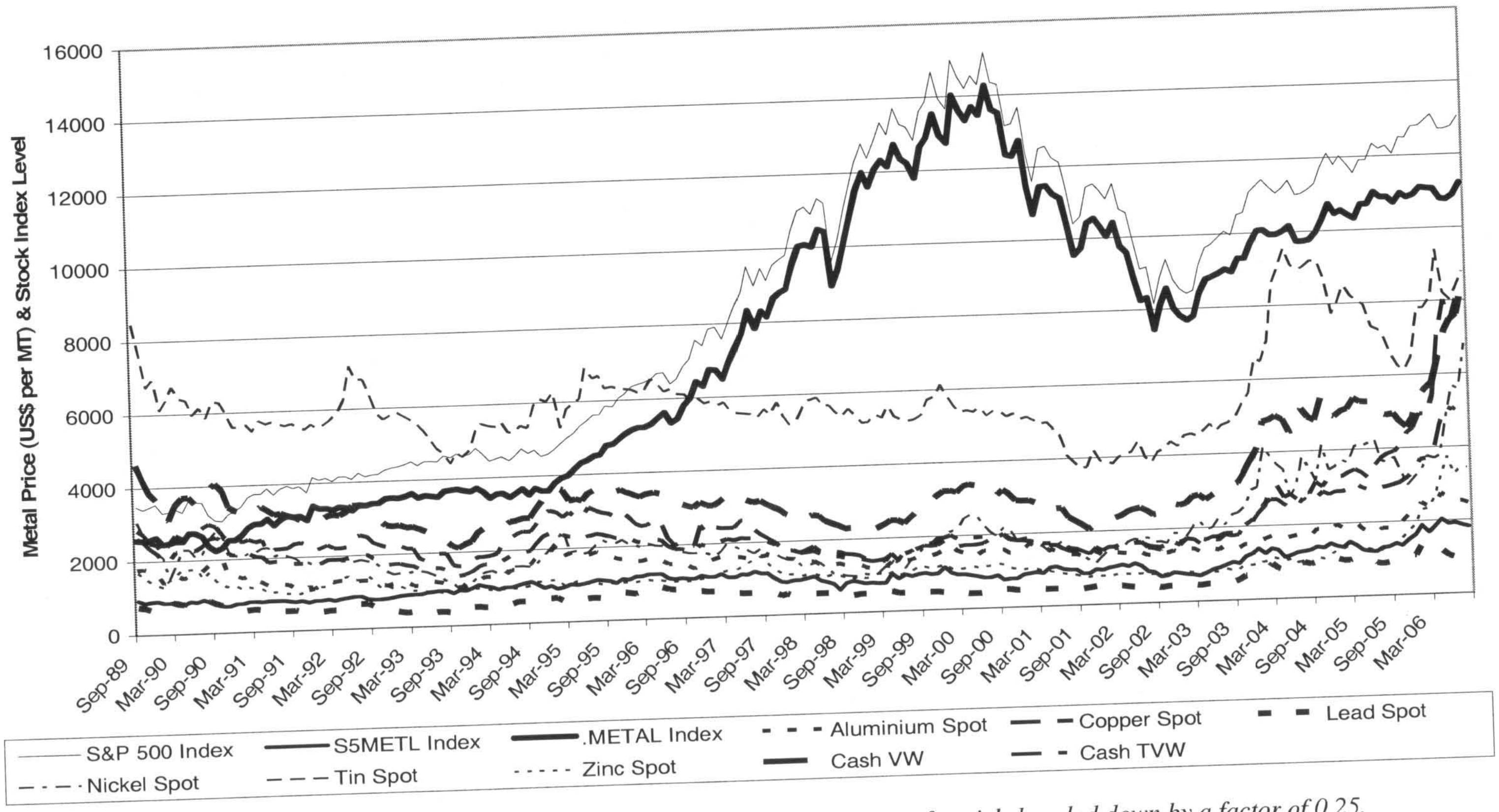
Prices for all three stock indices (SPX, S5METL, and .METAL), six metals (aluminium, copper, lead, nickel, tin, and zinc), and two metal indices (value-weighted and trade volume-weighted) over the entire 204-month duration covered in this project were plotted together for:

- The cash contract (Figure 5.4),
- The 3-month futures contract (Figure 5.5), and
- The 15-month futures metal contracts (Figure 5.6), respectively.

The objective here was to explore the extent to which stock market fluctuation coincided with price fluctuation in the metal markets. The exact degree of coterminous price movement is not calculated here: the levels of three stock indices were scaled up by a multiple of 10, and the price of the LME cash contract for nickel was scaled down by a factor of 0.25 to enhance comparability on a single scale.

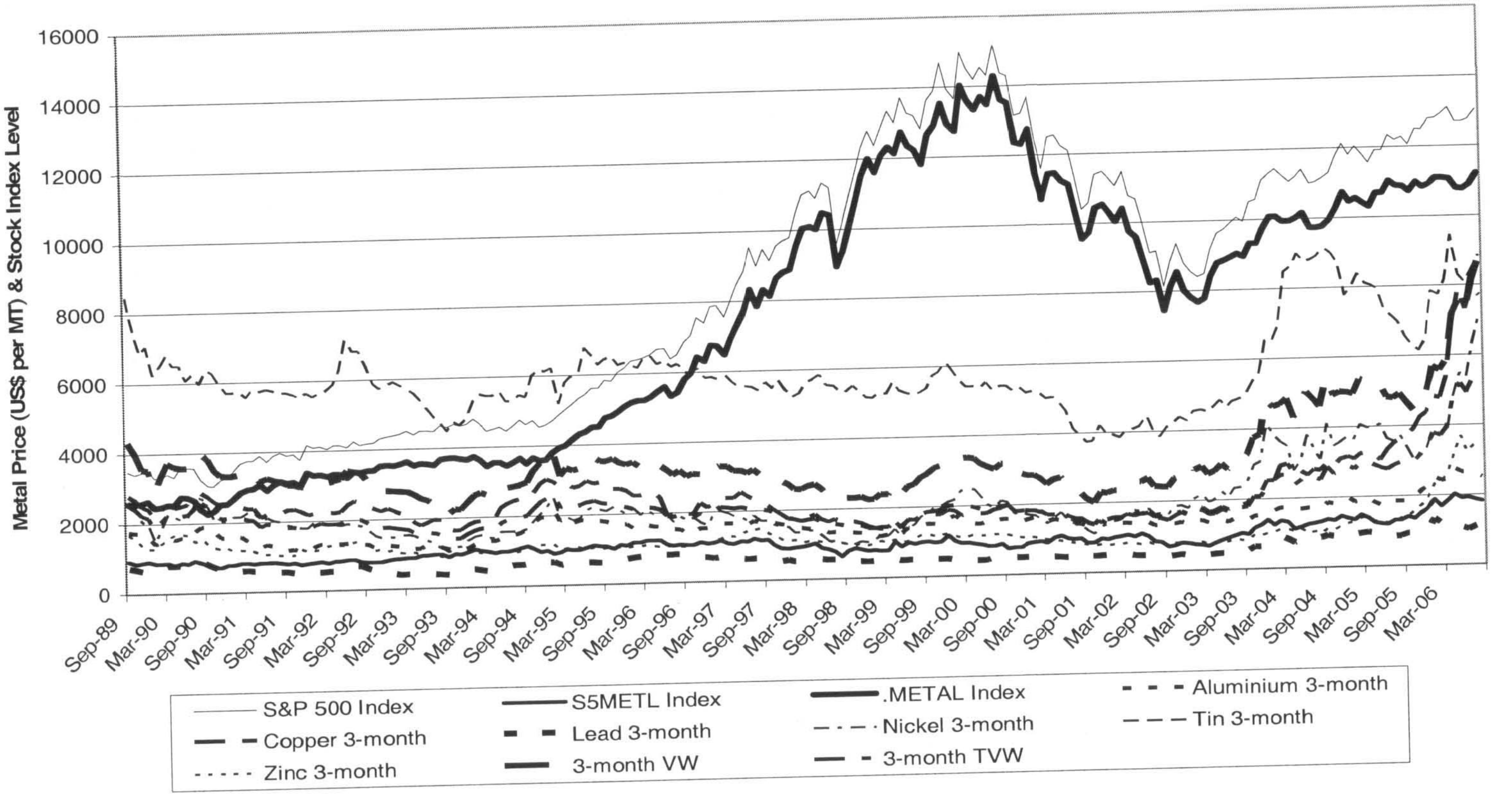
Month-wise spot prices were not plotted against futures prices, as seen in Heaney (2006) for copper, lead and zinc for the period November 1964 – December 2003.

