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## Neural Network Stock Price Prediction Algorithm Results

### Example Case #4

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# Table of Contents

Summary	Page 3
Example Case #4 Training Set	Page 5
Example Case #4 Forecast Set	Page 7
Market Performance Benchmark	Page 10
Performance Results – Super Nets	Page 13
Super Net #6 Performance	Page 17
Super Net #5 Performance	Page 21
Super Net #7 Performance	Page 25

# 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 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 test stocks over the investment period - in order for it to be considered “successful”.

Of a pool of 100 companies, 50 are used for training of the Neural Networks and the remaining 50 are used for forecast testing 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 a 24 year time span between 1991 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 24 year time span interval between 1991 and 2015.

When performing forecast testing, 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.

In this example case, the pool of companies from Example Case #3 were re-shuffled for training and forecast testing (page 9 illustrates how the companies were shuffled).

The high-achieving Neural Networks (called Super Nets) were able to achieve remarkable ROIs as shown on pages 14 through 25.

# Example Case #4 Training Set

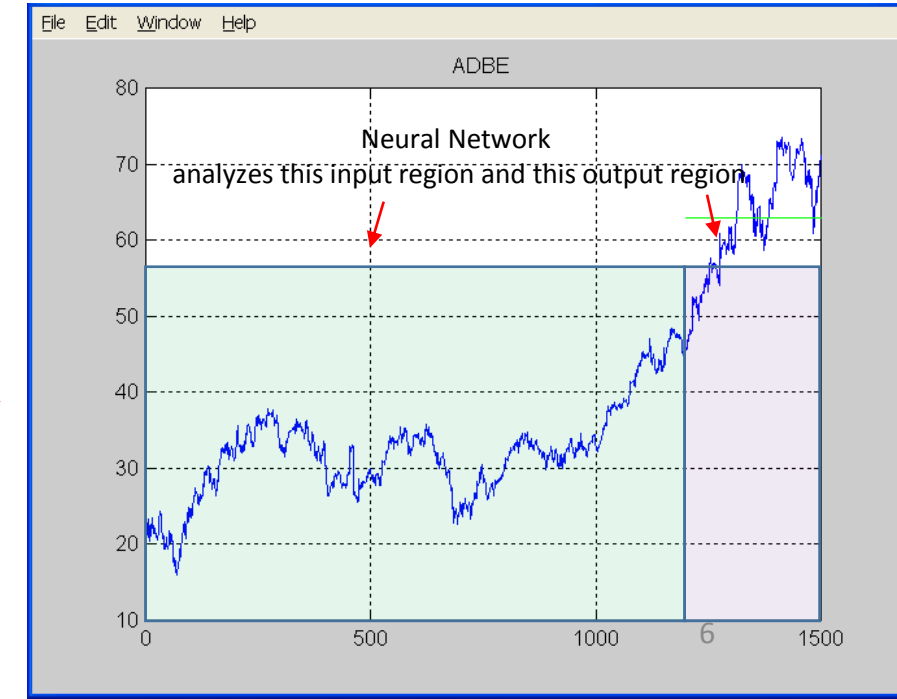
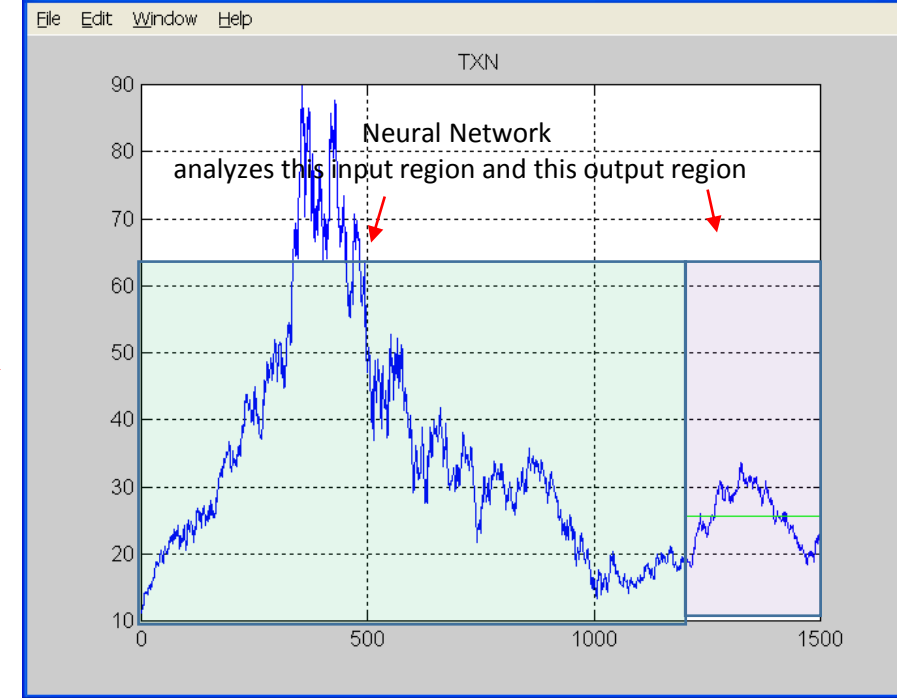
In this example case, a pool of 100 companies was used for training and forecast testing purposes. The criteria was that there had to be at least 24 years worth of available financial data. Capitalization and market sector were not considerations in the selection criteria – on the contrary, the selected companies covered a broad range of capitalizations and market sectors from the NYSE and NASDAQ exchanges.

