Risk Premia of Aluminum Forwards: a Guide for the Trader in the Primary Aluminum Metals Market

Clint Brown
Industrial Engineering Manager, Sanden International

Shekar Shetty
Associate Professor of Finance

Abstract

This paper tests whether forward prices contain a component related to the riskiness of the contract by utilizing an incomplete information mechanical forecasting rule as a model of trader expectations formation. In addition, the risk premia associated with the forward prices are calculated and examined for effectiveness in model development. In addition to risk, a 'hit/miss' variable is analyzed and a model is developed to provide further insight into the chance of success or failure encountered in the forwards market. The analysis is conducted with daily prices from the period July 1991 through December 1996, on the forward market for the primary metal -- aluminum, traded in the London Metals Exchange.

Introduction

The notion of devising a high-return, low-risk covered hedge on the London Metals Exchange, along with comments supplied by various management personnel in the aluminum industry, spawned the effort of this investigation. Questions concerning the relationship between forward prices and spot prices and the ability to discern the risk inherent with participating in the forwards market was the central theme of discussion.

The process of competitive price discovery is a major economic function and benefit of futures trading. In a dynamic market, the only certainty is that prices will change. Futures prices increase and decrease largely because of factors that influence buyers' and sellers' judgments about what a particular commodity will be worth months or years in the future. New supply and demand information develops, over time, and as new and more current information becomes available, judgements are reassessed and the price of a particular futures contract may move up or down . The trader's estimation of the riskiness of the contract may be a reflection of these ensuing price movements.

By examining the risk associated with futures markets, Dusak (1973), Grauer (1981), and Bodi and Rosinsky (1980) used the Sharpe-Lintner capital asset pricing model and found that virtually all commodity futures prices examined had no systematic risk. Breeden (1979), used the intertemporal asset pricing model and found that consumption betas for most of the futures contracts examined were not significantly different from zero. Therefore, futures prices did not appear to contain significant risk premia.

Hsieh and Kulatilaka (1982) found that there was evidence of risk premia in copper, tin, and zinc futures when comparing forward prices and a mechanical predictor as estimators of future spot prices. In other words, these forward prices included both trader expectations of future spot prices and a component relating to the riskiness of the contract. The analysis presented in the following sections is somewhat related to the study performed by Hsieh and Kulatilaka by examining risk premia associated with the aluminum forwards market.

Along with the notion of risk, many political and economic factors contribute to the way in which traders form expectations about future prices. Forward prices have often been used as indicators of these otherwise unobservable expectations. Therefore, the risk premium can be defined as the difference between the forward price and the expected future spot at the maturity date of the forward contract (Black, 1976). This will provide the basis for calculating the risk premia associated with the forward contracts.

Methodology

Three different forward contract durations (3, 15, & 27 months) for aluminum traded in the London Metals Exchange (LME) were used to test the hypothesis that a component of risk is evident in forward prices. In the model, traders form expectations through a 5-day moving average (5-PMA) mechanical predictor. If forward prices contain risk premia, then they should have a higher mean squared error in forecasting future spot prices than the mechanical predictor.

Next, the risk premia associated with each of the forward contracts are calculated as the difference between the forward prices and the expected spot as predicted by the mechanical forecasting model. These risk premia are then analyzed against spot prices to examine model development feasibility.

Finally, a ‘hit/miss’ value is calculated by subtracting the spot price at maturity from the forward contract price, under the assumption that the contract is held to maturity. The values reveal how much the trader would have gained or lost on the trade if held to maturity. The ‘hit/miss’ values are examined against spot prices and LME inventories over the historical data set in order to develop a decision making model(s) which may guide the trader with regard to market participation decisions dependent upon risk-tolerance.