Figure 5.4 Stock index and LME metal price (cash contract) movement between September 1989 and August 2006



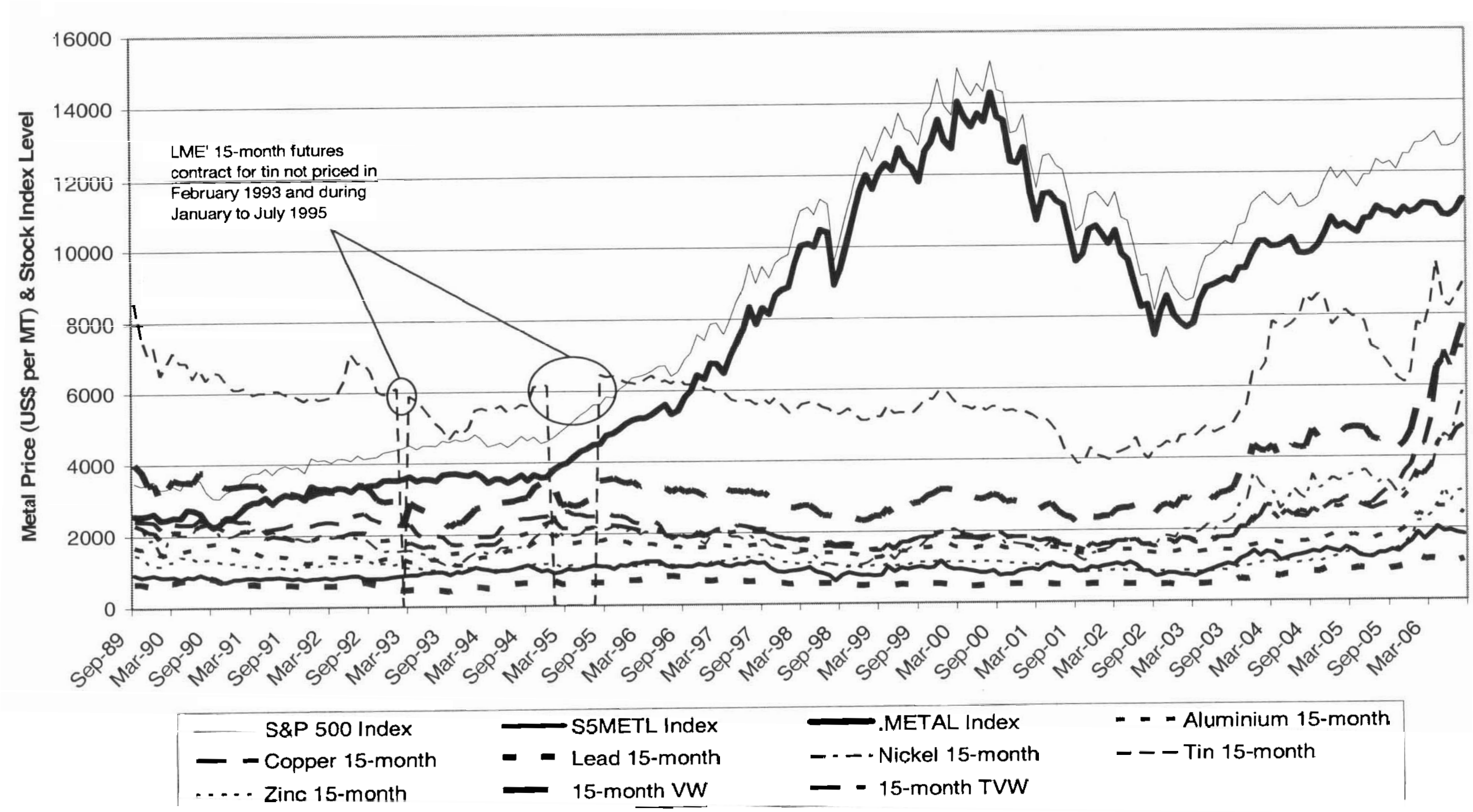
All three stock index levels scaled up by a multiple of 10, and the price of the LME cash contract for nickel scaled down by a factor of 0.25.

Figure 5.5 Stock index and LME metal price (3-month futures contract) movement between September 1989 and August 2006



All three stock index levels scaled up by a multiple of 10, and the price of the LME cash contract for nickel scaled down by a factor of 0.25.

Figure 5.6 Stock index and LME metal price (3-month futures contract) movement between September 1989 and August 2006



All three stock index levels scaled up by a multiple of 10, and the price of the LME cash contract for nickel scaled down by a factor of 0.25.

5.3 Correlations between the monthly returns

After the real returns were calculated as discussed in Section 5.1, correlations were run between the calculated monthly returns for the stock indices and those for the notional metal indices, using MatLab.

Here, the return series for each stock index was correlated with that on the notional indices for each of the cash, 3-month and 15-month futures LME contracts. A correlation between each such pair was run nine times: starting with the stock index lagging the metal index by eight quarters, i.e. two years, and running through to the stock index leading the metal index by eight quarters. Each correlation was run with the lag progressively being reduced by one quarter (lead progressively being increased by one quarter). As the maximum number of price observations was 204 and the first month's observation (that for September 1989) was lost in calculating the monthly return series, the concurrent run (having zero lead/lag between the two series) had the maximum number of data points at 203.

- Tables 5.1 shows the return correlations between the stock indices and various notional LME indices drawn up on a value-weighted basis, and

- Tables 5.2 shows the return correlations between the stock indices and various notional LME indices drawn up on a trade volume-weighted basis.

Table 5.1 Return correlations between the stock indices and the various notional LME indices drawn up on a value-weighted basis

Stock market (lag)/lead on metal market, in quarters	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)	0	1	2	3	4	5	6	7	8
Panel A: Correlation between stock index returns and returns on a notional index of cash contracts																	
S&P 500 (SPX)	0.0190	-0.0536	-0.0305	-0.0234	0.0033	0.0332	0.0009	-0.0513	0.0018	0.0305	0.0003	0.0492	0.0141	0.0439	-0.0765	-0.1110	-0.0927
S5METL	0.0554	0.0241	0.0782	0.0382	0.0349	0.0200	-0.0515	-0.1374	0.1030	0.0843	-0.0006	0.0284	0.1002	0.0009	0.0625	-0.0463	-0.0499
.METAL	0.0046	-0.0715	-0.0584	-0.0351	-0.0036	0.0207	0.0204	-0.0223	-0.0300	0.0190	0.0137	0.0468	-0.0116	0.0470	-0.1066	-0.1178	-0.1011
Panel B: Correlation between stock index returns and returns on a notional index of 3-month futures contracts																	
S&P 500 (SPX)	-0.0212	-0.0406	0.0047	-0.1053	0.0604	0.0541	0.0148	0.0299	0.2512	0.0907	-0.0599	0.0177	-0.1373	-0.1470	-0.1498	-0.0630	-0.0434
S5METL	-0.0207	0.0550	0.0351	-0.1498	0.0324	0.0078	-0.0271	-0.0431	0.4428	0.1279	0.0391	0.0599	0.0096	-0.1413	-0.0154	-0.0457	-0.0790
.METAL	-0.0179	-0.0540	-0.0065	-0.0802	0.0623	0.0565	0.0319	0.0517	0.1662	0.0620	-0.0812	0.0047	-0.1594	-0.1283	-0.1744	-0.0562	-0.0365
Panel C: Correlation between stock index returns and returns on a notional index of 15-month futures contracts																	
S&P 500 (SPX)	-0.0580	-0.0034	-0.0169	-0.0690	0.0563	0.0852	-0.0264	0.0018	0.2395	0.0424	-0.0357	-0.0373	-0.1069	-0.0382	-0.1704	-0.0810	-0.0144
S5METL	-0.0040	0.1040	0.0571	-0.1194	0.0348	0.0554	-0.0565	-0.0150	0.4193	0.1015	0.0371	0.0254	0.0073	-0.0733	-0.0253	-0.0391	-0.0959
.METAL	-0.0685	-0.0348	-0.0425	-0.0486	0.0545	0.0727	-0.0014	0.0097	0.1582	0.0094	-0.0549	-0.0467	-0.1207	-0.0176	-0.1951	-0.0805	0.0030

Table 5.2 Return correlations between the stock indices and the various notional LME indices drawn up on a trade volume-weighted basis

