Homework#1
Fin590ARB

Instructor: Austin Gerig

Due February 11, 2005

Choose one of the following futures contracts (each person in your group should choose a different contract). They are all traded at the CME or CBOT:

E-mini S&P 500
E-mini Nasdaq 100
E-mini Russell 2000
E-mini S&P MidCap 400
Mini-Sized Dow

1) Research that contract and write down what you find (where it trades, when it trades, average volume, tick increment, dollar value per tick, etc.)

2) Using the week of data provided, plot a histogram of the contract's returns for intervals of: 1 second, 30 seconds, 3 minutes, and 30 minutes (Four histograms in total). For example, if the interval is 1 second, and the data at 1 second increments is: 170, 171, 171, 171, 172, 171, 171 ... your histogram should reflect 1 occurrence of -1, 3 occurrences of 0, and 2 occurrences of +1.

Homework#1 Solutions
Fin590ARB

Austin Gerig

February 11, 2005

1   Futures Contract Information

See http://www.cme.com/ for:

E-mini S&P 500
E-mini Nasdaq 100
E-mini Russell 2000
E-mini S&P MidCap 400

See http://www.cbot.com/ for:

Mini-Sized Dow

Also see http://www.eurexchange.com/, http://www.eurexus.com/, and http://www.euronext.com/ for information on other popular futures contracts.

