1) **Title:** Market Efficiency Test of Lean Hog Futures prices using Inter-Day Technical Trading Rules

2) **Abstract:**

We investigated the effectiveness of most popular technical trading rules on the closing price data of lean hog futures prices to test for the existence of market inefficiencies. Signals (buy, sell or hold) generated by these rules were tested for their usefulness by examining two performance measures such as net profits and profit to drawdown ratio. Using these performance measures we ascertained the profitability and their persistence over the entire data series and during sub-periods of the data. Hog futures markets were efficient for the time period observed. Even though, some of the technical trading rules are profitable, there is no evidence that these profits are sustainable during certain time periods.

3) **Introduction:**

   a. **Problem Statement:**

   During the most recent years, with the introduction of online trading platforms that facilitated virtual trading around the clock, massive funds flow into the traditional commodities markets by hedge fund managers, increased trading volumes especially short term trading via day trading programs and sporadic outbreak and spread of swine flu (H1N1) on a global scale had led to considerable volatility (price fluctuations) in the lean hog price complex (both cash and futures prices). Particularly, the efficiency of the lean hog futures markets was called into question during these time periods. The main hypothesis of efficient markets hypothesis (EMH, Fama, 1970), points to the fact that if the markets are efficient then no one can consistently derive profits. If the markets are inefficient even for short time periods it will have deleterious effect on the entire hog industry.

   b. **Background:**

   There is large volume of literature examining the market efficiency of agricultural futures markets. Most of these academic studies are based on fundamental analysis and often involve quantitative modeling in the analysis. Many findings supported that the futures markets being efficient and/or at least unbiased in the long run. These studies found that the markets are weak-form to semi-strong form efficient. Few other studies found that the markets are inefficient at certain times or during sub-periods of strongly trending markets.

   Majority of the industry practitioners follow several technical trading methods in their daily trading activities. Several claims were made about these indicators to generate consistent profits. However, very little attention was give to the study of the technical trading rules in the academia. Technical trading rules have been applied successfully in
foreign exchange markets (90% of trades are based on technical indicators) and commodities markets (50-70% of trades are based on technical indicators). The use of technical analysis increases with the frequency of trading (Taylor and Allen, 1992). High frequency traders such as day traders rely upon several technical indicators to conduct their trades. Many market participants such as commodity brokers, fund or money managers, individual investors and speculators were known to extensively use the technical trading systems to trade wide variety of markets. Technical analysis is a broad collection of methods and strategies which attempts to forecast futures prices on the basis of past prices or other observable market statistics, such as volume and open interest. Technical analysis includes a variety of forecasting techniques such as chart analysis, pattern recognition analysis, seasonality and cycle analysis, and computerized technical trading systems. Technical analysis methods are proven to be effective in the short-time frame to earn profits.

**c. Literature Review:**

The efficient markets hypothesis (EMH) formalized by Fama (1970) and explained by Marshall (1989) states that the current price of any asset should accurately reflect current information, and subsequent price changes should be random. EMH suggests that no technical analysis procedure will be effective if the market is efficient.

McKenzie and Holt (2002) tested market efficiency and unbiasedness in four agricultural commodity futures markets – live cattle, hogs, corn and soybean meal – using the modern time series methodologies such as co-integration and error correction models. Results indicated each market is both efficient and unbiased in the long-run, although cattle, hogs and corn futures markets exhibited short-run inefficiencies and pricing biases. Specifically, their results showed hog futures prices contain a positive short-run time varying risk premium. Leuthold and Hartmann (1979) found hog futures markets to exhibit inefficiencies over certain time periods. Hales and Hayenga (1995) studied three technical analysis tools such as relative strength index (RSI), dual moving average and directional movement indicator and applied to 1987-1992 live hog futures prices. They found that out-of-sample performance of RSI rules were profitable.

Few studies have tested for the potential profitability of some technical rules (Brock et al. 1992, Levich and Thomas. 1993). Sweeney and Osler (1988, 1998) identified profitable technical strategies. There are many technical studies focused on equity (stocks) and foreign exchange markets. However, there are relatively few studies of technical analysis in commodity futures markets. Lukac and Brorsen, and Lukac, Brorsen and Irwin (1988a, 1988b, and 1989) studied the effectiveness of technical analysis in commodity futures markets. The results of some of these studies on technical trading
rules states that the profits could be achieved for sub-periods when a trend was observed in the data.