Stock market (lag)/lead on metal market, in quarters	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)	0	1	2	3	4	5	6	7	8
Panel A: Correlation between stock index returns and returns on a notional index of cash contracts																	
S&P 500 (SPX)	-0.0092	-0.0827	-0.0539	-0.0986	0.0648	0.0503	0.0352	-0.0327	0.1138	0.0981	-0.0156	0.0977	-0.0384	0.0123	-0.0495	-0.0597	-0.0993
S5METL	-0.0103	0.0148	0.0123	-0.0465	0.0576	0.0376	-0.0032	-0.0797	0.3246	0.1151	0.0231	0.1233	0.0789	0.0163	0.0116	0.0089	-0.0888
.METAL	-0.0095	-0.1016	-0.0692	-0.1013	0.0561	0.0377	0.0451	-0.0116	0.0395	0.0782	-0.0229	0.0839	-0.0672	0.0134	-0.0702	-0.0640	-0.0946
Panel B: Correlation between stock index returns and returns on a notional index of 3-month futures contracts																	
S&P 500 (SPX)	-0.0339	-0.0543	-0.0302	-0.1400	0.0795	0.0861	0.0549	0.0175	0.2298	0.1090	-0.0376	0.0643	-0.1133	-0.1057	-0.0968	-0.0320	-0.0552
S5METL	-0.0469	0.0407	0.0193	-0.1452	0.0486	0.0349	0.0211	-0.0283	0.4887	0.1339	0.0523	0.1155	0.0307	-0.0823	-0.0286	-0.0123	-0.0912
.METAL	-0.0277	-0.0690	-0.0420	-0.1227	0.0763	0.0855	0.0614	0.0352	0.1307	0.0799	-0.0628	0.0477	-0.1407	-0.0923	-0.1134	-0.0237	-0.0433
Panel C: Correlation between stock index returns and returns on a notional index of 15-month futures contracts																	
S&P 500 (SPX)	-0.0151	-0.0414	-0.0368	-0.1222	0.0969	0.0990	0.0417	-0.0198	0.2557	0.0683	-0.0200	0.0229	-0.0984	-0.0835	-0.1129	-0.0168	-0.0412
S5METL	-0.0250	0.0554	0.0472	-0.1433	0.0539	0.0506	0.0073	-0.0350	0.5076	0.1014	0.0585	0.0778	0.0439	-0.0647	-0.0121	0.0052	-0.1058
.METAL	-0.0133	-0.0609	-0.0577	-0.1052	0.0935	0.0946	0.0539	-0.0059	0.1590	0.0436	-0.0444	0.0132	-0.1261	-0.0690	-0.1352	-0.0165	-0.0251

5.4 Regression of the stock returns onto the returns on a notional metal index, and onto convenience yields for metals

Before running the regressions, a proxy variable for the convenience yield for each particular month, $CY_{t,T}$, was drawn up by presenting the positive difference between the spot price and futures price for a particular metal/notional index as a percentage of the former. Negative values for the difference between the spot price at the current time t, P_t, and the futures price at time T, P_T, i.e. for $(P_t - P_T)$ were assigned a value of zero, signifying the absence of a convenience yield. In line with Fama and French (1988) and Heaney (1998), this was when the convenience yield for carrying metal inventories did not dominate the costs of holding inventory.

$$CY_{t,T} = Max\left[\frac{P_t - P_T}{P_t}, 0\right] \tag{D}$$

Dividing the difference by the spot price, P_t imparted stationarity to the process. Two series of proxy variables – one each for the cash to 3-month (cash/3-month) convenience yield ($CY_{0,3}$), and the cash to 15-month (cash/15-month) convenience yield ($CY_{0,15}$), were obtained in this way.

Metal price observations for 203 months were considered in drawing up the series of month-wise proxy variables (of positive spot/futures price differences) for each metal, as well as for the value-weighted index. Table 5.3 shows the number of positive observations for the proxy variable (denoting the number of months with a positive convenience yield) obtained for each metal, and for the value-weighted index.

Table 5.3 Number of months (out of a total of 203) for which the proxy variable for convenience yield assumed a positive value

Aluminium	Copper	Lead	Nickel	Tin	Zinc	VW Index
Cash/3-month futures convenience yield						
33	102	68	101	56	36	94
Cash/15-month futures convenience yield						
64	108	67	104	58	63	91

The trade volume-weighted index used for the correlations discussed earlier was precluded from the regressions due to returns on it exhibiting lesser variation than the corresponding returns on a notional value-weighted index of metals. The next section of this project discusses this difference further.

For the regressions, a series of the real returns on a stock index were regressed onto the notional metal index return series, and onto the series of convenience yields – separately at first using the partial models (E) and (F), and then using the full equation (G).

$$r^{*}_{stock,t} = \alpha + \beta(Metal) + \varepsilon \tag{E}$$

$$r^{*}_{stock,t} = \alpha + \beta(Metal_{CY}) + \varepsilon \tag{F}$$

$$r^{*}_{stock,t} = \alpha + \beta(Metal) + \beta(Metal_{CY}) + \varepsilon \tag{G}$$

This was done for the series of returns on each of the three stock indices considered. As the correlation between stock returns and notional metal returns was seen to be considerably different (higher) when no lead or lag was built in between them, only zero lead/lag was considered in formulating these time series regressions. Each regression was first run on the corresponding variable (return/convenience yield/both) for each of the six metals individually, then for a value-weighted index of the six metals, and lastly for all the six metals considered together.

Table 5.4 Regression of S&P 500 returns onto the returns of the six base metals traded on the LME, as well as onto that of a notional index drawn up on a value-weighted basis

α	β(Al)	β(Cu)	β(Pb)	β(Ni)	β(Sn)	β(Zn)	β(Index)	R^2	ρ
Panel A: Regression of SPX returns onto cash contract returns									
0.4820	0.1291							0.0295	0.1718
1.7164	2.4724							0.0247	
0.4363		0.1140						0.0368	0.1918
1.5556		2.7701						0.0320	
0.4692			0.0930					0.0257	0.1604
1.6668			2.3036					0.0209	
0.5283				-0.0640				0.0227	0.1506
1.8712				-2.1593				0.0178	
0.5006					0.1255			0.0288	0.1698
1.7817					2.4426			0.0240	
0.4695						0.0645		0.0112	0.1058
1.6545						1.5083		0.0063	
0.4903							0.0015	0.0000	0.0018
1.7190							0.0259	-0.0050	
0.4938	0.0488	0.0655	0.0407	-0.0592	0.0602	-0.0224		0.0744	
1.7669	0.7354	1.1551	0.8421	-1.9976	1.0379	-0.4171		0.0461	
Panel B: Regression of SPX returns onto 3-month futures contract returns									
0.4833	0.1382							0.0282	0.1680
1.7199	2.4159							0.0234	
0.4332		0.1271						0.0389	0.1972
1.5462		2.8513						0.0341	
0.4711			0.1057					0.0250	0.1582
1.6730			2.2722					0.0202	
0.4193				0.1022				0.0585	0.2418
1.5118				3.5336				0.0538	
0.5024					0.1398			0.0335	0.1831
1.7927					2.6407			0.0287	
0.4731						0.0602		0.0080	0.0897
1.6645						1.2771		0.0031	
0.4432							0.1691	0.0631	0.2511
1.6047							3.6785	0.0584	
0.4250	-0.0016	0.0732	0.0452	0.0759	0.0505	-0.0841		0.0771	
1.5216	-0.0204	1.1239	0.7828	1.9245	0.8011	-1.3524		0.0489	
Panel C: Regression of SPX returns onto 15-month futures contract returns									
0.4913	0.1829							0.0275	0.1657
1.7476	2.3824							0.0226	
0.4115		0.1905						0.0602	0.2453
1.4844		3.5869						0.0555	
0.4743			0.1210					0.0210	0.1448
1.6809			2.0752					0.0161	
0.4185				0.1340				0.0706	0.2657
1.5196				3.9071				0.0660	
0.4112					-0.0016			0.0074	0.0861
1.4116					-1.2250			0.0025	
0.4765						0.0595		0.0051	0.0714
1.6739						1.0152		0.0002	
0.4478							0.2235	0.0758	0.2753
1.6329							4.0600	0.0712	
0.3125	-0.0231	0.1727	0.0599	0.1077	-0.0015	-0.1464		0.1126	
1.1135	-0.2313	2.2250	0.8901	2.5132	-1.1945	-1.9315		0.0855	

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

Table 5.5 **Regression of S&P 500 returns onto proxy variables for the convenience yields on the six base metals traded on the LME, as well as onto that of a notional index drawn up on a value-weighted basis**