2   Histogram of Returns for E-mini S&P 500

Results are plotted below in two figures. Fig. 1 shows the price evolution of the E-mini S&P 500 futures contract from October 18th-22nd, 2004. Fig. 2 plots the distribution of returns on several different time scales for the same week of data.
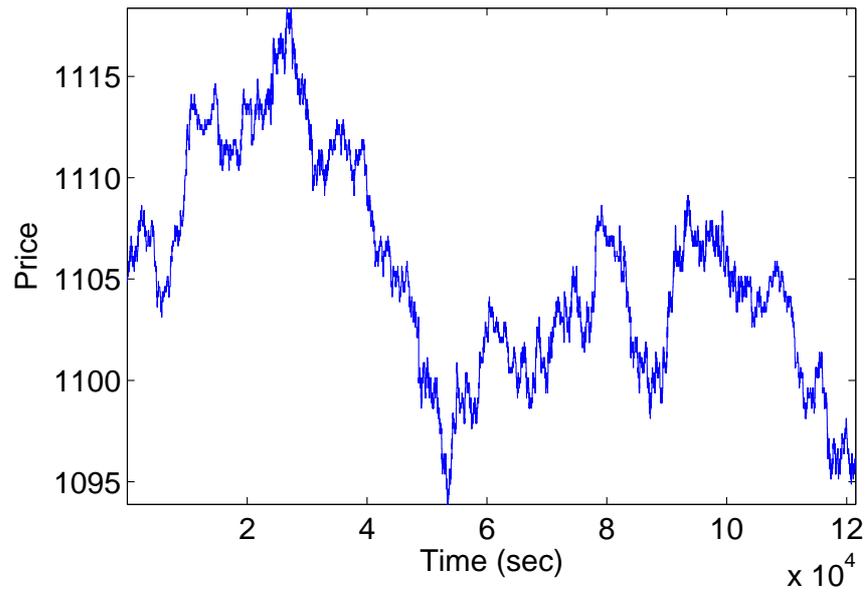
Figure 1: E-mini S&P 500 futures contract price for the week of 10/18/04 - 10/22/04. Data is from 08:30-15:15 CST daily.
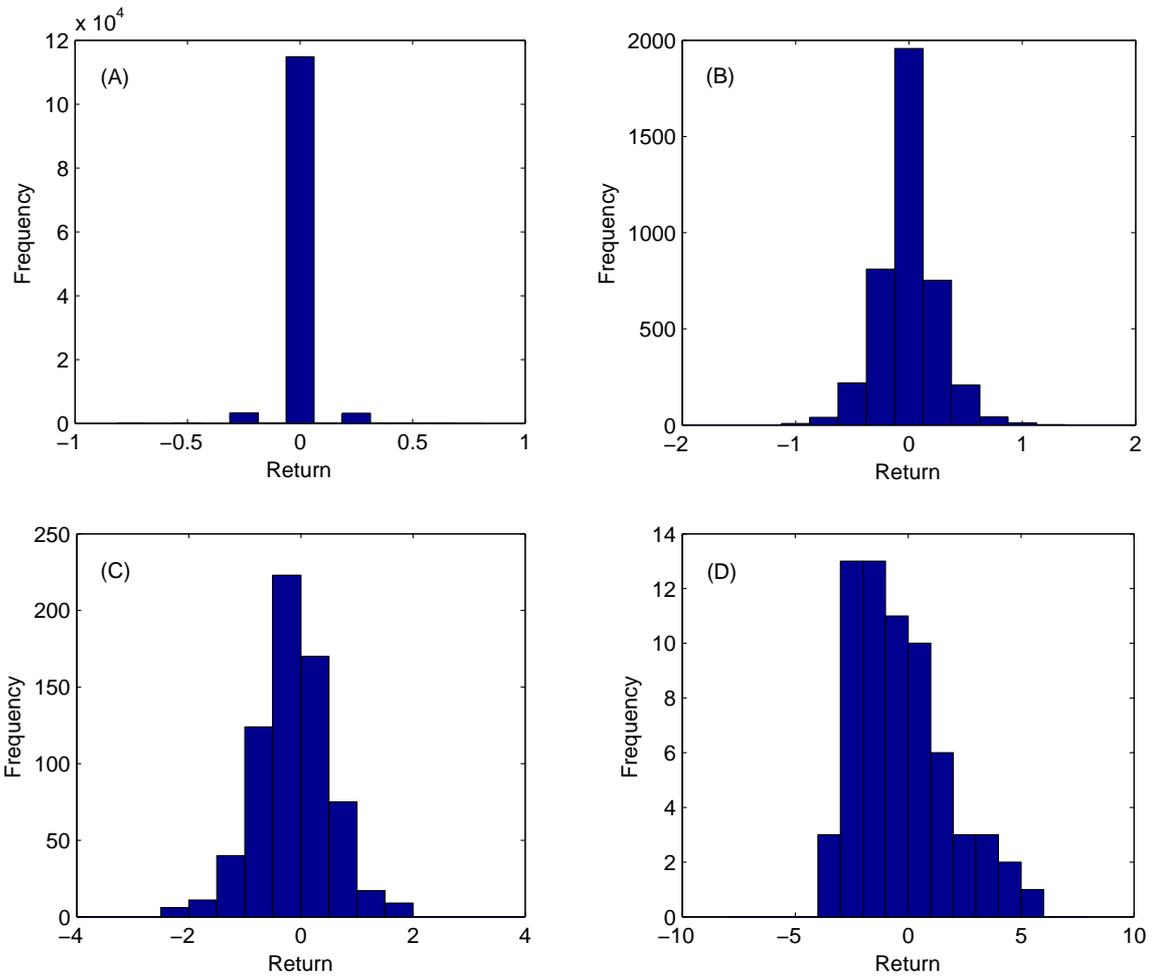
Figure 2: Four histograms of S&P 500 returns on scales of (A) 1 second, (B) 30 seconds, (C) 3 minutes, and (D) 30 minutes. Histograms are calculated using the week of data above.

3 Matlab Source Code

```
security1='MiniSP';
tick=.25;
month='10';
days=18:22;
year='04';
Asec=[];
Aplot=[];
AReturn1sec=[];
AReturn30sec=[];
AReturn3min=[];
AReturn30min=[];

for i=days
    day=int2str(i);
    tmp = load([security1 '_' month '.' day '.' year '_BookSec.csv']);
    Asec=[Asec; ((tmp(:,3)+tmp(:,18))/2)'];
end
Asec=Asec/100;
clear tmp

for i=1:length(days)
    Aplot=[Aplot, Asec(i,:)];
end
figure(1)
plot(Aplot)
xlabel('Time (sec)')
ylabel('Price')

AReturn=diff(Asec')';
for i=1:length(days)
    AReturn1sec=[AReturn1sec, AReturn(i,:)];
end
figure(2)
hist(AReturn1sec,-3*tick:tick/2:3*tick)
xlabel('Return')
ylabel('Frequency')

for i=1:length(days)
    for n=1:30:(length(AReturn(i,:)))-29
        tmp(1+(n-1)/30)=sum(AReturn(i,n:n+29));
    end
    AReturn30sec=[AReturn30sec, tmp];
    clear tmp
```

```
end
figure(3)
hist(AReturn30sec,-7*tick:tick:7*tick)
xlabel('Return')
ylabel('Frequency')

for i=1:length(days)
    for n=1:180:(length(AReturn(i,:)))-179
        tmp(1+(n-1)/180)=sum(AReturn(i,n:n+179));
    end
    AReturn3min=[AReturn3min, tmp];
    clear tmp
end
figure(4)
hist(AReturn3min,-15*tick:2*tick:15*tick)
xlabel('Return')
ylabel('Frequency')

for i=1:length(days)
    for n=1:1800:(length(AReturn(i,:)))-1799
        tmp(1+(n-1)/1800)=sum(AReturn(i,n:n+1799));
    end
    AReturn30min=[AReturn30min, tmp];
    clear tmp
end
figure(5)
hist(AReturn30min,-30*tick:4*tick:30*tick)
xlabel('Return')
ylabel('Frequency')
```

Homework#2
Fin590ARB

Instructor: Austin Gerig

Due March 18, 2005

1) Using the average of the bid/ask from the week of data you already have, estimate the following for one of the futures contracts (assume you can only be long or short one contract at a time):

 1.1) Maximum possible profit for the week
 1.2) Maximum possible profit using a continuation strategy
 1.3) Maximum possible profit using a reversal strategy

2) Using the two months of data provided, develop and analyze a trading strategy (it can involve one or a multiple of the contracts):

 2.1) Describe the strategy and define the entrance and exit signals
 2.2) Present the results of your strategy, e.g., profit distribution, stability of results, maximum drawdown, Sharpe ratio, etc.

 This is not intended to be a thorough exercise in strategy development - it is intended for you to get used to handling the data and to think about how to best present your results. You can choose any strategy you want (crossing moving averages, econometric modeling, pairs trading, etc.) - it needn't be profitable. You may disregard transaction costs and can assume transactions occur at the midpoint of the bid/ask. Assume you are trading only one contract at a time.

Homework#2 Solutions
Fin590ARB

Austin Gerig

March 18, 2005

1 Estimate Maximum Profits

Calculations are made using data from October 18th-22nd, 2004 (08:30-15:15 CST) for the E-mini S&P 500 contract (quote is taken as midpoint of best bid and best ask). Fig. 1 plots the data.
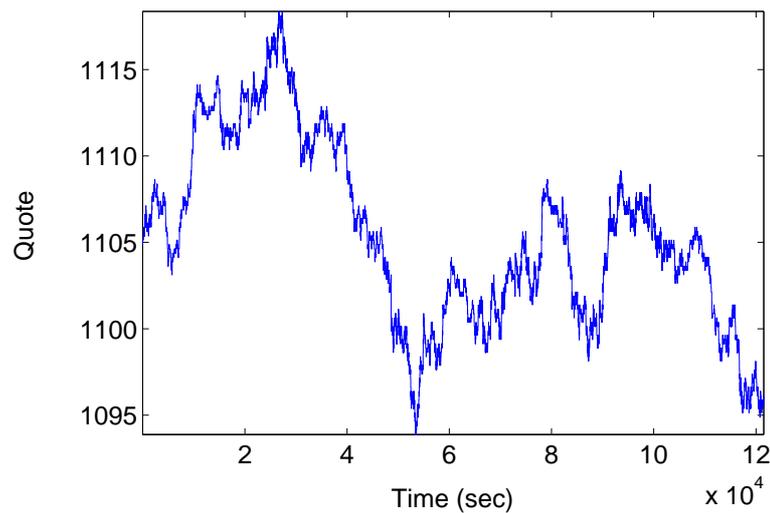

Figure 1: E-mini S&P 500 futures contract quote for the week of 10/18/04 - 10/22/04. Data is from 08:30-15:15 CST daily.