Data

The data sets used include prices from the 3, 15, and 27 month aluminum forwards contract markets over the period July, 1991 to December, 1996. Each data set is comprised of 1375 closing settlement spot and forward prices for all trading days during the period. The 5-PMA analysis provided 1369 observations while the 3-month, 15-month, and 27-month contracts provided 1311, 1059, and 807 observations, respectively. Table 1 shows the time horizons of each of the data sets.

Table 1
Data Analysis Time Horizons

5-PMA of Spot Prices	08/01/91 - 12/31/96
3-Mo. Forward Prices	08/01/91 - 09/30/96
15-Mo. Forward Prices	08/01/91 - 10/02/95
27-Mo. Forward Prices	08/01/91 - 10/03/94

The decrease in observations for each of the contract durations was necessary during risk and 'hit/miss' value analysis due to the respective contract maturity dates. Risk values were calculated, on the front end of the complete data set of 1375 observations, for the time horizons indicated above. The 'hit/miss' values were calculated from the tail end of the complete data set and pulled back to the appropriate time horizons for analysis against the spot price and LME inventories. All contracts were denominated in US$/Ton. The data was obtained through the London Metal Exchange via the Internet.

Analysis

Comparison of Forecasts

Table 2 shows the Mean Squared Error (MSE) for each of the models used to test the hypothesis. The MSE's obtained by using forward prices as predictors of future spot prices are all greater than the MSE obtained through the use of the 5-PMA mechanical forecasting model. Therefore, for each forward contract duration the presence of nonzero risk premia is evident and the null hypothesis that forward prices contain a component related to the riskiness of the contract is not accepted.

Table 2
Mean Squared Error of Alternative Forecasts

	(	Forward Price	)	
5-PMA	3-Month	15-Month	27-Month	No/Change*
628 (n=1369)	19604 (n=1311)	75998 (n=1059)	56832 (n=807)	319 (n=1374)

*This model is discussed in the next section

Calculation of Risk-Premia

The risk premia were calculated as the difference between the forward prices and the expected spot as predicted by the 5-PMA.

It should be noted, that the 5-PMA was not the only model considered to test the null hypothesis and calculate the risk premia. A time series forecast of spot price was also investigated through the Box-Jenkins (ARIMA) model. This model, intended for use over short to intermediate time horizons, could yield the information needed to calculate risk premia but would have required 50-60 runs of the model, increasing the data set by approximately 8-10 time periods after each run, to obtain all of the predicted values of spot price needed. For this reason, the model was not used. Assuming the Box-Jenkins MSE would have been lower than that of the 5-PMA, it could have been applied as a better model for calculating the risk premia.

In addition, a No/Change model was considered that assumed the next day's spot price was the same as the previous days spot. This model, listed in Table 2, produced an MSE lower than the 5-PMA and, theoretically, could have been used as a better model. Table 3 compares the risk premia derived from the 5-PMA and No/Change models for each of the contract durations. An explanation of the selection of the 5-PMA as the model of choice is given below Table 3.

Table 3

Descriptive Statistics

	N	Mean	Median	Min	Max	Range	Std.Dev	Kurtosis*
RISK3(N/C)	1306	25.48	25.00	-117.50	148.00	265.50	18.76	9.33
RISK3(5-PMA)	**1306**	**25.64**	**24.90**	**-162.50**	**130.40**	**292.90**	**24.988**	**4.47**
RISK15(N/C)	1054	77.57	106.00	-205.50	233.50	439.00	74.22	1.31
RISK15(5-PMA)	**1054**	**78.51**	**104.60**	**-250.50**	**247.40**	**497.90**	**74.28**	**1.23**
RISK27(N/C)	802	194.45	198.50	-5.00	338.50	343.50	44.89	1.86
RISK27(5-PMA)	**802**	**195.28**	**199.15**	**21.50**	**352.40**	**330.90**	**44.65**	**1.60**

* Kurtosis measures the "peakedness" of a distribution. If the kurtosis is clearly different than 0, then the distribution is either flatter or more peaked than normal; the kurtosis of the normal distribution is 0.