α	$\beta(Al_{CY})$	$\beta(Cu_{CY})$	$\beta(Pb_{CY})$	$\beta(Ni_{CY})$	$\beta(Sn_{CY})$	$\beta(Zn_{CY})$	$\beta(Index_{CY})$	R^2	ρ
	Panel A: Regression of SPX returns onto cash/3-month convenience yields								
0.5151	-10.1380							0.0006	0.0242
1.7534	-0.3439							-0.0044	
0.3339		11.2050						0.0036	0.0599
0.9850		0.8509						-0.0014	
0.4461			4.8221					0.0006	0.0239
1.4222			0.3389					-0.0044	
1.1567				-20.6190				0.0685	0.2618
3.5579				-3.8451				0.0639	
0.5072					-5.1723			0.0001	0.0109
1.6639					-0.1541			-0.0049	
0.5332						-9.0048		0.0011	0.0329
1.7822						-0.4670		-0.0039	
1.0293							-38.5400	0.0512	0.2263
3.1941							-3.2934	0.0465	
1.0022	13.0550	12.6290	2.6024	-21.6730	3.1110	-11.3140		0.0769	
2.5915	0.4396	0.8863	0.1670	-3.8619	0.0903	-0.5951		0.0487	
	Panel B: Regression of SPX returns onto cash/15-month convenience yields								
0.6135	-11.2880							0.0036	0.0603
1.9253	-0.8570							-0.0013	
0.3174		3.2221						0.0029	0.0542
0.8749		0.7701						-0.0020	
0.4468			1.5818					0.0004	0.0205
1.3861			0.2910					-0.0046	
1.1292				-13.3080				0.0566	0.2379
3.3974				-3.4727				0.0519	
0.4108					-0.0020			0.0095	0.0974
1.4193					-1.3878			0.0046	
0.5916						-4.6511		0.0029	0.0536
1.8833						-0.7604		-0.0021	
0.8560							-14.4100	0.0225	0.1501
2.6020							-2.1530	0.0177	
0.8898	-16.4990	4.4318	7.6961	-13.6390	-0.0019	-4.1246		0.0807	
2.2625	-1.0456	0.7910	1.1036	-3.3684	-1.2118	-0.6673		0.0525	

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

Table 5.6 Regression of S&P 500 returns onto (i) the returns of the six base metals traded on the LME, and (ii) onto proxy variables for the convenience yields on the six base metals traded on the LME, as well as onto those of a notional index drawn up on a value-weighted basis

α	β(Al)	β(Cu)	β(Pb)	β(Ni)	β(Sn)	β(Zn)	β(Index)	$\beta(Al_{CY})$	$\beta(Cu_{CY})$	$\beta(Pb_{CY})$	$\beta(Ni_{CY})$	$\beta(Sn_{CY})$	$\beta(Zn_{CY})$	$\beta(Index_{CY})$	R^2
Panel A: Regression of SPX returns onto cash contract returns and cash/3-month convenience yields															
0.5235	0.1321							-17.2070							0.0312
1.8052	2.5135							-0.5886							0.0215
0.3356		0.1114							7.2865						0.0383
1.0053		2.6856							0.5583						0.0287
0.5229			0.0984							-5.9538					0.0265
1.6750			2.3082							-0.4014					0.0168
1.2106				-0.0679							-21.0460				0.0940
3.7567				-2.3706							-3.9674				0.0849
0.5436					0.1275							-13.3190			0.0296
1.8035					2.4651							-0.3999			0.0199
0.5264						0.0674							-12.1980		0.0132
1.7656						1.5644							-0.6313		0.0033
1.0571							-0.0382							-40.0730	0.0532
3.2465							-0.6425							-3.3507	0.0437
0.9406	0.0089	0.0560	0.0424	-0.0641	0.0275	-0.0507		9.7141	16.6840	-6.8461	-18.1290	-0.0678	-8.0835		0.1172
2.3837	0.1283	0.9621	0.8284	-2.1740	0.4543	-0.9204		0.3157	1.1405	-0.4002	-2.7229	-0.0019	-0.4212		0.0615
Panel B: Regression of SPX returns onto 3-month futures contract returns and cash/3-month convenience yields															
0.4983	0.1375							-6.1568							0.0284
1.7155	2.3942							-0.2109							0.0187
0.2790		0.1269							11.0290						0.0424
0.8363		2.8453							0.8522						0.0328
0.4803			0.1063							-1.0094					0.0251
1.5445			2.2417							-0.0705					0.0153
0.9278				0.0439							-14.4780				0.0732
2.3381				1.0067							-1.7827				0.0639
0.5220					0.1399							-6.0817			0.0337
1.7374					2.6361							-0.1839			0.0240
0.5148						0.0600							-8.7888		0.0091
1.7213						1.2705							-0.4565		-0.0008
0.7039							0.1218							-17.6990	0.0689
1.9505							1.9515							-1.1214	0.0596
0.7836	-0.0214	0.0928	0.0629	0.0161	0.0406	-0.1073		10.6250	19.7540	-2.9931	-16.3580	-2.5096	-12.6200		0.1048
1.7616	-0.2697	1.3982	1.0636	0.3072	0.6329	-1.6693		0.3537	1.3438	-0.1794	-1.8741	-0.0716	-0.6552		0.0483

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

Table 5.6 (contd.) Regression of S&P 500 returns onto (i) the returns of the six base metals traded on the LME, and (ii) onto proxy variables for the convenience yields on the six base metals traded on the LME, as well as onto those of a notional index drawn up on a value-weighted basis

α	β(Al)	β(Cu)	β(Pb)	β(Ni)	β(Sn)	β(Zn)	β(Index)	$\beta(Al_{CY})$	$\beta(Cu_{CY})$	$\beta(Pb_{CY})$	$\beta(Ni_{CY})$	$\beta(Sn_{CY})$	$\beta(Zn_{CY})$	$\beta(Index_{CY})$	R^2
Panel C: Regression of SPX returns onto cash contract returns and cash/15-month convenience yields															
0.7260	0.1555							-22.5610							0.0428
2.3007	2.8613							-1.6676							0.0333
0.3867		0.1121							0.9397						0.0370
1.0790		2.6601							0.2232						0.0274
0.5322			0.0982							-2.3179					0.0265
1.6581			2.3167							-0.4114					0.0168
1.1236				-0.0536							-12.5330				0.0723
3.4003				-1.8378							-3.2699				0.0630
0.4263					0.1227							-0.0019			0.0370
1.4896					2.3898							-1.3021			0.0274
0.6234						0.0767							-7.2651		0.0178
1.9912						1.7431							-1.1590		0.0080
0.8557							0.0064							-14.4380	0.0226
2.5943							0.1087							-2.1503	0.0128
0.7604	0.0549	0.0479	0.0417	-0.0523	0.0487	-0.0361		-24.6340	6.6181	2.4905	-8.6707	-0.0019	-3.3412		0.1252
1.9357	0.7636	0.8293	0.8213	-1.7680	0.8335	-0.6417		-1.4444	1.1334	0.3293	-1.8456	-1.1977	-0.5306		0.0700
Panel D: Regression of SPX returns onto 15-month futures contract returns and cash/15-month convenience yields															
0.6848	0.2027							-17.7590							0.0362
2.1712	2.5974							-1.3429							0.0265
0.3620		0.1886							0.9359						0.0604
1.0248		3.4972							0.2269						0.0510
0.4951			0.1227							-0.7594					0.0211
1.5441			2.0539							-0.1378					0.0113
0.7977				0.0978							-7.4956				0.0834
2.2413				2.4174							-1.6710				0.0742
0.4114					0.0001							-0.0021			0.0095
1.4102					0.0182							-0.6485			-0.0004
0.6032						0.0697							-5.9410		0.0096
1.9209						1.1688							-0.9566		-0.0003
0.6077							0.2058							-6.1705	0.0795
1.8540							3.5163							-0.8917	0.0702
0.6764	-0.0472	0.2056	0.0730	0.0691	0.0013	-0.1636		-21.7780	7.6056	1.0832	-7.5909	-0.0028	-7.5258		0.1512
1.6885	-0.4628	2.6150	1.0691	1.3832	0.4462	-2.0935		-1.3693	1.3553	0.1518	-1.4776	-0.8922	-1.2229		0.0976

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

Table 5.7 Regression of S&P 500's Metals and Mining sub-index returns onto the returns of the six base metals traded on the LME, as well as onto that of a notional index drawn up on a value-weighted basis