1.1 Maximum Profit

The maximum possible profit, P^*, trading the E-mini S&P 500 contract (assuming long or short only one contract at a time) is the sum of the absolute value of the returns:

$$P^* = \frac{\$12.50}{.25} \sum_i |x_i|, \tag{1}$$

where x_i is the one-second return for the contract at time i. P^* is calculated to be $82,825.00. Compare this to a) $462.50, the profit from a sell and hold strategy, and b) $1225.00 the amount of profit from selling at the highest point and buying at the lowest point.

1.2 Maximum Profit Using Continuation Strategy

More than one answer is acceptable. Here, I'll consider a movement in the price of the contract as profitable if it is preceded by a movement in the same direction. Construct a series $\{y_i\} = \{x_i : x_i \neq 0\}$, this is just the series with a tick movement considered as the fundamental time-step. The maximum profit is:

$$P^*_{cont} = \frac{\$12.50}{.25} \sum_i \begin{cases} |y_i| & \text{if} \quad y_i \cdot y_{i-1} > 0 \\ 0 & \text{otherwise} \end{cases}. \tag{2}$$

This is calculated to be $30,568.75.

1.3 Maximum Profit Using Reversal Strategy

More than one answer is acceptable. Here, I'll consider a movement in the price of the contract as profitable if it is preceded by a movement in the opposite direction. Using y_i again, the maximum profit is:

$$P^*_{rev} = \frac{\$12.50}{.25} \sum_i \begin{cases} |y_i| & \text{if} \quad y_i \cdot y_{i-1} < 0 \\ 0 & \text{otherwise} \end{cases}. \tag{3}$$

This is calculated to be $52,193.75. Notice that $P^* \approx P^*_{cont} + P^*_{rev}$, the only reason this is inexact is that the first movement on each day is untradable in the continuation and reversal strategies. Notice also that $P^*_{rev} > P^*_{cont}$, this is because the first order autocorrelations in returns on the E-mini S&P 500 are negative (something we've noticed before).

2 Strategy Presentation

The strategy developed below is based on the negative first order autocorrelations in the spread between the E-mini Nasdaq 100 and the E-mini S&P 500 futures contracts. Profitability is greatly exaggerated - each full trade (entrance and exit) involves 6 contract transactions. To seriously present this strategy, transaction costs should be estimated and included (both the exchange fees and any costs associated with using market instead of limit orders). Note that using the midpoint of the best bid and best ask as the price series is equivalent to assuming one market and one limit order for entrance/exit.

Also, all results are shown in-sample. In general, you should choose 1/3 to 1/2 of your data to develop a strategy and the rest to test the strategy out of sample. You can, however, judge the robustness of your strategy by comparing, in-sample, the consistency of profits - does the profit distribution of your strategy look similar for different sections of in-sample data?

2.1 Description of Strategy

A portfolio is constructed as follows:

$$F_i = N_i - 2S_i, \tag{4}$$

where N_i and S_i are the price series (midpoint of best bid and best ask) of the E-mini Nasdaq 100 and the E-mini S&P 500 respectively. This series is plotted in Fig. 2 for the data available (08:30-15:15 CST October 11,14,15,18-22,25-28 and November 2,4,5,9-11,12,15-19,22-24, 2004).
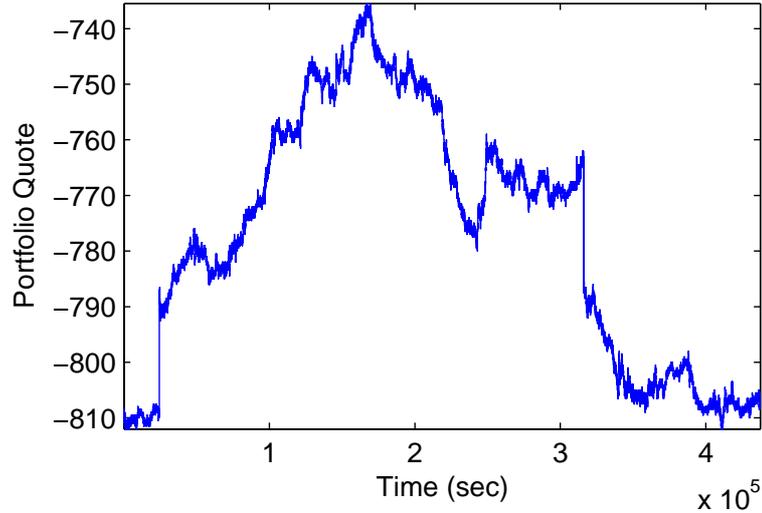

Figure 2: Plot of portfolio time series, $F_i = N_i - 2S_i$, for the dates specified in the text. Dates are not consecutive.