The most noticeable differences in the table are found in the risk associated with the 3-Month contract. The min./max., SD, and kurtosis values of the 3-Month No/Change and 5-PMA models are noticeably different when compared to the values obtained with the 15 & 27 month No/Change and 5-PMA models. It is uncertain whether the differences between the No/Change and 5-PMA noted in the 3-Month risk data would significantly alter the analysis to follow. However, this information has been provided to help clarify the selection of the 5-PMA as the model of choice.

Histograms built from the 5-PMA risk values were used to calculate the percent ranges listed in Table 4 below. The percents and ranges reveal that the data is fairly compressed over the time horizons investigated when compared with min./max. values in Table 3.

Table 4

Relevant Histogram Percentages

Risk Value	3-Mo.	Risk Value	15-Mo.	Risk Value	27-Mo.

1-50	77	1-100	56	151-200	37
		101-200		201-250	41

Ex. - 77% of the risk values for the 3-Mo. contract were >=1 and <=50.

This information, related to the compressed nature of the data, made it difficult to develop a model based on the relationship between risk values, spot prices, and LME inventories. No trends were identified that would allow ranges of risk premia to be categorized as more or less likely to pay off in the future.

Hit/Miss Risk-Tolerance Model(s)

One of the goals of this paper was to develop a model to assist the trader that did not require complex statistical packages/analysis to make a decision. This was attempted through the analysis of the calculated risk in the preceding section(s) but could not be completely developed due to the difficulty in identifying relationships/ranges of relationships between risk premia , spot prices, and LME inventories across the data sets. The following model makes use of a ‘hit/miss’ variable calculated by subtracting the spot price at maturity from the forward contract price. This calculation reveals how much the trader would have gained/lost if the contract were held to maturity. This variable is related to risk and can be analyzed over certain periods of the time horizons to provide insight into the chances of success or failure in playing the market.

There was an obvious relationship, visually, between the spot prices and the ‘hit/miss’ values for each contract duration. Regression analysis was used to generate the following tables (Table 5, 6, and 7) which provide a fairly confident means of whether or not to make a trade. This is due to the model’s ability to be incorporated into the present versus only supplying the trader with historical percentage statistics of success/failure.

The most significant LME inventory and spot price ranges that may assist the trader with regard to the market participation decision are shown. Significant models are considered to contain adjusted R-Squared (ARS) values greater than .70. This value of significance splits the middle between the generally accepted significance of a business application (.5-.6) and scientific application (.85-.9). Tables 5, 6, and 7 list regression statistics for equations (1) through (9). Each table is followed by a depiction of LME inventory and spot price conditions that were prevalent during each period.

Table 5

3-Mo. Contract **

Time Horizon	N	ARS	Std. Error of Estimate	Independent Var. (t-value)	Equation (F-Value)	Range of Spot Price	Range of LME Inv.	Equation Ref.
CDS *	1306	09	140.42	-11.34	128	1019 - 2146	522K - 2661.5K	
8/1/92-12/9/93	297	.78	50.64	-32.48	1055	1019 - 1350	1400K - 2400K	(1)
10/13/94-6/7/95	163	.68	98.70	-18.41	339	1019 - 2146	800K - 2200K	(2)

* Complete Data Set
** All t and F values significant at alpha=.05

Equations (3-Mo. Contract):

(1) Hit/Miss = 1892.424 - (1.663 x spot price)
(2) Hit/Miss = 2463.639 - (1.339 x spot price)

Equation (1) was derived over a period of steadily rising LME inventories (slope +.46), and with no spikes, over the range specified. The spot price range was low, beginning at around 1350, and continued on a slow downward trend, as a direct reflection of the rising inventories. Equation (2) was developed over a sharp decline in inventories (slope -1.24), over the range shown, also with no spikes during the period. Spot prices during the front end of the period peaked at 2146 but by mid-period remained steady at around 1800 (+/- 100).

Table 6

15-Mo. Contract **

Time Horizon	N	ARS	Std. Error of Estimate	Independent Var. (t-value)	Equation (F-Value)	Range of Spot Price	Range of LME Inv.	Equation Ref.
CDS *	1054	.33	287.75	-22.94	526	1019 - 2146	522K - 2661.5K	
8/1/91-3/11/93	408	.65	70.48	-27.43	752	1019 - 1350	522K - 1700K	(3)
5/19/94-7/21/95	285	.79	95.71	-32.54	1059	1350 - 2146	600K - 2661.5K	(4)
5/19/94-1/5/95	141	.91	53.21	-38.13	1453	1350 - 2150	1700K - 2661.5K	(5)

* Complete Data Set
** All t and F values significant at alpha=.05

Equations(15-Mo. Contract):

(3) Hit/Miss = 1532.433 - (1.39 x spot price)
(4) Hit/Miss = 1523.406 - (.970 x spot price)
(5) Hit/Miss = 1513.151 - (.936 x spot price)

Equation (3) parameters include steady rises inventories (slope +.30) over the range indicated. One major spike occurred, approximately 400K tons above the 1350K level, during mid August of 1992 but does not appear to alter the effectiveness of the equation. Spot prices during this period cycled from the upper to the lower parameters indicated just over twice during this period. The inventory levels for Equation (4) were on a sharp decline (slope -1.24), as described for Equation (2). The time period, however, included more data on the front and back end of the data set than in Equation (2). Spot prices during this period began at 1350 and increased sharply to peak at 2146 during the middle of the period, then decreased to approximately 1800 (+/-100) for the remainder of the range indicated. Equation (5) was built over the front half of the Equation (4) data set. It is a better model, as indicated by the ARS value but utilizes a smaller sample.

Table 7

27-Mo. Contract **

Time Horizon	N	ARS	Std. Error of Estimate	Independent Var. (t-value)	Equation (F-Value)	Range of Spot Price	Range of LME Inv.	Equation Ref.
CDS *	802	.26	241.69	-16.73	279	1019 - 1611	522K - 2661.5K	
9/30/93-9/7/94	237	.92	61.71	-50.57	2557	1019 - 1550	2200K - 2661.5K	(6)
7/2/93-4/20/94	203	.735	60.21	-23.63	558	1019 - 1350	1900K - 2600K	(7)
2/3/94-8/8/94	126	.81	58.75	-23.05	531	1250 - 1650	2500K - 2661.5K	(8)
8/1/91-12/31/91	104	.88	59.43	-27.08	733	1019 - 1350	522K - 1000K	(9)

* Complete Data Set

** All t and F values significant at alpha=.05

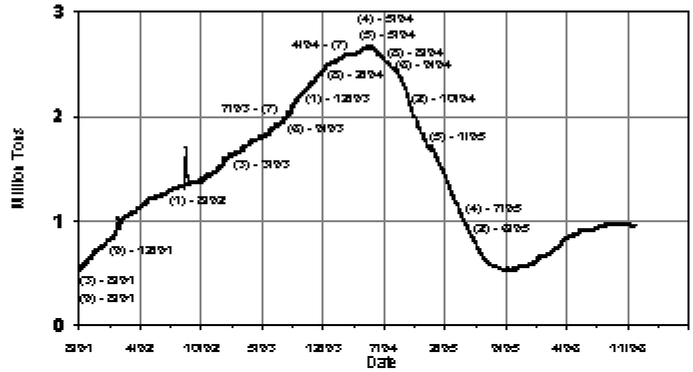
Equations(27-Mo. Contract):

(6) Hit/Miss = 1771.225 - (1.335 x spot price)
(7) Hit/Miss = 1602.605 - (1.16 x spot price)
(8) Hit/Miss = 1880.028 - (1.431 x spot price)
(9) Hit/Miss = 2766.446 - (2.570 x spot price)