α	β(Al)	β(Cu)	β(Pb)	β(Ni)	β(Sn)	β(Zn)	β(Index)	R^2	ρ
Panel A: Regression of S5METL returns onto cash contract returns									
0.3285	0.5021							0.1332	0.3650
0.6761	5.5579							0.1289	
0.1310		0.4843						0.1980	0.4449
0.2797		7.0440						0.1940	
0.2912			0.3074					0.0839	0.2896
0.5827			4.2893					0.0793	
0.4329				-0.1208				0.0241	0.1552
0.8383				-2.2273				0.0192	
0.3917					0.3770			0.0776	0.2786
0.7816					4.1134			0.0731	
0.2623						0.3050		0.0747	0.2733
0.5220						4.0281		0.0701	
0.3350							0.1598	0.0106	0.1030
0.6452							1.4683	0.0057	
0.2419	0.1734	0.3358	0.0932	-0.1110	0.0881	-0.0015		0.2486	
0.5249	1.5845	3.5908	1.1703	-2.2728	0.9207	-0.0175		0.2256	
Panel B: Regression of S5METL returns onto 3-month futures contract returns									
0.3308	0.5905							0.1538	0.3922
0.6891	6.0444							0.1496	
0.1007		0.5783						0.2403	0.4902
0.2209		7.9736						0.2365	
0.2824			0.4307					0.1242	0.3523
0.5779			5.3376					0.1198	
0.1553				0.2958				0.1462	0.3824
0.3213				5.8676				0.1420	
0.3980					0.4276			0.0936	0.3060
0.8011					4.5565			0.0891	
0.2598						0.3515		0.0819	0.2863
0.5190						4.2356		0.0774	
0.2090							0.5458	0.1961	0.4428
0.4462							7.0010	0.1921	
0.1178	0.1060	0.4207	0.1914	0.0805	0.0694	-0.1276		0.2828	
0.2613	0.8379	4.0023	2.0557	1.2641	0.6819	-1.2718		0.2609	
Panel C: Regression of S5METL returns onto 15-month futures contract returns									
0.3648	0.8127							0.1618	0.4022
0.7637	6.2278							0.1576	
0.0636		0.7183						0.2553	0.5053
0.1408		8.3007						0.2516	
0.3016			0.4460					0.0851	0.2917
0.6041			4.3231					0.0805	
0.1644				0.3671				0.1581	0.3976
0.3425				6.1442				0.1539	
0.3365					-0.0005			0.0002	0.0149
0.6288					-0.2115			-0.0048	
0.2734						0.3735		0.0599	0.2447
0.5399						3.5787		0.0552	
0.2311							0.6826	0.2109	0.4593
0.4982							7.3304	0.2070	
0.0251	0.1915	0.5812	0.1849	0.1529	-0.0010	-0.2581		0.3048	
0.0552	1.1831	4.6219	1.6960	2.2029	-0.4923	-2.1025		0.2836	

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

Table 5.8 Regression of S&P 500's Metals and Mining sub-index returns onto proxy variables for the convenience yields on the six base metals traded on the LME, as well as onto that of a notional index drawn up on a value-weighted basis

α	$\beta(Al_{CY})$	$\beta(Cu_{CY})$	$\beta(Pb_{CY})$	$\beta(Ni_{CY})$	$\beta(Sn_{CY})$	$\beta(Zn_{CY})$	$\beta(Index_{CY})$	R^2	ρ
Panel A: Regression of S5METL returns onto cash/3-month convenience yields									
0.5039	-58.7650							0.0059	0.0768
0.9396	-1.0918							0.0009	
0.5157		-11.0150						0.0010	0.0322
0.8302		-0.4564						-0.0039	
0.2291			14.3890					0.0015	0.0390
0.3991			0.5527					-0.0035	
1.7267				-42.2470				0.0859	0.2930
2.9287				-4.3447				0.0813	
0.5705					-64.8630			0.0055	0.0745
1.0252					-1.0587			0.0006	
0.4554						-19.7810		0.0016	0.0395
0.8318						-0.5606		-0.0034	
1.5619							-85.8510	0.0758	0.2754
2.6827							-4.0609	0.0712	
1.9052	-10.8390	-14.1580	34.5110	-41.3670	-51.9930	-28.1380		0.0968	
2.7208	-0.2016	-0.5488	1.2230	-4.0710	-0.8338	-0.8174		0.0691	
Panel B: Regression of S5METL returns onto cash/15-month convenience yields									
0.3613	0.0307							0.0000	0.0001
0.6183	0.0013							-0.0050	
0.2676		1.7503						0.0003	0.0161
0.4025		0.2282						-0.0047	
-0.0016			13.1170					0.0086	0.0930
-0.0027			1.3239					0.0037	
1.6167				-26.1530				0.0652	0.2554
2.6696				-3.7455				0.0606	
0.3190					-0.0011			0.0008	0.0285
0.5994					-0.4045			-0.0042	
0.3511						0.4884		0.0000	0.0031
0.6097						0.0436		-0.0050	
1.1179							-29.8160	0.0288	0.1697
1.8622							-2.4416	0.0240	
1.3142	5.8788	-8.9690	30.6430	-31.0710	-0.0018	1.7205		0.0978	
1.8427	0.2054	-0.8828	2.4231	-4.2318	-0.6446	0.1535		0.0701	

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

Table 5.9 **Regression of S&P 500's Metals and Mining sub-index returns onto (i) the returns of the six base metals traded on the LME, and (ii) onto proxy variables for the convenience yields on the six base metals traded on the LME, as well as onto those of a notional index drawn up on a value-weighted basis**

α	β(Al)	β(Cu)	β(Pb)	β(Ni)	β(Sn)	β(Zn)	β(Index)	β(Al$_{CY}$)	β(Cu$_{CY}$)	β(Pb$_{CY}$)	β(Ni$_{CY}$)	β(Sn$_{CY}$)	β(Zn$_{CY}$)	β(Index$_{CY}$)	R^2
Panel A: Regression of S5METL returns onto cash contract returns and cash/3-month convenience yields															
0.5366	0.5170							-86.4350							0.1459
1.0768	5.7245							-1.7201							0.1373
0.5234		0.4944							-28.3990						0.2048
0.9420		7.1583							-1.3073						0.1968
0.4839			0.3268							-21.3980					0.0869
0.8745			4.3241							-0.8138					0.0778
1.8288				-0.1287							-43.0570				0.1132
3.1336				-2.4816							-4.4819				0.1043
0.6820					0.3908							-89.8280			0.0882
1.2751					4.2572							-1.5198			0.0791
0.4238						0.3132							-34.6220		0.0794
0.8039						4.1129							-1.0136		0.0702
1.5054							0.0777							-82.7370	0.0782
2.5597							0.7227							-3.8304	0.0690
1.1745	0.1640	0.3218	0.0896	-0.1168	0.0692	-0.0085		-27.2180	-14.1710	-11.2220	-11.4190	-33.1660	-16.2750		0.2652
1.7822	1.4215	3.3117	1.0474	-2.3735	0.6837	-0.0922		-0.5296	-0.5801	-0.3928	-1.0269	-0.5619	-0.5077		0.2188
Panel B: Regression of S5METL returns onto 3-month futures contract returns and cash/3-month convenience yields															
0.4322	0.5859							-41.8020							0.1568
0.8726	5.9823							-0.8398							0.1484
0.2659		0.5785							-11.8150						0.2415
0.4891		7.9625							-0.5604						0.2339
0.3694			0.4365							-9.5573					0.1248
0.6849			5.3076							-0.3846					0.1160
0.2225				0.2880							-1.9136				0.1463
0.3192				3.7638							-0.1341				0.1378
0.6159					0.4287							-67.6500			0.0997
1.1601					4.5722							-1.1575			0.0907
0.3476						0.3511							-18.5170		0.0833
0.6602						4.2232							-0.5463		0.0741
0.0037							0.5831							13.9390	0.1971
0.0060							5.4971							0.5196	0.1891
0.5114	0.1049	0.4195	0.2068	0.0720	0.0686	-0.1345		-14.7360	3.8197	-12.7670	-1.6956	-34.8270	-25.5710		0.2887
0.7046	0.8102	3.8734	2.1442	0.8416	0.6547	-1.2827		-0.3007	0.1592	-0.4691	-0.1191	-0.6088	-0.8137		0.2438

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

Table 5.9 (contd.) Regression of S&P 500's Metals and Mining sub-index returns onto (i) the returns of the six base metals traded on the LME, and (ii) onto proxy variables for the convenience yields on the six base metals traded on the LME, as well as onto those of a notional index drawn up on a value-weighted basis