**d. Objective(s):**

The current study aimed at two objectives:

1) To conduct tests for market efficiency on the most recent inter-day data of lean hog daily futures price series using the technical trading rules.

2) To identify the relative time periods of profitability, if these exist, on an inter-day basis in lean hog futures price series using the technical indicators.

**4) Data & Methodology:**

**a. Data Sources:**

Daily data was purchased from CME group from the years from 2009 to 2011. Intra-day or tick-by-tick data cost was five times more than the budgeted amount for this project and hence we limited the data acquisition to inter-day data only. Due to this limitation of the data, the study objectives were changed slightly from that of the original proposal and the analysis was conducted on the inter-day data.

For lean hogs futures three years of data for all the contract months (Feb, Apr, May, Jun, Jul, Aug, Oct, Dec) was collected. Each contract was separated and analyzed based on three years of observations. The most active three months prior to the listed contract month was used from each year to construct the series for each futures contract. For example, for February contract January, previous year December and November contracts were considered.

We analyzed the most recent 2009-2011 contract year(s) lean hog futures daily data using the technical trading rules to test for the market efficiency. We restricted the scope of the data analysis to three years due to the cost of the data. Expiration month data was not considered due to the decreased volume and less participation by speculators.

**b. Methods:**

We applied several popular technical trading rules to study the objectives that were set forth in this study. Most widely studied technical indicators such as MA’s (Moving Average), MACD (Moving Average Convergence and Divergence), RSI (Relative Strength Index), Directional Movement Index (DMI) and ADX were used. Each indicator construction and their application will not be discussed here due to space limitations.
In this study two fitness functions were studied to each indicator such as net profits and ratio of profits to drawdown. Net profits are the simplest and most common measure of usefulness of a trading strategy. Net profits of a position can be stated as follows:

$$\Pi = \sum_{t=1}^{T} (p_{t+1} - p_t) I_t - \Phi \text{ abs } (I_t - I_{t-1})$$

Where $I_t \in (-1,0,1)$ is the trading position at time $t$ and $\Phi$ is the transactions cost.

Profits are not the only measure of a successful trading strategy. Other useful criteria might be low variance or small intermediate losses. The second fitness measure considered uses the concept of drawdown, or intermediate loss as a proxy of variability, to measure a strategy’s fitness. The drawdown of a strategy is defined as the difference between the highest intermediate profit and its current value, or, if $\Pi_T = \sum_t \Pi_t$, then drawdown is:

$$\delta_t = \max_{t=1,\ldots,T} (\max_{t=1,\ldots,T} (\Pi_t) - (\Pi_t))$$

From this we calculated the second fitness measure, the ratio of profit to maximum drawdown, $\Pi/\delta$. If there are consistent profits and high ratio or profit to maximum drawdown ratios resulting from the trading model then the market is inefficient. A weak form test for market efficiency examines whether profits can be earned by trading a model which bases its forecasts using a set of technical trading rules.

5) Results and Discussion:

The following widely followed technical analysis indicators were used on each contract month. Moving averages are widely followed measures in the market place and hence we did analysis using the MA(10) and MA(20). Technical indicators such as Relative Strength Index-RSI(14), Moving Average Convergence and Divergence-MACD (12,26), Average Directional Index -ADX(14), and Stochastic Oscillator were also examined.

Each indicator was used separately at first to generate signals. Based on the oversold and overbought conditions and the values of these indicators sell, buy orders were placed with filters being used based on the days following the signal generation. Filter days are 1 day following the signal and 3 days following the signal. If a position was opened based on signal generated and the rollover into the next month contract month happened then that trade was not considered into fitness measures computation.

For moving average indicator of 10 and 20, many signals were generated for the low moving average, some with no profit (wash) as well as loss. After considering for the trading costs the profits are not significant. The drawdown is high. However, MA(20) had resulted in
better prediction, on an average the profit per trade was around $244. June, July and August month contracts have shown the significant profits with the MA (20). The average drawdown was around $220.