The strategy is to buy and sell this portfolio at opportune times. A new time series, f_i, is created:

$$f_1 = F_1, \tag{5}$$

$$f_2 = \begin{cases} F_{t_1} = f_1 + 2.5 & \text{if} \quad t_1 < t_2 \\ F_{t_2} = f_1 - 2.5 & \text{if} \quad t_2 < t_1 \end{cases}, \tag{6}$$

$$f_3 = \begin{cases} F_{t_1} = f_2 + 2.5 & \text{if} \quad t_1 < t_2 \\ F_{t_2} = f_2 - 2.5 & \text{if} \quad t_2 < t_1 \end{cases}, \tag{7}$$

$$f_4 = \dots. \tag{8}$$

This series is just the original series, F_i, but is only updated when the portfolio's quoted price changes by 2.5 or more. The plot of f_i is shown in Fig. 3.

Entrance signals are as follows: Buy (go long) the portfolio at time, i, whenever the following condition holds:

$$f_{i-3} < f_{i-2} < f_{i-1} > f_i. \tag{9}$$

Short sell (go short) the portfolio at time, i, whenever:

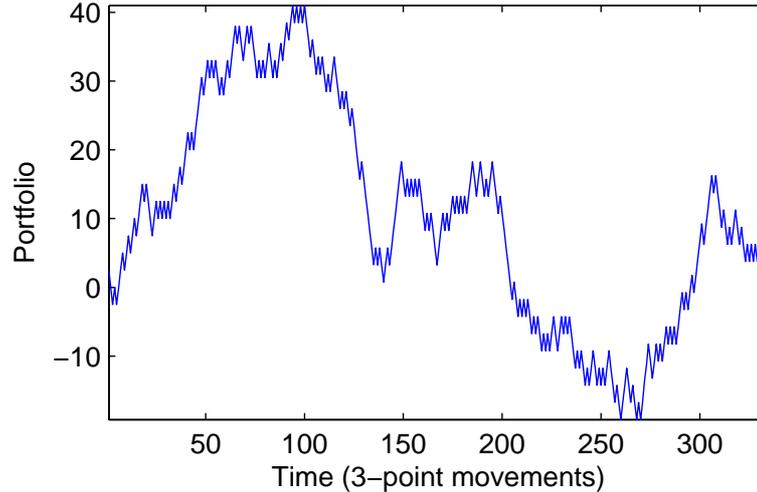$$f_{i-3} > f_{i-2} > f_{i-1} < f_i. \tag{10}$$

3

Figure 3: Plot of portfolio time series, f_i, for the dates specified in the text - it is updated whenever the portfolio's value changes by 2.5 or more. Note that price differences from one day to the next are ignored.

Positions are exited at f_{i+1}. In essence, we anticipate [up, up, down] states will be followed by an up state, and [down, down, up] states will be followed by a down state. These conditions were chosen by applying all possible [up/down, up/down, up/down] states and choosing the two most profitable. A neural net or genetic algorithm would also have given this result, but because there are only $2^3 = 8$ states, an exhaustive search was easily performed.

2.2 Strategy Results

The results of the strategy are summarized in Figs. 4 and 5 and in Table I. The strategy produced 56 trades during the days studied. Assuming only one portfolio contract (3 total contracts) outstanding at any time, the total profit was 70.5 points which is approximately $70.5 \cdot \$22.50 = \$1586.25$ (If the E-mini S&P 500 contributes a full portfolio point, it would pay \$25; if the E-mini Nasdaq 100 contributes a full portfolio point, it would pay \$20).
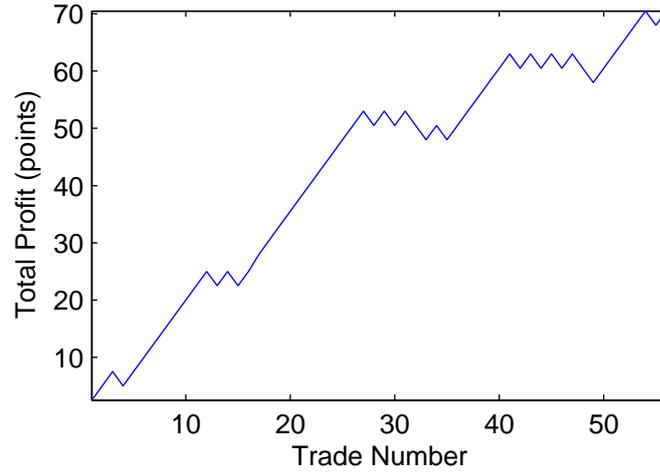
4

Figure 4: Plot of total profit as a function of trade number for the strategy discussed above. Average profit was 1.26 points.
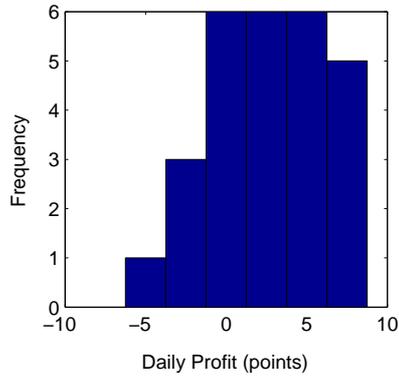

Figure 5: Distribution of daily profits for the strategy described above.

Table I
Strategy Results

Total Profit	Sharpe Ratio	Max Drawdown	# Trades	% Win
$1586.25	11.53	5 pts	56	75%

	Profit/Trade	Profit/Day	Day StdDev	
	$28.33	$58.75	$80.91	

3 Matlab Source Code

3.1 Estimate Maximum Profits

```
%initializations
security1='MiniSP';
tick=.25;
dollars_per_tick=12.5;
month='10';
days=18:22;
year='04';
Asec=[];
Aplot=[];
AReturn1sec=[];

%load data
for i=days
    day=int2str(i);
    tmp = load([security1 '_' month '.' day '.' year '_BookSec.csv']);
    Asec=[Asec; ((tmp(:,3)+tmp(:,18))/2)'];
end
Asec=Asec/100;
clear tmp

%plot data
for i=1:length(days)
    Aplot=[Aplot, Asec(i,:)];
end
figure(1)
plot(Aplot)
xlabel('Time (sec)')
ylabel('Quote')

%maximum profit
```

```matlab
AReturn=diff(Asec')';
for i=1:length(days)
    AReturn1sec=[AReturn1sec, AReturn(i,:)];
end
profit=(dollars_per_tick/tick)*sum(abs(AReturn1sec))

%maximum continuation profit
profit=0;
for i=1:length(days)
    tmp=AReturn(i,:);
    tmp=tmp(tmp~=0);
    for j=2:length(tmp)
        if tmp(j)*tmp(j-1)>0
            profit=profit+abs(tmp(j));
        end
    end
end
profit=(dollars_per_tick/tick)*profit

%maximum reversal profit
profit=0;
for i=1:length(days)
    tmp=AReturn(i,:);
    tmp=tmp(tmp~=0);
    for j=2:length(tmp)
        if tmp(j)*tmp(j-1)<0
            profit=profit+abs(tmp(j));
        end
    end
end
profit=(dollars_per_tick/tick)*profit
```

3.2 Strategy Presentation

```matlab
%initializations
security1='MiniNas';
security2='MiniSP';
ratio=2;
tick=.50;
n_ticks=5;
input_length=3; %how far in the past to look
days1=[11 14 15 18:22 25:28];
days2=[2 4 5 9:11 12 15:19 22:24];
year='04';
security1_sec=[];
```

```
security2_sec=[];

%load data
month='10';
for i=days1
    day=int2str(i);
    if i<10
        day=['0' int2str(i)];
    end
    tmp1 = load([security1 '\' security1 '_' month '.' day...
     '.' year '_BookSec.csv']);
    tmp2 = load([security2 '\' security2 '_' month '.' day...
     '.' year '_BookSec.csv']);
    security1_sec=[security1_sec; ((tmp1(:,3)+tmp1(:,18))/2)'];
    security2_sec=[security2_sec; ((tmp2(:,3)+tmp2(:,18))/2)'];
end
month='11';
for i=days2
    day=int2str(i);
    if i<10
        day=['0' int2str(i)];
    end
    tmp1 = load([security1 '\' security1 '_' month '.' day...
     '.' year '_BookSec.csv']);
    tmp2 = load([security2 '\' security2 '_' month '.' day...
     '.' year '_BookSec.csv']);
    security1_sec=[security1_sec; ((tmp1(:,3)+tmp1(:,18))/2)'];
    security2_sec=[security2_sec; ((tmp2(:,3)+tmp2(:,18))/2)'];
end
security1_sec=security1_sec/100;
security2_sec=security2_sec/100;
clear tmp1 tmp2

%form a portfolio based on linear combination of markets
portfolio_sec=security1_sec-ratio*security2_sec;
clear security1_sec security2_sec
portfolio_return=diff(portfolio_sec')';
figure(1)
tmp=portfolio_sec';
plot(tmp(:))
xlabel('Time (sec)')
ylabel('Portfolio Quote')
clear tmp

%main loop
```

```
plot_time_series=[];
profit=0;
plot_profit=[];
portfolio_dim=size(portfolio_return);
profit_day=zeros(1,portfolio_dim);
for i=1:portfolio_dim(1)
    tmp=portfolio_return(i,:);

    %form a time series (1-timestep = portfolio movement of...
     'n_ticks' ticks)
    cum_return=0;
    time_series=[];
    for j=1:length(tmp)
        cum_return=cum_return+tmp(j);
        if cum_return>=n_ticks*tick|cum_return<=-n_ticks*tick
            time_series=[time_series, cum_return];
            cum_return=0;
        end
    end
    plot_time_series=[plot_time_series, time_series];
    time_series_tmp=time_series;
    time_series=time_series>0; %vector with 0=downtick, 1=uptick

    for j=1:length(time_series)-input_length
        input=time_series(j:j+input_length-1);
        if input==[1 1 0]
            profit=profit+time_series_tmp(j+input_length);
            profit_day(i)=profit_day(i)+...
             time_series_tmp(j+input_length);
            plot_profit=[plot_profit, profit];
        end
        if input==[0 0 1]
            profit=profit-time_series_tmp(j+input_length);
            profit_day(i)=profit_day(i)-...
             time_series_tmp(j+input_length);
            plot_profit=[plot_profit, profit];
        end
    end
end

%results
figure(2)
plot(cumsum(plot_time_series))
xlabel('Time (3-point movements)')
ylabel('Portfolio')
```

```
plot_profit(length(plot_profit))/length(plot_profit)

figure(3)
plot(plot_profit)
xlabel('Trade Number')
ylabel('Total Profit')

figure(4)
hist(profit_day,min(profit_day):2.5:max(profit_day))
xlabel('Daily Profit (points)')
ylabel('Frequency')

mean(profit_day)
std(profit_day)
sharpe=252*mean(profit_day)/(sqrt(252)*std(profit_day))
```

Final Project
Fin590ARB

Instructor: Austin Gerig

Due May 5th, 2005
220 Wohlers 11:30AM - 1:30PM

Final Project

Using the equity index futures data provided, develop and analyze a trading strategy for one or a multiple of contracts. Be sure to divide the data into in-sample and out-of-sample sections. Include an estimation of transaction costs. Each group will need to:

1) Turn in a written report of your strategy (no requirements for size).
2) Give a 15 minute presentation, preferably in powerpoint, of your results (leave $\approx$ 3 minutes for questions).

You will not be required to implement your strategy on TT's platform. Grading for the final project will be as follows, 50% instructor assessment, 25% intrateam assessment (if you contributed your fair share, you will receive the full 25%), 25% interteam assessment. Everyone will need to hand in this sheet on May 5th.

Name_____

Intrateam Assessment

Name of Team Member   % Credit this Team Member
should receive (must add to 100)

1) _____

2) _____

3) _____

4) _____

Name_____   Team Number_____

Interteam Assessment

Team Number	Presentation Rating (1-5)	Analysis Rating (1-5)	Comments
1)	_____	_____	_____
2)	_____	_____	_____
3)	_____	_____	_____
4)	_____	_____	_____
5)	_____	_____	_____