α	β(Al)	β(Cu)	β(Pb)	β(Ni)	β(Sn)	β(Zn)	β(Index)	β(Al_{CY})	β(Cu_{CY})	β(Pb_{CY})	β(Ni_{CY})	β(Sn_{CY})	β(Zn_{CY})	β($Index_{CY}$)	R^2
Panel C: Regression of S5METL returns onto cash contract returns and cash/15-month convenience yields															
0.7583	0.5486							-39.7390							0.1455
1.3893	5.8365							-1.6984							0.1370
0.5776		0.5016							-8.4610						0.2038
0.9684		7.1500							-1.2073						0.1958
0.2639			0.3052							1.0010					0.0839
0.4631			4.0535							0.1001					0.0747
1.6063				-0.1002							-24.7040				0.0816
2.6690				-1.8872							-3.5389				0.0724
0.3664					0.3760							-0.0006			0.0779
0.7149					4.0897							-0.2473			0.0687
0.4849						0.3227							-10.5080		0.0788
0.8736						4.1364							-0.9457		0.0696
1.1083							0.1702							-30.5560	0.0408
1.8531							1.5829							-2.5097	0.0312
0.9949	0.1806	0.3343	0.0609	-0.1021	0.0553	0.0005		-20.1010	-8.2418	12.9430	-10.9080	-0.0027	-1.4516		0.2695
1.5141	1.5010	3.4639	0.7178	-2.0638	0.5653	0.0051		-0.7047	-0.8439	1.0232	-1.3880	-1.0263	-0.1378		0.2234
Panel D: Regression of S5METL returns onto 15-month futures contract returns and cash/15-month convenience yields															
0.6576	0.8425							-26.8700							0.1677
1.2258	6.3478							-1.1945							0.1594
0.4411		0.7331							-7.1384						0.2595
0.7685		8.3673							-1.0652						0.2521
0.1698			0.4352							4.8123					0.0862
0.2995			4.1196							0.4937					0.0770
0.4716				0.3377							-6.0740				0.1606
0.7565				4.7674							-0.7730				0.1522
0.3368					0.0017							-0.0028			0.0013
0.6281					0.3240							-0.4725			-0.0086
0.4149						0.3848							-6.6353		0.0616
0.7416						3.6227							-0.5996		0.0522
0.3041							0.6745							-2.8172	0.2112
0.5475							6.7998							-0.2403	0.2033
0.8450	0.1844	0.6109	0.1824	0.1010	0.0012	-0.2397		-23.9200	-3.5625	10.0920	-8.8847	-0.0033	-10.4620		0.3237
1.2910	1.1077	4.7557	1.6361	1.2385	0.2677	-1.8773		-0.9205	-0.3885	0.8655	-1.0585	-0.6465	-1.0405		0.2810

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

Table 5.10 Regression of .METAL sub-index returns onto the returns of the six base metals traded on the LME, as well as onto that of a notional index drawn up on a value-weighted basis

α	β(Al)	β(Cu)	β(Pb)	β(Ni)	β(Sn)	β(Zn)	β(Index)	R^2	p
Panel A: Regression of .METAL returns onto cash contract returns									
0.5680	0.0742							0.0092	0.0958
1.9414	1.3641							0.0042	
0.5448		0.0590						0.0093	0.0963
1.8578		1.3710						0.0043	
0.5593			0.0594					0.0099	0.0993
1.9115			1.4142					0.0049	
0.6078				-0.0591				0.0182	0.1348
2.0830				-1.9289				0.0133	
0.5801					0.0894			0.0138	0.1173
1.9871					1.6751			0.0089	
0.5612						0.0359		0.0033	0.0571
1.9104						0.8112		-0.0017	
0.5773							-0.0262	0.0009	0.0300
1.9639							-0.4253	-0.0041	
0.5965	0.0300	0.0213	0.0251	-0.0557	0.0579	-0.0123		0.0361	
2.0287	0.4294	0.3574	0.4933	-1.7885	0.9480	-0.2180		0.0066	
Panel B: Regression of .METAL returns onto 3-month futures contract returns									
0.5692	0.0714							0.0071	0.0842
1.9435	1.1984							0.0022	
0.5450		0.0620						0.0087	0.0933
1.8575		1.3286						0.0038	
0.5627			0.0557					0.0065	0.0808
1.9199			1.1500					0.0016	
0.5208				0.0747				0.0294	0.1714
1.7939				2.4669				0.0246	
0.5813					0.0984			0.0156	0.1250
1.9932					1.7856			0.0107	
0.5659						0.0242		0.0012	0.0349
1.9245						0.4957		-0.0037	
0.5406							0.1154	0.0276	0.1662
1.8634							2.3895	0.0228	
0.5319	-0.0206	0.0209	0.0155	0.0758	0.0485	-0.0652		0.0369	
1.8080	-0.2492	0.3053	0.2551	1.8231	0.7309	-0.9955		0.0075	
Panel C: Regression of .METAL returns onto 15-month futures contract returns									
0.5733	0.0950							0.0070	0.0835
1.9574	1.1876							0.0020	
0.5228		0.1208						0.0227	0.1508
1.7938		2.1626						0.0179	
0.5625			0.0779					0.0082	0.0904
1.9208			1.2867					0.0032	
0.5181				0.1021				0.0385	0.1963
1.7936				2.8377				0.0337	
0.4813					-0.0019			0.0093	0.0964
1.6041					-1.3726			0.0044	
0.5676						0.0227		0.0007	0.0264
1.9295						0.3749		-0.0043	
0.5421							0.1612	0.0371	0.1926
1.8782							2.7819	0.0323	
0.4089	-0.0588	0.1191	0.0414	0.0998	-0.0017	-0.1217		0.0649	
1.3766	-0.5555	1.4499	0.5817	2.2000	-1.2635	-1.5169		0.0363	

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

Table 5.11 Regression of .METAL sub-index returns onto proxy variables for the convenience yields on the six base metals traded on the LME, as well as onto that of a notional index drawn up on a value-weighted basis

α	$\beta(Al_{CY})$	$\beta(Cu_{CY})$	$\beta(Pb_{CY})$	$\beta(Ni_{CY})$	$\beta(Sn_{CY})$	$\beta(Zn_{CY})$	$\beta(Index_{CY})$	R^2	ρ
Panel A: Regression of .METAL returns onto cash/3-month convenience yields									
0.5471	10.6830							0.0006	0.0248
1.8062	0.3514							-0.0044	
0.3526		15.7570						0.0067	0.0817
1.0104		1.1624						0.0017	
0.5401			3.5615					0.0003	0.0171
1.6697			0.2427					-0.0047	
1.1287				-17.2020				0.0449	0.2118
3.3252				-3.0726				0.0401	
0.5683					1.4535			0.0000	0.0030
1.8080					0.0420			-0.0050	
0.6125						-8.3490		0.0009	0.0296
1.9853						-0.4199		-0.0041	
1.0033							-30.7870	0.0307	0.1753
2.9875							-2.5245	0.0259	
0.9097	30.3920	17.5940	-2.4274	-19.1190	9.3465	-9.7805		0.0599	
2.2607	0.9836	1.1867	-0.1497	-3.2742	0.2608	-0.4944		0.0312	
Panel B: Regression of .METAL returns onto cash/15-month convenience yields									
0.6814	-9.9557							0.0027	0.0516
2.0728	-0.7327							-0.0023	
0.3733		3.7143						0.0037	0.0606
0.9984		0.8613						-0.0013	
0.5740			-0.0390					0.0000	0.0005
1.7270			-0.0070					-0.0050	
1.1215				-11.4320				0.0393	0.1982
3.2430				-2.8670				0.0345	
0.4838					-0.0023			0.0112	0.1056
1.6225					-1.5059			0.0062	
0.6928						-5.5162		0.0038	0.0616
2.1399						-0.8750		-0.0012	
0.8796							-12.0900	0.0149	0.1222
2.5829							-1.7452	0.0100	
0.8804	-15.9280	6.2769	3.9003	-11.2750	-0.0019	-5.1799		0.0621	
2.1493	-0.9692	1.0758	0.5370	-2.6737	-1.1804	-0.8047		0.0334	

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

Table 5.12 Regression of .METAL sub-index returns onto (i) the returns of the six base metals traded on the LME, and (ii) onto proxy variables for the convenience yields on the six base metals traded on the LME, as well as onto those of a notional index drawn up on a value-weighted basis

α	β(Al)	β(Cu)	β(Pb)	β(Ni)	β(Sn)	β(Zn)	β(Index)	β(Al_{CY})	β(Cu_{CY})	β(Pb_{CY})	β(Ni_{CY})	β(Sn_{CY})	β(Zn_{CY})	β($Index_{CY}$)	R^2
Panel A: Regression of .METAL returns onto cash contract returns and cash/3-month convenience yields															
0.5517	0.0730							6.7737							0.0094
1.8249	1.3332							0.2222							-0.0005
0.3534		0.0541							13.8560						0.0144
1.0142		1.2488							1.0171						0.0045
0.5887			0.0623							-3.2616					0.0101
1.8139			1.4057							-0.2115					0.0002
1.1782				-0.0623							-17.5950				0.0651
3.4907				-2.0782							-3.1667				0.0557
0.5940					0.0901							-4.3006			0.0138
1.8959					1.6751							-0.1242			0.0040
0.6086						0.0383							-10.1640		0.0045
1.9712						0.8589							-0.5080		-0.0054
1.0463							-0.0591							-33.1570	0.0351
3.0872							-0.9544							-2.6636	0.0255
0.9508	-0.0218	0.0163	0.0291	-0.0603	0.0216	-0.0426		30.0130	21.7880	-6.7046	-19.4530	3.6172	-8.0741		0.0847
2.2949	-0.3009	0.2666	0.5411	-1.9502	0.3389	-0.7365		0.9289	1.4187	-0.3733	-2.7831	0.0975	-0.4007		0.0269
Panel B: Regression of .METAL returns onto 3-month futures contract returns and cash/3-month convenience yields															
0.5382	0.0729							12.7930							0.0080
1.7784	1 2179							0.4207							-0.0019
0.3259		0.0617							15.6720						0.0153
0.9342		1.3242							1.1582						0.0055
0.5579			0.0554							0.5244					0.0065
1.7237			1.1217							0.0352					-0.0034
1.0643				0.0123							-15.4750				0.0452
2.5630				0.2707							-1.8207				0.0357
0.5787					0.0983							0.8141			0.0156
1.8507					1.7808							0.0237			0.0058
0.6051						0.0240							-8.2627		0.0021
1.9554						0.4910							-0.4148		-0.0079
0.8405							0.0609							-20.3590	0.0349
2.2187							0.9302							-1.2288	0.0253
0.8496	-0.0443	0.0452	0.0354	0.0108	0.0347	-0.0911		28.3610	22.6780	-2.4120	-18.4040	1.4009	-11.1600		0.0715
1.8189	-0.5319	0.6486	0.5698	0.1968	0.5145	-1.3492		0.8991	1.4690	-0.1377	-2.0079	0.0381	-0.5518		0.0128