In Equation (6), the inventory level began the period at 2200K tons, peaking at 2661.5K during mid-June 1994, and returned to 2300K at the end of the period. The inventory slope at the front end of this period was approximately +.25. After the peak, slope was around -.9 through the end of the period. Spot prices began the period at approximately 1125, dipped to a low of 1019 quickly, then rose steadily over the remainder of the period to 1550. Equation (7) was developed at the end of steadily rising inventories (slope +.46) over the ranges indicated. Spot prices began at approximately 1200, dropped to 1019 at the middle of the period, and then rose steadily to 1350. Inventories only ranged from 2500K to 2661.5K for Equation (8), holding a slope of +.25. This was a fairly flat period of inventory at the end of a long rising inventory period of slope +.30. Spot prices had a slight positive slope over the range indicated. Equation (9) was derived during a period of steadily rising inventories (slope +.30) over the range shown. Spot prices began the period at 1275 and ended just under 1100 with one spike of 1225 at the middle of the period.

Graph 1 shows the range of LME inventories for Equations (1) through (9), as depicted in the preceding sections.

Graph 1: LME Inventories



It should be noted that as spot prices were graphed against the ‘hit/miss’ values, an analogy became apparent. The values had an inverse relationship as if viewing a mountain image on the surface waters of a lake. All of the ‘hit/miss’ values for each contract duration had this inverted relationship when compared against spot prices. The 3-Mo. data, across the entire data set, is more unclear than the 15 and 27 Mo. contracts. As if wind were blowing across the water, giving the mountains a distorted appearance, the 3-Mo. data set has less distinct features against the spot price but the general inverted relationship is evident. This is seen in the low ARS for the complete data set of the 3-Mo. contract. The ‘hit/miss’ values of the 15 and 27 Mo. data sets appear as the mountains would reflect on a calm day when compared against the spot prices. However, there is a distortion in the magnitude of both the spot and ‘hit/miss’ values at various intervals over the complete time horizons. The ARS’s for each of these contract durations was higher than found in the 3-Mo. contract.

Equations (1) through (9) were constructed from sections of the data sets that produced the best reflections of ‘hit/miss’ values against the spot prices. As indicated by the significant ARS’s generated from these equations, the spot price can be used to predict a ‘hit/miss’ value that may be expected if the trade is made and contract held to maturity. If the trader is confident that the status of the current market closely resembles conditions explained for one of the equations, with regard to LME inventories and spot prices, the appropriate equation could then be used to calculate the ‘hit/miss’ value. The standard error of the estimate, for the equation used, would then be subtracted from the ‘hit/miss’ value. If the result is a positive ‘hit/miss’ value, then the expected return should be positive. The spot price used in each equation is simply the current market price/ton at the time of decision.

Conclusions

In this paper, the hypothesis that a component of risk is evident in forward prices was accepted through the application of a 5-Period Moving Average. An assessment of the calculated risk values against spot prices and LME inventories, revealed that no trends could be readily identified that would allow for model development with the calculated risk premia. A ‘hit/miss’ variable was investigated that did provide the framework for model development within the confines of spot price and LME conditions. The trader will have to decide whether the conditions described for a given model meet or exceed prevailing market conditions of spot prices and LME inventories.

Future development of the models presented may require incorporation of other market variables such as interest rates or the producer price index. In addition, outlier analysis may be helpful in equation development to produce equations in which more variation of ‘hit/miss’ values are explained by spot prices (i.e., higher ARS values).

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Biographies

Clint Brown is Industrial Engineering Manager at Sanden International in Dallas, Texas. He received his engineering degree from University of Arkansas at Fayetteville in 1989 and MBA from Henderson State University in 1997.

Shekar Shetty is Associate Professor of Finance at Henderson State University. He received his Ph.D. in finance from the University of North Texas in 1992. Before joining Henderson in 1996, Dr. Shetty taught at the University of South Dakota and Texas Christian University.