Relative Strength Index (RSI) is a momentum oscillator that measures the speed and change of price movements. Using RSI we considered if the oscillator above 70 to be overbought and below 30 to be oversold condition. We picked the MA(14) following the most popular approach. Much longer time period of 20 days should have resulted in less number of signals. RSI indicator proved to be much better indicator in contract months for April, June, July, August and October. The average number of signals generated for each month was around 6, ignoring the rollover times. The average profit for trade was $450 with maximum profit of $1250 in August contract and a minimum of $80. The drawdowns were considerably less with an average at $120.

MACD, Moving Average Convergence and Divergence, is a lagging indicator since it is based on the moving averages. Base on the MACD line, signal line and the difference (divergence) between MACD line the signals were generated. Signal line crossovers are the primary cues provided by the MACD. The standard interpretation is to buy when the MACD line crosses up through the signal line, or sell when it crosses down through the signal line. The upwards move is called a bullish crossover and the downwards move a bearish crossover. Many false signals were generated. MACD proved to be less effective with an average profit of $180 and also with an average drawdown of $350.

ADX, Average Directional Index, is directional movement indicator that measures the strength of the trend without regard to direction. Plus and minus directional movements were calculated and a 14 day smoothing constant was applied to derive the ADX. ADX value of 25 and above was chosen to indicate the presence of trend. There several periods when the ADX value reached and stayed above 25 for most of the contract months. The average profits were at $120 and the maximum draw down was at $820 with an average of $250. It seems that this directional movement indicator did not perform well for the time period considered.

Stochastic oscillator is a momentum indicator that uses support and resistance levels. %K and %D values are calculated using 3 day period. Buying signal occur when the %K line crosses and rises above the %D line. Conversely, a cross-over where the %K line drops below the %D to be a sell sign. If either the %K or %D falls below 20 and then starts to rise again above 20, this may be considered a buy sign. Similarly, a sell signal occurs if the indicator rises above 80 and then begins to fall below 80. Using the signals generated we observed the average profit to be $220 and the average draw down to be at $180.
We also developed a trading model based on a combination of MA(20) and RSI as they proved to be more successful in generating profitable trades. The average profit was at $350 and the average drawdown was 120. The model performed well during certain times when the data had trend component in it.

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Moving Average</th>
<th>MACD</th>
<th>RSI</th>
<th>ADX</th>
<th>Stochastic Oscillator</th>
<th>MA(20) and RSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Profits (average)</td>
<td>MA(10): $40, MA(20): $244</td>
<td>$180</td>
<td>$450</td>
<td>$120</td>
<td>$220</td>
<td>$350</td>
</tr>
<tr>
<td>Ratio of profit to Maximum drawdown</td>
<td>MA(10): 1:1, MA(20): 2.4:1</td>
<td>0.50:1</td>
<td>3.75:1</td>
<td>-2.08:1</td>
<td>1.2:1</td>
<td>1.9:1</td>
</tr>
</tbody>
</table>

Table 1: Performance measure for various technical trading indicators.

From the table 1 based on the net profits and ratio of profit to maximum drawdown, MA(20) and the RSI proved to be quite successful. ADX and Stochastic oscillator generated the lowest values. It was evident from the data that stronger prices prevailed during summer (June, Aug) months and lower prices during winters (April, Oct). And also the strength of trend indicated by the ADX during these time periods did not prove to result in significant profits. A combination of MA(20) and RSI resulted in better outcome with fewer trades and less drawdown. Using the technical trading indicators on inter-day data profits were observed during certain time periods for some of the lean hog contract futures. But these profits are not present consistently. Therefore, the hog futures markets are efficient in other time periods.

Further study using the tick-by-tick or intra-day high frequency data should be considered for using the most popular trading rules or indicators. This sort of testing should be done on a day by day data as well as during the sub-periods of intra-day data. By doing such sub-period analysis we can investigate about the time dependent inefficiency. This research only considered the inter-day data, and continuous contract months for three year period.

6) Bibliography:


