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## Neural Network

# Stock Price Prediction Algorithm Results

## Example Case #1

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# Summary

The concept behind this technology is that company stock price profiles contain patterns that are indicative of future movements and directions. Ted Warren published a book in the 1960s about how to recognize and invest (and profit) based on certain easily recognizable geometric patterns (this approach falls under the heading of Technical Analysis). A type of artificial intelligence, called Artificial Neural Networks, takes this concept a quantum leap forward because it can recognize complex patterns that are not discernable to the human eye. Fundamentally the Neural Network is analyzing the history of the stock and then predicting where the price will end up over the next year (up or down).

Thus a Neural Network is “trained” to recognize patterns in company price and volume (and other data) profiles, and then to predict the high-end or low-end price of each stock over the next year. In this case Neural Networks were trained with inputs spanning a period of 1,200 trading days and outputs of the high/low price points over the next 300 trading days. Refer to pages 5, 6, & 7 for more details.

The performance of each Neural Network is forecast-tested by having it analyze the stock profiles of other companies (forecast set) which were not in its training data set (companies that it had never “seen” before). The Neural Network stock selection set needs to be able to beat the market average Return on Investment (ROI) – that is the net increase/decrease of all of the forecast set stocks over the investment period - in order for it to be considered “successful”.

Of a pool of 98 companies, 49 are used for training of the Neural Networks and the remaining 49 are used for forecast testing (forecast pool of stocks) of these same Neural Networks. Prior to training and forecast testing, the training/test time window intervals of the companies and their data are shuffled in random order by the software such that they fall somewhere in the overall time span between 2005 and 2015.

# Summary

These time intervals (set by the software) span 1,200 trading days and are for training input to the Neural Network. The 300 trading days following each of these 1,200 trading day intervals are used for the training output to the Neural Network. Again - these time intervals are randomly selected by the software and can lie anywhere in the overall time span interval between 2005 and 2015.

When performing forecast testing on the forecast pool of stocks, a rule set is implemented which makes the buy/sell decision based on the value of the Neural Network output signal-strength for a particular stock. If the Neural Network predicted price point exceeds the rule set specified percentage of the purchase price, the stock is purchased. The stock is then held until the end of the investment time period (300 trading days) and sold.

The high-achieving Neural Networks (called Super Nets) were able to achieve remarkable ROIs as shown in pages 12 through 25.

# Example Case #1 Training Set

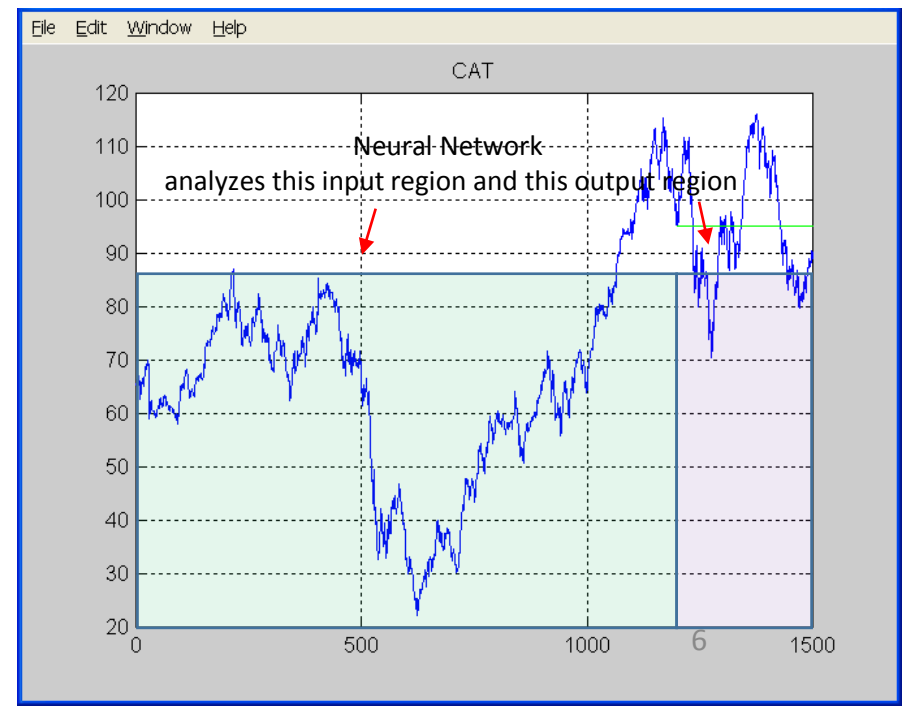
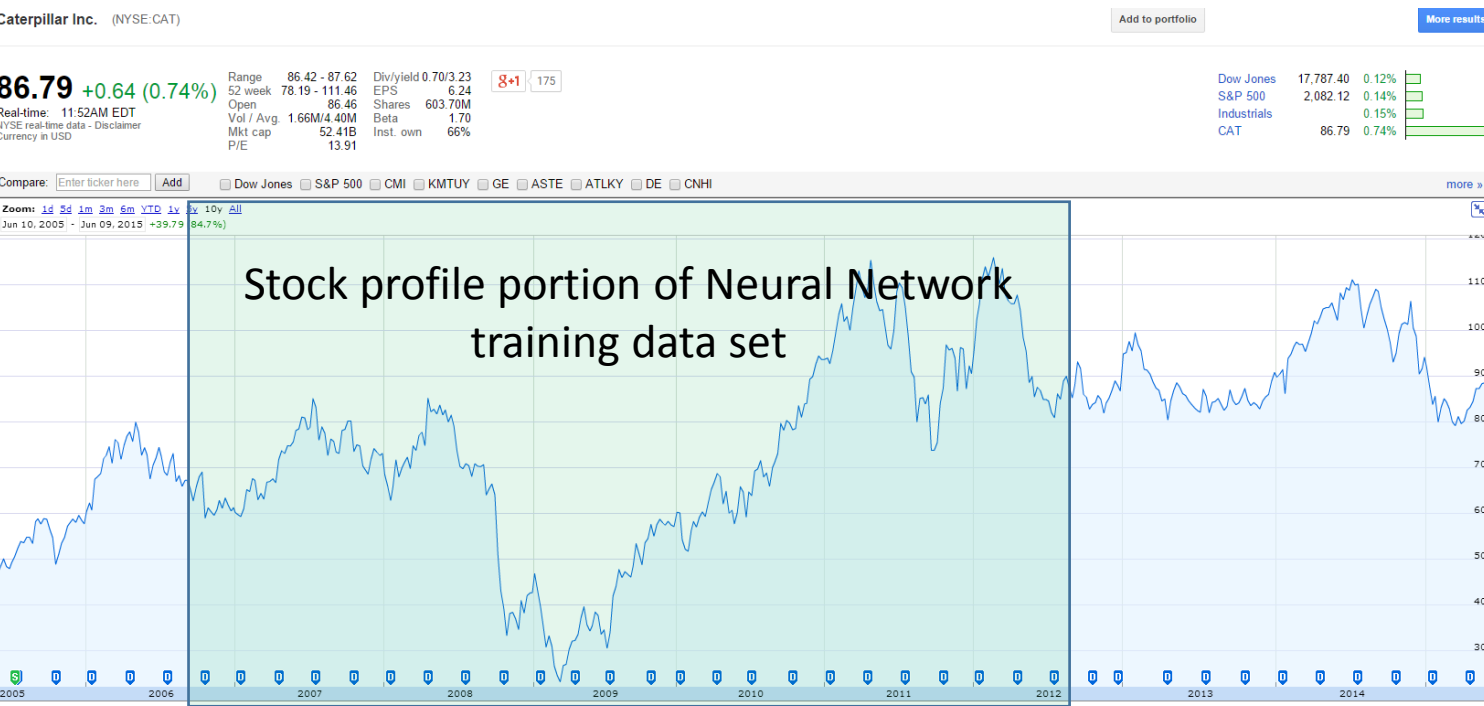
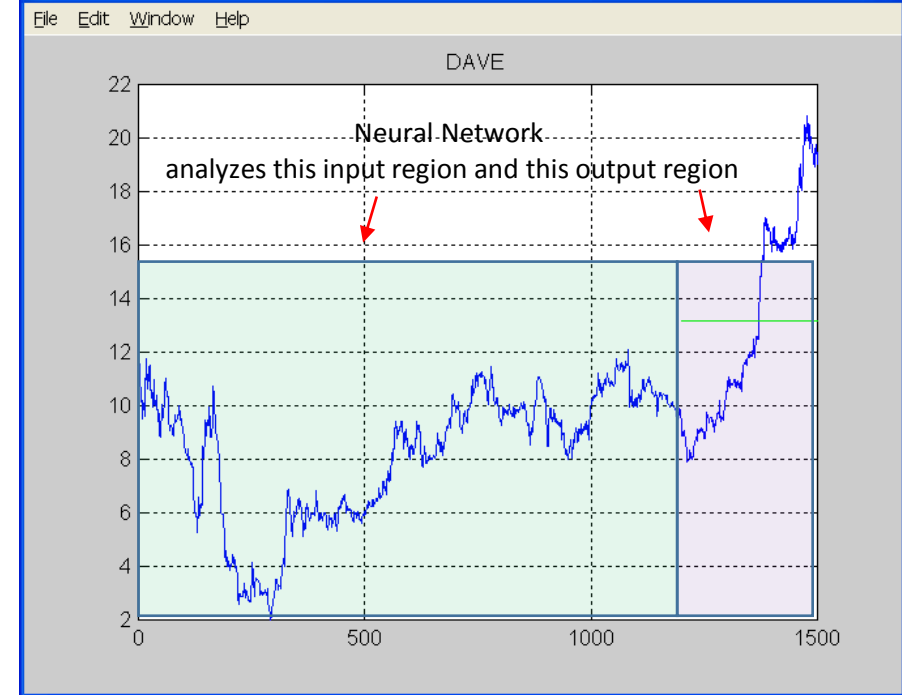
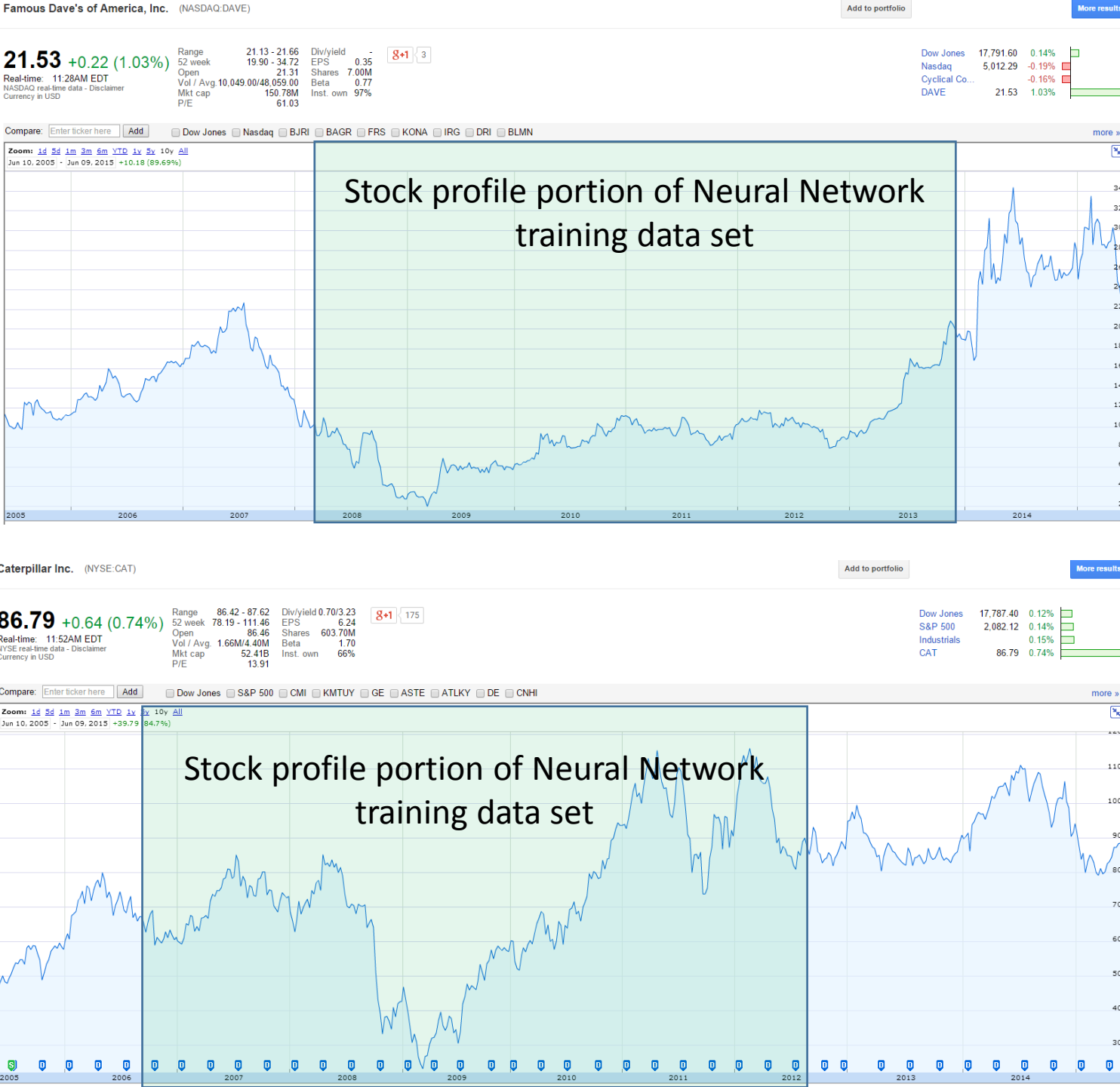
In this example case, a pool of 98 companies was used for training and forecast testing purposes. The criteria was that there had to be at least 10 years worth of available financial data. Capitalization and market sector were not considerations in the selection criteria – on the contrary, the selected companies covered a broad range of capitalizations and market sectors from the NYSE and NASDAQ exchanges.

The training and forecast sets were generated from time windows of 1,500 days for which the start date was randomly selected by the software, inside a 10 year time interval – early 2005 to early 2015.

The following 49 companies were used for training,

NTT,	SYKE,	TSS,	CAT,	SUBK,	ODP,	BBY,
AEP,	SJW,	ABM,	PSMT,	SYBT,	RJET,	ANIK,
STT,	CAMP,	COH,	TXN,	RSTI,	MTZ,	GCO,
AMAG,	ENL,	RDWR,	RBCAA,	UEIC,	IRM,	TAYD,
AMIC,	PAYX,	ICON,	MDT,	FINL,	AFL,	CSU,
DAVE,	CHKP,	SPLS,	QCOM,	AGU,	TR,	PKI,
BGCP,	BCO,	CLCT,	HCKT,	EZPW,	ADBE,	TSO,

Two examples of the training interval are shown in the next page.



# Example Case #1 Forecast Test Set

The following 49 companies were used for forecast testing.

NWN,	VZ,	AXTI,	SNE,	ADTN,	MMM,	OLED,
SENEB,	DGX,	SCI,	UDR,	REV,	OXY,	A,
CVGI,	ACIW,	CSCO,	BDC,	SJR,	BGG,	EQT,
ERIC,	SHLM,	LAMR,	VMC,	ANGO,	VICR,	YHOO,
PNK,	UGI,	BBOX,	GRMN,	MATW,	KELYA,	DRI,
BKE,	TGT,	AIR,	CTSH,	ATU,	ACET,	MLM,
RENT,	BBBY,	BKMJ,	BEAV,	WBS,	LLY,	HAS,

# Market Performance Benchmark

Market investment in all of the test stock

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)	Portfolio Value (\$)
NWN	100.0	48.8	42.7	87.4	-12.6	87.4
VZ	100.0	30.3	37.0	122.2	22.2	209.6
AXTI	100.0	2.3	2.6	112.4	12.4	322.0
SNE	100.0	21.8	12.4	56.7	-43.3	378.7
ADTN	100.0	25.9	22.8	88.0	-12.0	466.7
MMM	100.0	92.6	128.6	138.9	38.9	605.6
OLED	100.0	20.3	45.0	221.6	121.6	827.2
SENEB	100.0	20.3	30.2	148.9	48.9	976.1
DGX	100.0	54.8	55.2	100.7	0.7	1076.8
SCI	100.0	11.1	17.2	154.8	54.8	1231.6
UDR	100.0	24.3	25.5	104.8	4.8	1336.4
REV	100.0	10.0	15.8	158.0	58.0	1494.4
OXY	100.0	77.5	101.0	130.4	30.4	1624.8
A	100.0	32.9	34.5	104.9	4.9	1729.7
CVGI	100.0	17.8	12.2	68.9	-31.1	1798.6
ACIW	100.0	21.3	20.3	95.3	-4.7	1893.9
CSCO	100.0	25.6	25.2	98.5	-1.5	1992.3
BDC	100.0	50.1	72.5	144.6	44.6	2137.0
SJR	100.0	18.8	21.6	114.4	14.4	2251.4
BGG	100.0	24.2	20.7	85.3	-14.7	2336.7
EQT	100.0	40.3	48.8	121.1	21.1	2457.8
ERIC	100.0	9.2	12.4	134.3	34.3	2592.1
SHLM	100.0	30.1	36.7	121.8	21.8	2713.9
LAMR	100.0	40.7	32.3	79.3	-20.7	2793.2
VMC	100.0	43.3	49.6	114.8	14.8	2908.0
ANGO	100.0	13.1	10.1	77.0	-23.0	2985.0
VICR	100.0	8.2	16.2	197.4	97.4	3182.4
YHOO	100.0	14.9	14.9	100.0	0.0	3282.4
PNK	100.0	8.7	15.0	171.8	71.8	3454.2
UGI	100.0	16.2	21.8	134.7	34.7	3588.9
BBOX	100.0	31.0	21.9	70.8	-29.2	3659.6

The software “invests” (simulated, of course) an equal amount of money in the forecast pool of 49 forecast companies and only sells the stock at the end of the investment period (300 trading days in this case). This produces a “market average” ROI – in this case the market average ROI for these stocks was **19.2%** (see next page).

Thus the Neural Network stock price predictors have to produce an ROI that beats this number in order to be considered “successful”.

Continued on next page ...



# Market Performance Benchmark

GRMN	100.0	47.0	34.1	72.6	-27.4	3732.2
MATW	100.0	33.9	37.5	110.5	10.5	3842.7
KELYA	100.0	19.2	15.0	78.1	-21.9	3920.8
DRI	100.0	39.2	44.4	113.1	13.1	4034.0
BKE	100.0	38.9	39.5	101.5	1.5	4135.5
TGT	100.0	64.1	74.0	115.5	15.5	4250.9
AIR	100.0	14.7	25.2	171.2	71.2	4422.1
CTSH	100.0	24.8	31.1	125.4	25.4	4547.5
ATU	100.0	29.4	34.0	115.8	15.8	4663.3
ACET	100.0	12.2	17.0	139.3	39.3	4802.7
MLM	100.0	91.4	66.9	73.2	-26.8	4875.9
RENT	100.0	12.9	26.0	202.2	102.2	5078.1
BBBY	100.0	51.0	58.4	114.4	14.4	5192.6
BKMU	100.0	6.5	7.3	112.3	12.3	5304.9
BEAV	100.0	31.8	44.5	139.9	39.9	5444.8
WBS	100.0	22.1	29.7	134.3	34.3	5579.1
LLY	100.0	41.8	55.1	131.9	31.9	5711.0
HAS	100.0	36.9	47.6	129.2	29.2	5840.1

Initial Market Investment = \$4900.0

Final Market Portfolio Value = \$5840.1

Total Return on Market Investment = 19.2 percent

# Performance Results

The total market average ROI for this group of forecast pool of stocks was **19.2%**

Monte Carlo testing was performed by generating 100 Neural Networks (for each Monte Carlo test), each of which was trained on the 49 training stocks and then forecast-tested on 49 stocks. Each Neural Network would output a predicted price point for each of the 49 stocks.

When performing forecast testing, a threshold can be set in the software such that only stocks, for which the Neural Network predicts a certain percentage ROI, will be purchased. For example, if the threshold is set at 50%, then only stocks that the Neural Network predicts will have an ROI of 50% or higher will be purchased.

For this set of Monte Carlo test runs, the threshold was set to 50%. The average performance of the Neural Networks for each of the Monte Carlo runs (100 Neural networks generated and each made predictions for the forecast pool of 49 stocks) are shown below:

1. **40.4% @ a threshold of 50%**
2. **41.8% @ a threshold of 50%**
3. **42.2% @ a threshold of 50%**
4. **39.7% @ a threshold of 50%**
5. **36.4% @ a threshold of 50%**

# Performance Results – Super Nets

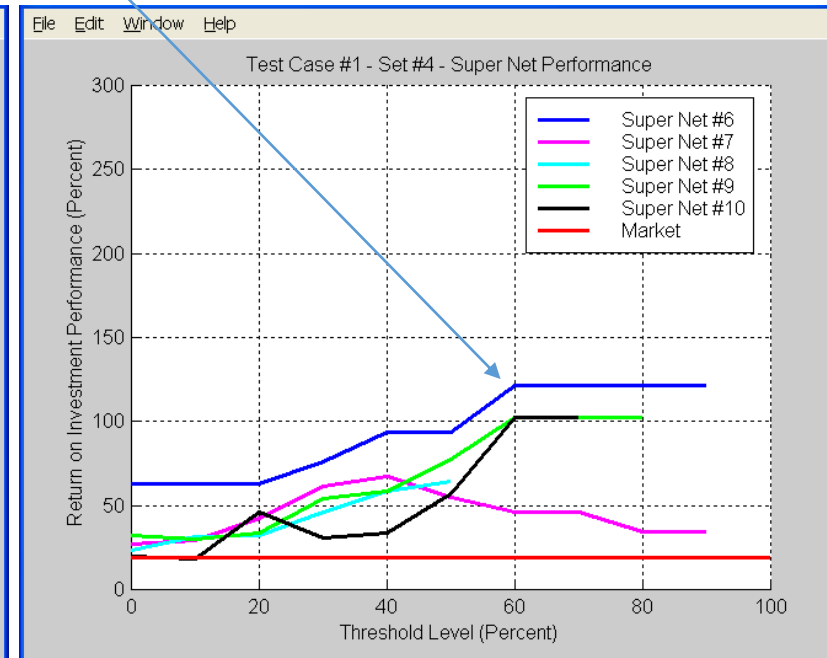
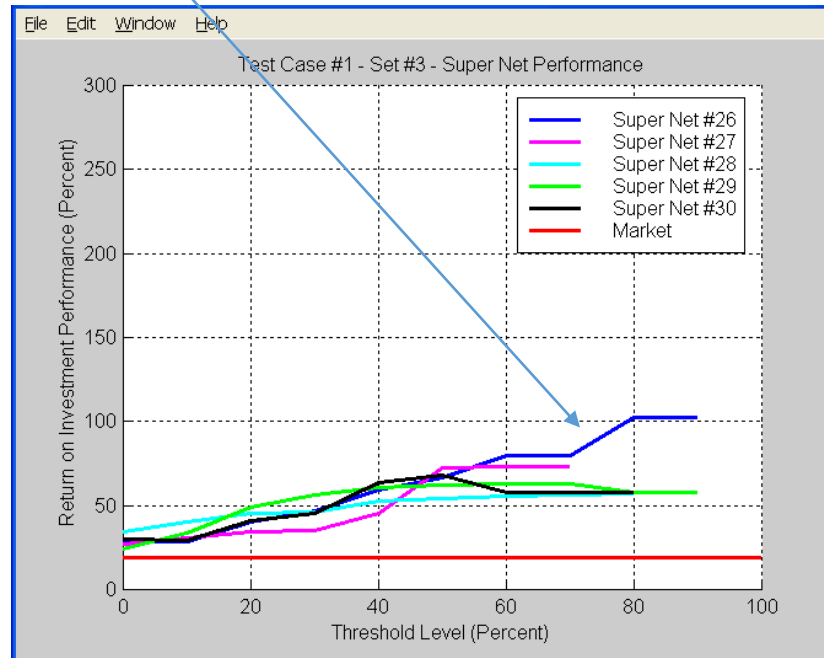
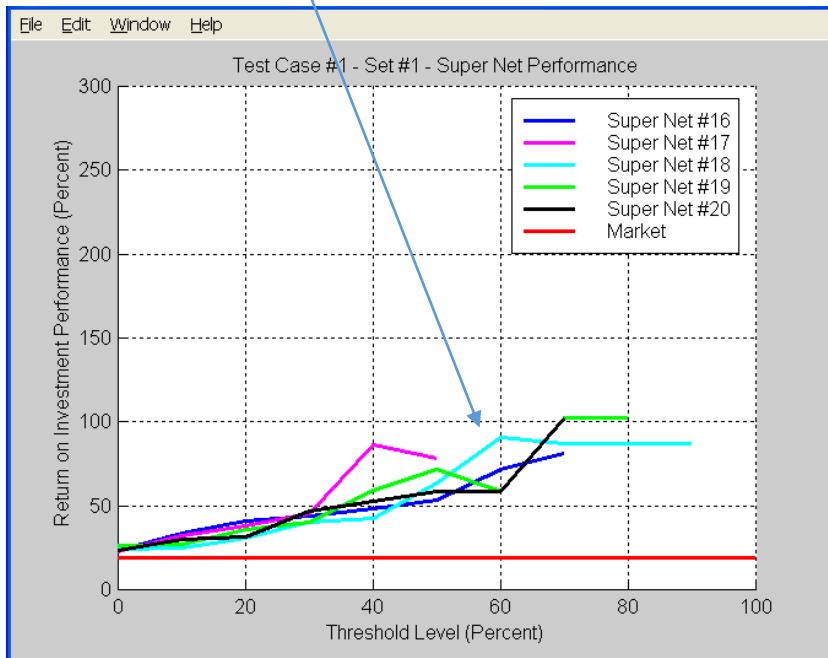
When performing forecast testing, a threshold can be set in the software such that only stocks, for which the Neural Network predicts a certain percentage ROI, will be purchased. For example, if the threshold is set at 50%, then only stocks for which the Neural Network predicts will have an ROI of 50% or higher will be purchased.

Several sets of high-achieving Neural Networks, called “Super Nets”, were generated to demonstrate their superior performance in picking stocks at the various threshold levels. The rest of this document discusses the performances for three Super Nets.

# Performance Results – Super Nets

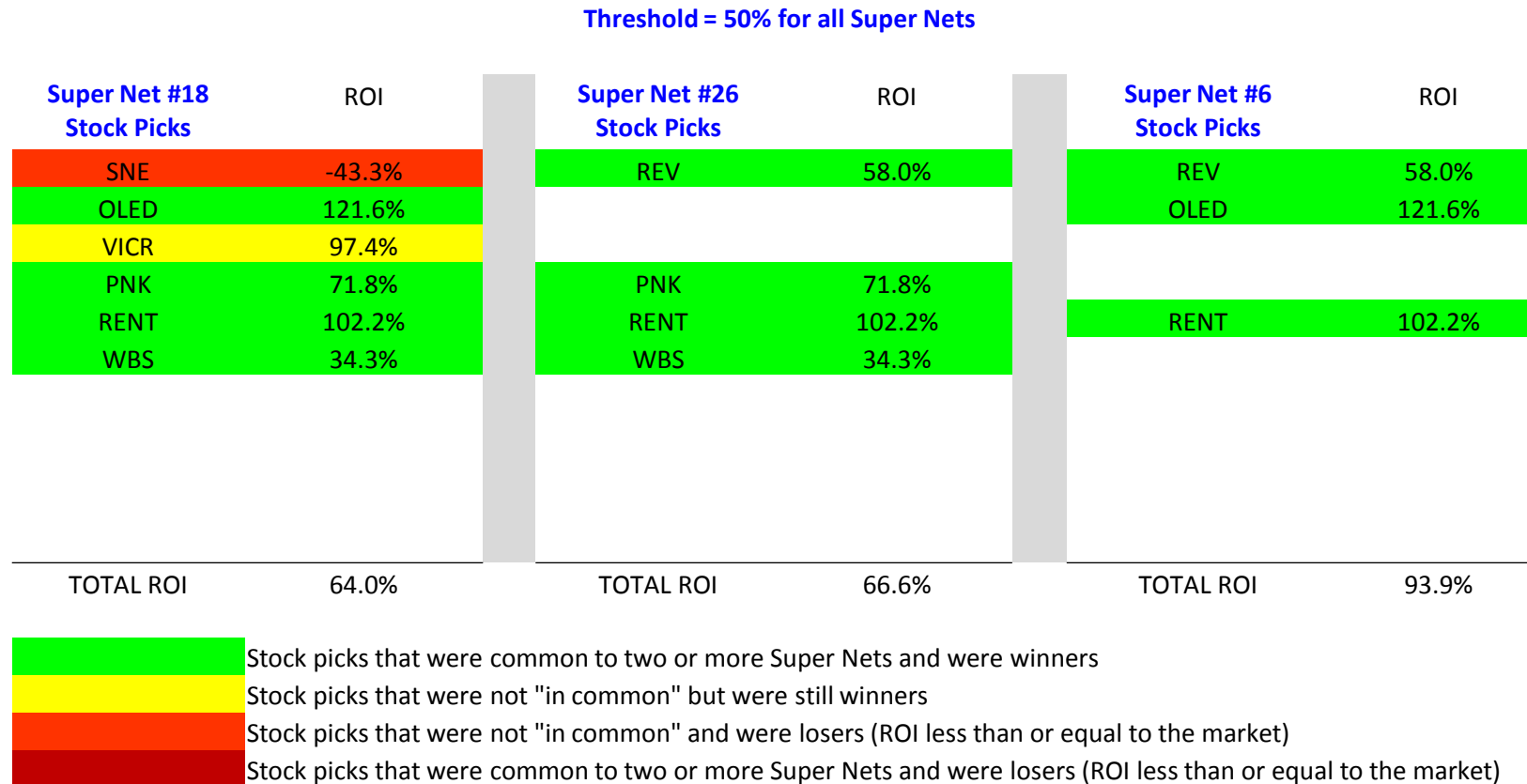
The plots on this page show Super Net ROI performance for threshold levels varying from 0% to 100%. The market ROI (aggregate return of the pool of forecast stocks) of **19.2%** is shown in red for comparison purposes.

Super Net 18 (Set 1, below left), Super Net 26 (Set 3, below middle), and Super Net 6 (Set 4, below right) were selected to demonstrate performance in the following pages.



# Performance Results – Super Nets

A comparison of the three Super Net stock picks, at the 50% threshold level, is shown below. Notice that there is overlap between the three Super Nets and that one of the Super Nets also picked another winner as well as a loser. These Super Nets can be combined as a “Wolf Pack” to hunt together for stocks that are going to rise significantly in the next year.





# Super Net #18 Performance

The performance of Super Net #18 (Set 1) is demonstrated in the following page for threshold levels 70%, 50%, and 30%. Note that the advantage of using the lower threshold levels is that an investor can maintain a larger diversified portfolio of stocks while still achieving superior ROIs.

On the next page, performance at the 70% threshold level is shown on the top left section. The performance at the 50% threshold level is shown in the middle. The performance at the 30% threshold level is shown on the lower right section.

A green bar represents a winning stock pick that was added to the portfolio as the threshold was dropped. A red bar represents a losing stock pick that was added to the portfolio. Note that “losing stock pick” refers to any stock that performs at the same level of the market ROI (19.2% in this case) or below.

# Super Net #18 Performance



Neural Network Rule Set Threshold = 70.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
PNK	100.0	8.7	15.0	171.8	71.8
RENT	100.0	12.9	26.0	202.2	102.2

The threshold is lowered to 50% and the Super Net picks 4 more companies – three are big winners and one is a significant loser

The threshold is lowered to 30% and the Super Net picks 5 more companies – one is big winner, one is a minor winner, two are significant losers, and one is a minor loser.

Neural Network Rule Set Threshold = 50.0 percent






Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
SNE	100.0	21.8	12.4	56.7	-43.3 
OLED	100.0	20.3	45.0	221.6	121.6 
VICR	100.0	8.2	16.2	197.4	97.4 
PNK	100.0	8.7	15.0	171.8	71.8
RENT	100.0	12.9	26.0	202.2	102.2
WBS	100.0	22.1	29.7	134.3	34.3 

Initial NNet Investment = \$600.0

Final NNet Portfolio Value = \$984.0

Total Return on NNet Investment = 64.0 percent

Neural Network Rule Set Threshold = 30.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
SNE	100.0	21.8	12.4	56.7	-43.3
OLED	100.0	20.3	45.0	221.6	121.6
REV	100.0	10.0	15.8	158.0	58.0 
BGG	100.0	24.2	20.7	85.3	-14.7 
VMC	100.0	43.3	49.6	114.8	14.8 
VICR	100.0	8.2	16.2	197.4	97.4
PNK	100.0	8.7	15.0	171.8	71.8
BBOX	100.0	31.0	21.9	70.8	-29.2 
RENT	100.0	12.9	26.0	202.2	102.2
WBS	100.0	22.1	29.7	134.3	34.3
HAS	100.0	36.9	47.6	129.2	29.2 

Initial NNet Investment = \$1100.0

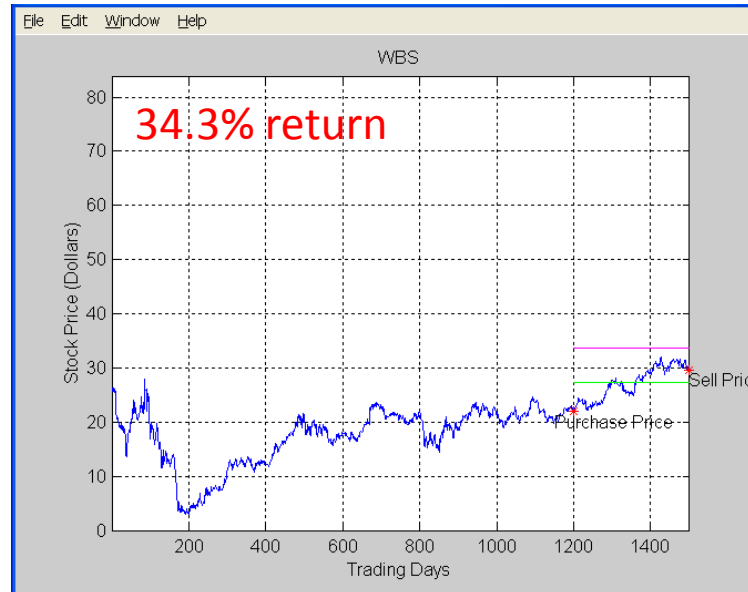
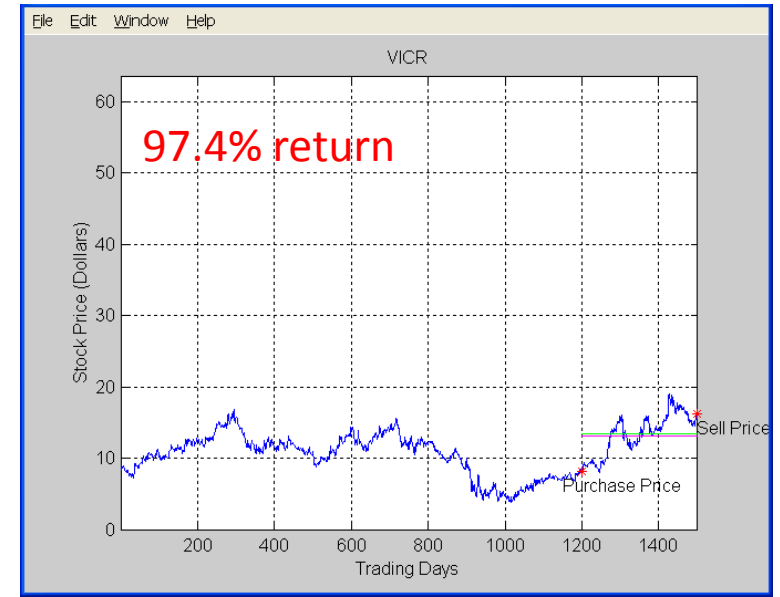
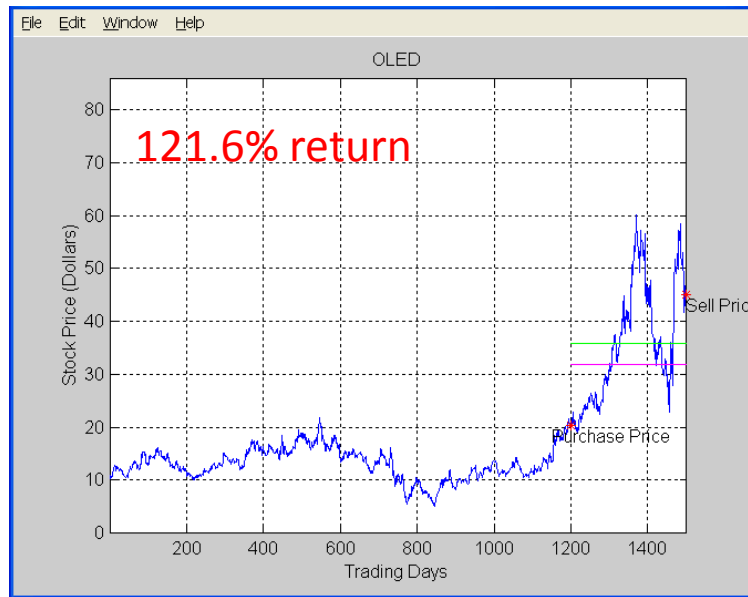
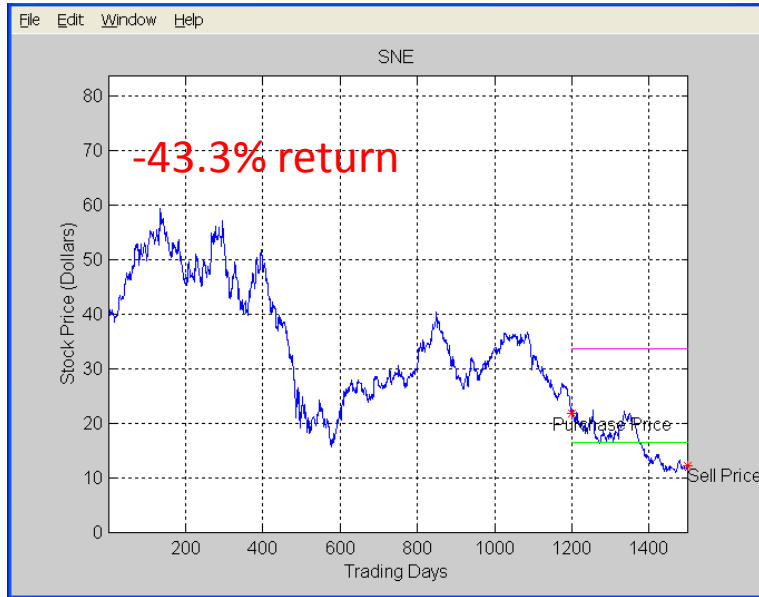
Final NNet Portfolio Value = \$1542.0

Total Return on NNet Investment = 40.2 percent



# Super Net #18 Performance

The following plots are of the four companies that were added to the mix for the 50% threshold level.





# Super Net #26 Performance

The performance of Super Net #26 (Set 3) is demonstrated on the following page for threshold levels 70%, 50%, and 30%. Note that the advantage of using the lower threshold levels is that an investor can maintain a larger diversified portfolio of stocks while still achieving superior ROIs.

On the next page, performance at the 70% threshold level is shown in the top left section. The performance at the 50% threshold level is shown in the middle. The performance at the 30% threshold level is shown in the lower right section.

A green bar represents a winning stock pick that was added to the portfolio as the threshold was dropped. A red bar represents a losing stock pick that was added to the portfolio. Note that “losing stock pick” refers to any stock that performs at the same level of the market (19.2% in this case) or below.

# Super Net #26 Performance

Neural Network Rule Set Threshold = 70.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
REV	100.0	10.0	15.8	158.0	58.0
RENT	100.0	12.9	26.0	202.2	102.2

The threshold is lowered to 50% and the Super Net picks 2 more companies – both are big winners

Initial NNet Investment = \$200.0

Final NNet Portfolio Value = \$360.2

Total Return on NNet Investment = 80.1 percent

Neural Network Rule Set Threshold = 50.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
REV	100.0	10.0	15.8	158.0	58.0
PNK	100.0	8.7	15.0	171.8	71.8
RENT	100.0	12.9	26.0	202.2	102.2
WBS	100.0	22.1	29.7	134.3	34.3

The threshold is lowered to 30% and the Super Net picks 5 more companies – three are big winners, one is a minor loser, and the other is a significant loser.

Initial NNet Investment = \$400.0

Final NNet Portfolio Value = \$666.3

Total Return on NNet Investment = 66.6 percent

Neural Network Rule Set Threshold = 30.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
SNE	100.0	21.8	12.4	56.7	-43.3
SCI	100.0	11.1	17.2	154.8	54.8
REV	100.0	10.0	15.8	158.0	58.0
VMC	100.0	43.3	49.6	114.8	14.8
VICR	100.0	8.2	16.2	197.4	97.4
PNK	100.0	8.7	15.0	171.8	71.8
RENT	100.0	12.9	26.0	202.2	102.2
WBS	100.0	22.1	29.7	134.3	34.3
HAS	100.0	36.9	47.6	129.2	29.2

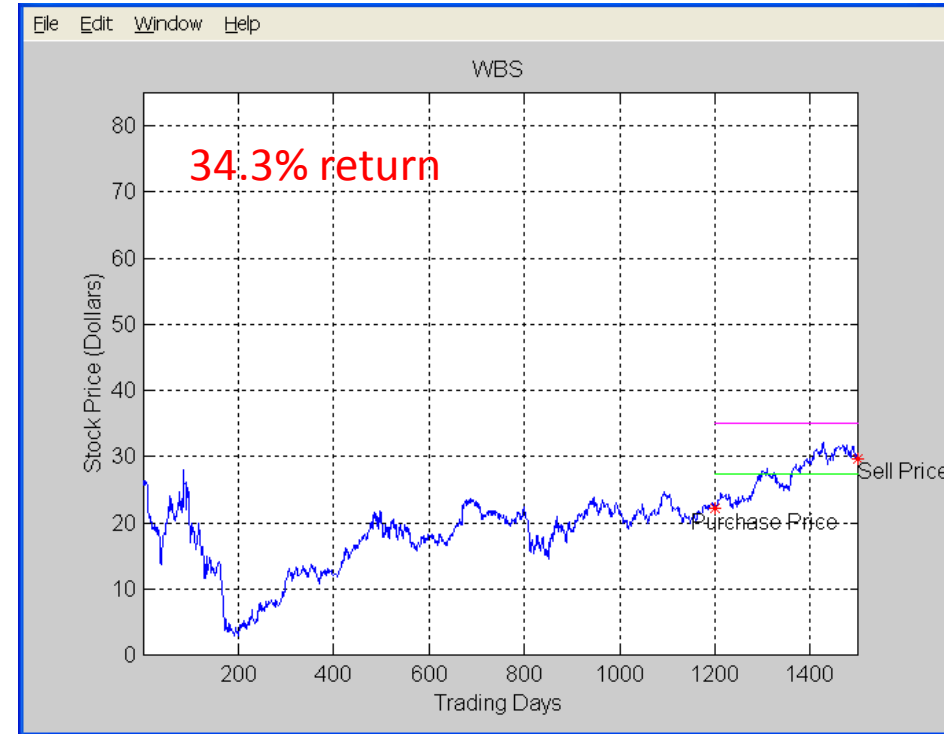
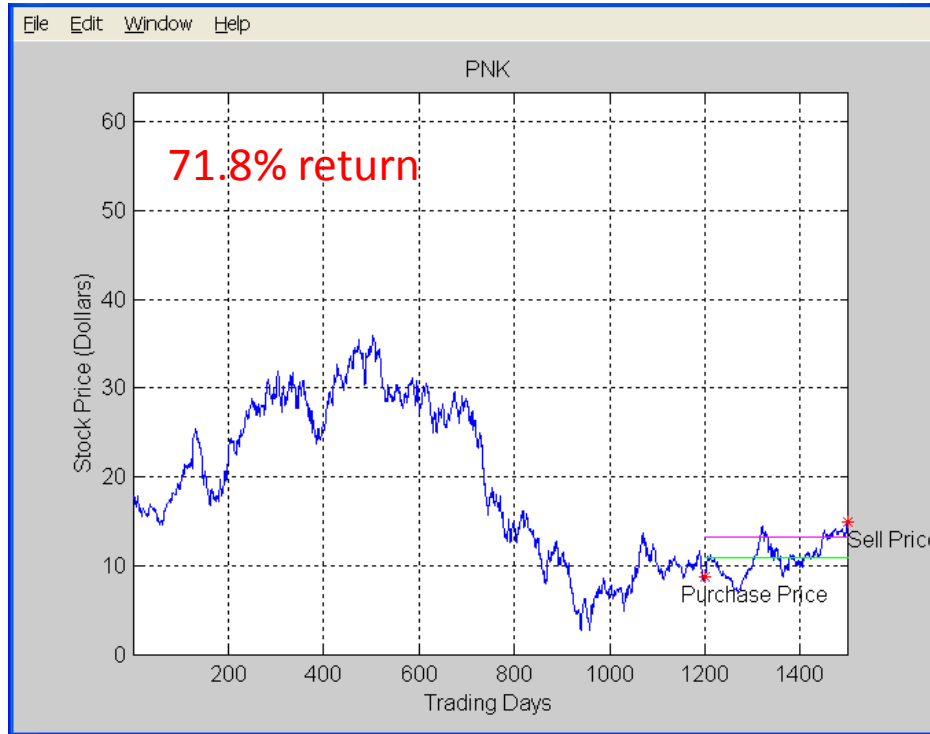
Initial NNet Investment = \$900.0

Final NNet Portfolio Value = \$1319.2

Total Return on NNet Investment = 46.6 percent

# Super Net #26 Performance

The following plots are of the two companies that were added to the mix for the 50% threshold level.





# Super Net #6 Performance

The performance of Super Net #6 (Set 4) is demonstrated on the following page for threshold levels 70%, 50%, and 30%. Note that the advantage of using the lower threshold levels is that an investor can maintain a larger diversified portfolio of stocks while still achieving superior ROIs.

On the next page, performance at the 70% threshold level is shown on the top left section. The performance at the 50% threshold level is shown in the middle. The performance at the 30% threshold level is shown on the lower right section.

A green bar represents a winning stock pick that was added to the portfolio as the threshold was dropped. A red bar represents a losing stock pick that was added to the portfolio. Note that “losing stock pick” refers to any stock that performs at the same level of the market (19.2% in this case) or below.

# Super Net #6 Performance

Neural Network Rule Set Threshold = 80.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
OLED	100.0	20.3	45.0	221.6	121.6

Initial NNet Investment = \$100.0

Final NNet Portfolio Value = \$221.6

Total Return on NNet Investment = 121.6 percent

The threshold is lowered to 50% and the Super Net picks 2 more companies – both are big winners.

The threshold is lowered to 30% and the Super Net picks 1 more companies – it is a minor winner.

Neural Network Rule Set Threshold = 50.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
OLED	100.0	20.3	45.0	221.6	121.6
REV	100.0	10.0	15.8	158.0	58.0
RENT	100.0	12.9	26.0	202.2	102.2

Initial NNet Investment = \$300.0

Final NNet Portfolio Value = \$581.8

Total Return on NNet Investment = 93.9 percent

Neural Network Rule Set Threshold = 30.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
OLED	100.0	20.3	45.0	221.6	121.6
REV	100.0	10.0	15.8	158.0	58.0
EQT	100.0	40.3	48.8	121.1	21.1
RENT	100.0	12.9	26.0	202.2	102.2

Initial NNet Investment = \$400.0

Final NNet Portfolio Value = \$702.9

Total Return on NNet Investment = 75.7 percent



# Super Net #6 Performance

The following plots are of the two companies that were added to the mix for the 50% threshold level.