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

Table 5.12 (contd.) Regression of .METAL sub-index returns onto (i) the returns of the six base metals traded on the LME, and (ii) onto proxy variables for the convenience yields on the six base metals traded on the LME, as well as onto those of a notional index drawn up on a value-weighted basis

α	β(Al)	β(Cu)	β(Pb)	β(Ni)	β(Sn)	β(Zn)	β(Index)	β(Al_{CY})	β(Cu_{CY})	β(Pb_{CY})	β(Ni_{CY})	β(Sn_{CY})	β(Zn_{CY})	β($Index_{CY}$)	R^2
Panel C: Regression of .METAL returns onto cash contract returns and cash/15-month convenience yields															
0.7493	0.0938							-16.7570							0.0161
2.2712	1.6514							-1.1848							0.0062
0.4065		0.0537							2.6217						0.0110
1.0856		1.2187							0.5959						0.0011
0.6308			0.0653							-2.6302					0.0108
1.8908			1.4811							-0.4491					0.0010
1.1163				-0.0502							-10.7060				0.0522
3.2416				-1.6517							-2.6802				0.0427
0.4947					0.0862							-0.0022			0.0239
1.6652					1.6173							-1.4424			0.0142
0.7126						0.0479							-7.1493		0.0093
2.1981						1.0516							-1.1014		-0.0006
0.8808							-0.0221							-11.9940	0.0156
2.5808							-0.3607							-1.7263	0.0057
0.7829	0.0302	0.0040	0.0311	-0.0490	0.0483	-0.0282		-21.1750	8.4339	0.7541	-8.4661	-0.0018	-3.9876		0.0841
1.8888	0.3985	0.0659	0.5815	-1.5692	0.7833	-0.4748		-1.1769	1.3691	0.0945	-1.7081	-1.0941	-0.6002		0.0263
Panel D: Regression of .METAL returns onto 15-month futures contract returns and cash/15-month convenience yields															
0.7071	0.1100							-13.4670							0.0407
2.0496	1.3499							-0.9753							0.0311
0.7071		0.1160							2.3082						0.0407
2.0496		2.0470							0.5326						0.0311
0.7071			0.0814							-1.5927					0.0407
2.0496			1.3136							-0.2785					0.0311
0.7071				0.0657							-7.5272				0.0407
2.0496				1.5476							-1.5992				0.0311
0.7071					-0.0002							-0.0020			0.0407
2.0496					-0.0748							-0.6195			0.0311
0.7071						0.0332							-6.1304		0.0407
2.0496						0.5386							-0.9553		0.0311
0.7071							0.1429							-6.3681	0.0407
2.0496							2.3200							-0.8743	0.0311
0.7048	-0.0887	0.1535	0.0584	0.0633	0.0012	-0.1456		-17.7860	9.0759	-0.8437	-7.4534	-0.0027	-7.4457		0.0995
1.6566	-0.8198	1.8379	0.8053	1.1942	0.4074	-1.7548		-1.0531	1.5229	-0.1113	-1.3661	-0.8163	-1.1393		0.0427

The numbers in small type represent the t-statistics for the values of α and all β's, and the corrected R^2 for the values of R^2.

6 DISCUSSION

In Figure 5.1, the correlation between the S&P 500 (SPX) and the Metals and Mining sub-index within it (S5METL) is seen to have been the highest (0.72) in the period September 2001 ~ August 2006, and the lowest (0.51) in the 7-year period immediately preceding it. These observations are consistent with the Intuitive Rationale (Section 3) of this project, that non-ferrous/base metals (and the resources sector in general) have driven the economy most recently like never before, to the extent that they have allowed financial markets to overcome the tech bust really fast. That even the lowest correlations amount to more than 0.50 suggests considerable economic importance of the metals and mining industry as a whole, which is remarkable considering the uniformly high correlation (>0.95) for all sub-periods between the broad index and the rest of the index excluding this industry (.METAL). The growing all-pervasiveness of the metals industry in the immediate past is underlined by the significantly higher correlation between S5METL and .METAL in September 2001 ~ August 2006 (0.56), than at any other sub-period covered here.

Figure 5.2 shows some interesting results for the correlations between the value-weighted and the trade-volume weighted notional indices drawn up for LME contracts of three different maturities – cash (i.e. spot or immediate delivery), 3-month futures, and 15-month futures. Each notional value-weighted index was constructed using the returns on the averaged prices of each of the six metal contracts having a particular maturity. These value-weighted returns (based on a simple average of metal prices) were weighted by the trade volume of futures and options contracts for each metal between January and August of both 2005 and 2006 in drawing up the trade volume-weighted index. The correlations among the cash contracts are relatively higher during the exact same sub-periods over which those among the 15-month contracts are relatively lower. This points towards the market's expectation of a mean-reverting correction in futures prices during times of unexpectedly high/low spot prices, and of a corresponding compensatory change in future trade volumes a year ahead.

To the extent that lower (higher) trade volumes would at least partly offset unexpectedly high (low) spot prices for metals, the correlations among the trade volume-weighted indices expectedly vary to a much lesser extent than those for the corresponding value-weighted indices over the various sub-periods. This compensatory effect of trade volumes with regard to spot and futures prices is further reflected in Figure 5.3. Here, the variation of the correlations among value-weighted notional returns is replicated, though to a much lesser degree, by the variation of the correlations among trade volume-weighted returns over the corresponding sub-periods.

Tables 6.1 and 6.2 indicate the means and standard deviations of returns on the three stock indices considered, and of those on the metal contracts and notional indices of various maturities, respectively. The standard deviation of the returns on 15-month metal contracts being less than those on the corresponding cash contracts point towards Fama and French's interpretation of Samuelson's hypothesis – that futures prices vary less than spot prices. However, the second part of the same postulation, that futures prices vary less as contract maturity approaches, is not supported here.

Table 6.1 Means and standard deviations of returns on the S&P 500, its Metals and Mining sub-index, and the .METAL sub-index, for the period October 1989 – August 2006

S&P 500	S5METL	.METAL
0.491	0.362	0.573
4.051	*7.416*	*4.177*

Italicized values represent the standard deviations of returns on the respective index.

Table 6.2 Means and standard deviations of returns on metal contracts of various maturities, and on notional indices of these drawn up on value-weighted (VW) and trade volume-weighted (TVW) bases, for the period October 1989 – August 2006

Aluminium	Copper	Lead	Nickel	Tin	Zinc	VW Index	TVW Index
Means and standard deviations of returns on cash (spot) contracts							
0.066	0.476	0.229	0.590	-0.080	0.326	0.167	0.203
5.391	*6.813*	*6.985*	*9.527*	*5.481*	*6.645*	*4.781*	*4.506*
Means and standard deviations of returns on 3-month futures contracts							
0.052	0.451	0.184	0.698	-0.085	0.290	0.280	0.271
4.925	*6.286*	*6.066*	*9.589*	*5.307*	*6.040*	*6.016*	*5.302*
Means and standard deviations of returns on 15-month futures contracts							
-0.004	0.415	0.135	0.538	-0.126	0.236	0.191	0.214
3.670	*5.216*	*4.850*	*8.033*	*4.701*	*4.860*	*4.990*	*4.198*

Italicized values represent the standard deviations of returns on the respective metal/notional index.

Cursory examination of Figures 5.4 through 5.6 shows that price movements in the S&P 500's Metals and Mining sub-index do not influence those in the broader index or the rest of the index, to any notable degree, though returns on the industry's sub-index are seen to be more volatile than either of the latter from Table 6.1. Also, stock prices and metal prices have only been concurrent to a notable degree after late 2002-early 2003. In line with the previous discussion, copper and aluminium, having the most diverse usage in other industries, have recorded the largest gains overall since that time.

Tables 5.1 and 5.2 point towards no significant correlation between stock index returns and those on notional metal indices – regardless of whether the latter is constructed on a value-weighted basis, or on a trade volume-weighted basis. However, the correlation between the industry sub-index (S5METL) and the futures contracts on the LME is the greatest when there is zero lag between the two markets, and it levels off to insignificant levels within two quarters when the former leads the latter. This points to market sentiment in the immediate/short-term time-frame being shaped by the aggregate metal supply-demand gap/equilibrium prevalent at the time. Any exuberance/depressed sentiment in the stock market regarding future metal prices gets checked as the stock market resumes its most recent trend and notional returns on metals stabilize after the metal demand/supply shock.

As well, in the case of value-weighted index of metals (Table 5.1), even though the magnitude of correlation is not very large, correlation is generally higher when S5METL lags the notional metal price index than when it leads, though the case is the opposite for SPX and .METAL. Intuitively, this is not entirely unexpected, since it implies that demand and profit growth in other industries (higher stock returns on .METAL, and on SPX) spawns increased demand for metal (higher metal prices on the LME) which positively affects the metals and mining industry's performance to a greater degree (higher stock returns on S5METL) during the immediate future.

The regression of stock returns onto notional metal returns and onto convenience yields on metals was set up in the manner of Fama and French (1992). First, the effect of any one metal's (and the value-weighted index's) return on a stock index's return was evaluated in isolation, and then the stock index returns were regressed onto the returns for all six metals considered together in one multiple regression. The trade volume-weighted notional index was not used in setting up these regressions because the compensatory effect of trade volumes on price movement and return fluctuation implies that variation in notional returns on metals returns is better captured using a value-weighted index.

The proxy variable for the convenience yield was derived by simplifying the initial model of Fama and French (1988):

$$F(t,T) - S(t) = S(t)R(t,T) + W(t,T) - C(t,T) \qquad \text{(H)}$$

Fama and French (1988) assumed the warehousing and other storage costs, *W(t,T)*, to be constant, and the convenience yield, *C(t,T)*, to dominate the warehousing costs and the interest earning foregone, *S(t) R(t,T)*, only when the spot price, *S(t)*, was greater than the futures price, *F(t,T)*. For this project, the interest earning foregone was also assumed constant for each period (month) under consideration.

Notional returns on the cash contracts for five of the six individuals metals yield statistically significant regression coefficients when S&P 500 returns are regressed onto them, though they do not explain the variation in stock returns to any considerable extent, as evidenced by the low R^2 values. Zinc has the lowest R^2 of all, and its statistically insignificant β reinforces its returns' lack of explanatory power, observed for the two futures contracts as well. That the highest R^2 values are obtained for the multiple regression onto all metal returns taken together, appears only to be an artefact of the greater number of independent variables introduced into the model.

Nickel is the only metal for which the convenience yield assumes a statistically significant (albeit negative) coefficient when S&P 500 returns are regressed onto it, over both a 3-month and a 15-month time horizon. The correlation of nickel's convenience yield with the broad market index is also the highest in absolute terms, vis-à-vis other metals. This probably points to nickel's having diverse but non-essential usage in industry: a high convenience yield in times of low stock market returns (i.e. slower economic growth) is consistent with the two-state nature of commodity pricing. In the absence of much explanatory power, i.e. a low R^2, the statistically significant β for the value-weighted metal index in both cases cannot be used to draw any conclusions.

The introduction of convenience yield as an explanatory variable in addition to notional metal returns does not increase the explanatory power of the model in any notable manner, as seen in Table 5.6. The goodness of fit (R^2) of the regression model for each of the metals individually is still under 0.10, i.e. 10%. Of all the regression coefficients for convenience yield, only that for nickel is statistically significant, which is also when it yields the highest R^2 in combination with the return on the spot contract – this is true for both the cash/3-month- as well as the cash/15-month convenience yield. Returns on the cash as well as futures contracts for aluminium, copper, and lead uniformly assume statistically significant coefficients, which indicates their widespread consumption in industry, but they do not provide statistically significant explanatory power for S&P 500 returns, even in combination with the convenience yields on these metals.

A possible explanation for these observations could be obtained by looking at the underlying price data and the implied existence of convenience yields. With respect to the cash/15-month convenience yield, the most widely used non-ferrous metals were in backwardation since the following months (until August 2006):

- Aluminium, copper and lead since October 2003,
- Nickel since May 2002, and
- Zinc since August 2005.

Additionally, tin was in backwardation between July 2003 and February 2006, and all of these were continuous pricing trends, never broken for more than a month, if at all. In other words, quite a large number of the positive monthly convenience yield observations from Table 5.3 belong to the most recent 2~3 year sub-period, during which they have not abated. Considering the increasingly widespread market sentiment regarding shortages, it appears that the convenience yield has gradually been incorporated into stock market expectations – in terms of better performance for the metal and mining industry, and tighter margins for most other industries. In this way, the short-term, unexpected nature of demand shocks, and their consequent impact on stock markets has been dissipated. Therefore, convenience yields are currently positive, but they are continuous and expected, which is why they do not help to predict stock market returns in any major way. The impact of an anticipated versus an unanticipated switch to a more expansionary/contractionary monetary policy is an interesting macroeconomic parallel of such a phenomenon.

The observations from the regression of returns on the .METAL sub-index (i.e. the S&P 500 less its Metals and Mining sub-index) in Tables 5.10 through 5.12 essentially mirror those for the S&P 500 (Tables 5.4 through 5.6). The explanatory power of the notional returns is even weaker (even lower values of R^2), though nickel still has statistically significant regression coefficients – for returns and convenience yields considered in isolation and taken together (regressions onto cash contract returns and cash/3-month, or cash/15-month convenience yields). Interesting all regressions of returns on the .METAL index onto the returns on 15-month futures contracts and cash/15-month convenience yields yield the same value for R^2 (0.0407), corrected R^2 (0.0311), and α (0.7071, significant with a t-statistic of 2.0496), regardless of which metal is considered.

Regressions of returns on the industry sub-index (S5METL) onto the metal returns and convenience yields (Tables 5.7 through 5.9) present the most interesting observations. The notional returns on copper and aluminium assume the greatest explanatory power (19.80%, 24.03%, 25.53%; and 13.32%, 15.38%, and 16.18% for the cash, 3-month and 15-month futures contracts for copper and aluminium, respectively). On the other hand, the explanatory power of returns on nickel falls considerably, even being the lowest of the six metals in the case of the regression onto cash contract returns. However, when the sub-index returns are regressed onto convenience yields, nickel again is the only metal with predictive power that is statistically significant to any degree overall, i.e. significant t-statistics for regression coefficients, and a goodness of fit of any notable magnitude. The return on the cash contract for each of the six metals assumes significance in predicting market returns, when combined with its convenience yield. But among all the regression coefficients obtained for convenience yield, only that for nickel is significant.

The multiple regressions involving the notional returns and/or the convenience yields on all six metals are mostly seen to have higher explanatory power than the metals considered individually. However, the statistically insignificant regression coefficients for all except nickel point to the R^2 being artificially high on account of a large number of explanatory variables being included in these regressions. As well, in the absence of much more rigorous testing of returns for the individual metals, it would be erroneous to draw conclusions based on the statistics obtained from regressions onto the returns and/or convenience yields for the notional value-weighted index of metals.

7 CONCLUSION

In summary, the returns on each of the 3 stock indices/sub-indices considered were regressed onto various combinations of notional returns and convenience yields on metal 72 times each, yielding 48, 11 and 64 statistically significant values of α (at the 10% level of significance) for the SPX, S5METL and .METAL indices respectively. This observation, along with the fact that only five, 32, and zero values respectively for the coefficient of determination (R^2) were seen to be greater than 0.10, indicate that the variables in this project only partially describe what could be just one dimension of the total relationship between metal markets and stock markets, even within the more specific context of using metal market returns and convenience yields to predict stock returns. This is true especially for the broad market index, i.e. the S&P 500 (SPX), as well as for its component that excludes the metals and mining industry (S5METL).

On the basis of the inconclusive evidence from this project, the average investor would be advised to examine industry/company fundamentals within the constraints of his experience and knowledge. In the absence of further, more definitive insights into the nature of the relationship between non-ferrous metal prices/returns, and those on the stock markets, trends in the former may not be used in isolation to predict corresponding trends for the latter.

However, some very interesting avenues for further analysis are indicated by this project, particularly with reference to the Canadian stock market. A study into the corresponding correlations of metal prices with Canadian stock market levels could be more insightful, given the greater importance of metals (and other resources) for Canada's economy. This could be done as a comparative study vis-à-vis the US stock markets, or vis-à-vis correlations with the prices of/notional returns on other resources, e.g. oil and gas, gold/precious metals, and/or lumber.

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