The training and forecast test sets were generated from time windows of 1,500 days for which the start date was randomly selected by the software, inside a 24 year time interval – early 1991 to early 2015.

The following 50 companies were used for training,

BAX,	GSK,	BIG,	KR,	WWW,	HOG,	HMC,
ALTR,	HD,	CB,	SAN,	LRCX,	EFX,	PPL,
GE,	PCG,	COP,	ADM,	KO,	WMT,	ENB,
CMCSA,	PEP,	TXN,	BF-A,	ADBE,	ONB,	SYMC,
CPB,	BEN,	CGNX,	MLHR,	EMC,	NKE,	MSFT,
LLTC,	CSX,	ITW,	HAL,	DOW,	DE,	CRUS,
PG,	HPQ,	WY,	CELG,	ED,	JCI,	AVP,
GIS,						

Two examples of the training intervals are shown on the next page.



# Example Case #4 Forecast Test Set

The following 50 companies were used for forecast testing.

EA,	DIS,	JBHT,	EXC,	HRL,	JPM,	TSN,
GLW,	XOM,	AIRM,	IDTI,	F,	ETN,	ZION,
MCD,	ORCL,	BMJ,	NUE,	NSC,	CAJ,	PGR,
BCS,	JWN,	CTAS,	TROW,	VLO,	BCE,	ARG,
ATRO,	MMC,	HSY,	CAG,	CTL,	JKHY,	MENT,
HCP,	GT,	GGG,	ADSK,	CASY,	CLX,	KMB,
CAH,	PTC,	AET,	WDC,	ABT,	PFE,	BA,
SSL,						

# Data Set Shuffling

While the same data set of 100 companies that was used for Example Case #3 was used for this Example Case #4, the company data sets were shuffled such that some of the companies in the Example Case #3 training set now appeared in the Example Case #4 forecast test set, and some companies in the Example Case #3 forecast test set now appeared in the Example Case #4 training set.

More specific details can be seen on the next page.



# Data Set Shuffling

Note that about 44% of the **training companies** in Example Set #3 were used as **forecast test companies** in Example Set #4. The software generated the scrambling of companies for the new forecast test set.

## Example Set #3 Training Companies

BAX,	GSK,	BIG,	KR,	WWW,	HOG,	HMC,
ALTR,	HD,	CB,	SAN,	LRCX,	EFX,	PPL,
GE,	PCG,	COP,	ADM,	KO,	WMT,	ENB,
CMCSA,	PEP,	TXN,	BF-A,	ADBE,	ONB,	SYMC,
CPB,	BEN,	CGNX,	MLHR,	EMC,	NKE,	MSFT,
LLTC,	CSX,	ITW,	HAL,	DOW,	DE,	CRUS,
PG,	HPQ,	WY,	CELG,	ED,	JCI,	AVP,
GIS,						

## Example Set #4 Training Companies

ADSK,	ED,	JPM,	MLHR,	ABT,	DIS,	ORCL,
COP,	BMY,	BIG,	HCP,	ITW,	DE,	ONB,
CAJ,	AET,	TSN,	GE,	PPL,	WWW,	KMB,
EFX,	LLTC,	MCD,	BCS,	JCI,	CB,	BA,
HPQ,	SAN,	ALTR,	NSC,	ADM,	CTAS,	AIRM,
CAG,	BCE,	CELG,	JBHT,	CRUS,	GIS,	GLW,
CSX,	PCG,	GSK,	LRCX,	ADBE,	CGNX,	EMC,
CTL,						

## Example Set #3 Forecast Test Companies

EA,	DIS,	JBHT,	EXC,	HRL,	JPM,	TSN,
GLW,	XOM,	AIRM,	IDTI,	F,	ETN,	ZION,
MCD,	ORCL,	BMY,	NUE,	NSC,	CAJ,	PGR,
BCS,	JWN,	CTAS,	TROW,	VLO,	BCE,	ARG,
ATRO,	MMC,	HSY,	CAG,	CTL,	JKHY,	MENT,
HCP,	GT,	GGG,	ADSK,	CASY,	CLX,	KMB,
CAH,	PTC,	AET,	WDC,	ABT,	PFE,	BA,
SSL,						

## Example Set #4 Forecast Test Companies

MENT,	ZION,	TROW,	ARG,	BAX,	WDC,	HD,
HAL,	HRL,	PGR,	ETN,	NKE,	VLO,	XOM,
KO,	IDTI,	EA,	HOG,	CASY,	HSY,	SYMC,
F,	HMC,	ATRO,	NUE,	PG,	GGG,	MSFT,
TXN,	SSL,	EXC,	PEP,	ENB,	AVP,	GT,
CLX,	JKHY,	CAH,	CMCSA,	DOW,	PFE,	BF-A,
KR,	JWN,	WMT,	BEN,	WY,	MMC,	PTC,
CPB,						

28 of 50 carried over

22 of 50 carried over

22 of 50 carried over

28 of 50 carried over

# Market Performance Benchmark

Market investment in all of the test stock

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)	Portfolio Value (\$)
MENT	100.0	15.0	18.3	121.9	21.9	121.9
ZION	100.0	20.1	17.0	84.5	-15.5	206.4
TROW	100.0	32.5	46.1	142.2	42.2	348.6
ARG	100.0	6.2	5.6	90.8	-9.2	439.4
BAX	100.0	56.3	67.1	119.2	19.2	558.6
WDC	100.0	34.7	64.4	185.7	85.7	744.4
HD	100.0	36.5	50.3	137.8	37.8	882.2
HAL	100.0	14.4	11.9	82.9	-17.1	965.1
HRL	100.0	7.7	9.1	118.5	18.5	1083.6
PGR	100.0	12.3	8.3	67.4	-32.6	1151.1
ETN	100.0	22.9	16.5	72.1	-27.9	1223.1
NKE	100.0	32.1	19.5	60.7	-39.3	1283.8
VLO	100.0	9.1	17.2	189.8	89.8	1473.6
XOM	100.0	79.3	90.8	114.4	14.4	1588.0
KO	100.0	24.6	22.2	90.5	-9.5	1678.5
IDTI	100.0	7.7	5.2	67.7	-32.3	1746.2
EA	100.0	55.1	54.5	99.0	-1.0	1845.2
HOG	100.0	46.5	15.9	34.3	-65.7	1879.5
CASY	100.0	36.0	46.4	129.0	29.0	2008.5
HSY	100.0	69.3	97.6	140.8	40.8	2149.3
SYMC	100.0	16.5	15.2	92.1	-7.9	2241.5
F	100.0	5.5	11.3	204.2	104.2	2445.6
HMC	100.0	21.5	21.1	98.0	-2.0	2543.6
ATRO	100.0	16.1	18.2	113.3	13.3	2656.9
NUE	100.0	12.5	26.5	211.8	111.8	2868.7
PG	100.0	63.6	60.8	95.6	-4.4	2964.2
GGG	100.0	44.3	71.9	162.2	62.2	3126.4
MSFT	100.0	58.3	30.5	52.3	-47.7	3178.8
TXN	100.0	18.7	21.1	113.1	13.1	3291.9
SSL	100.0	35.2	40.7	115.6	15.6	3407.5
EXC	100.0	28.9	33.1	114.3	14.3	3521.8
PEP	100.0	69.2	50.6	73.0	-27.0	3594.9
ENB	100.0	26.5	36.8	138.7	38.7	3733.6
AVP	100.0	26.5	33.5	126.1	26.1	3859.7

The software “invests” (simulated, of course) an equal amount of money in each of the 50 forecast test 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 **12.0%** (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

GT	100.0	52.3	63.6	121.8	21.8	3981.5
CLX	100.0	52.7	55.0	104.3	4.3	4085.8
JKHY	100.0	5.8	7.6	131.7	31.7	4217.6
CAH	100.0	32.1	31.5	98.1	-1.9	4315.6
CMCSA	100.0	26.8	17.3	64.5	-35.5	4380.1
DOW	100.0	26.3	30.8	117.0	17.0	4497.1
PFE	100.0	27.1	23.0	84.7	-15.3	4581.8
BF-A	100.0	24.2	32.3	133.6	33.6	4715.4
KR	100.0	26.4	22.7	86.1	-13.9	4801.5
JWN	100.0	9.1	20.0	219.1	119.1	5020.7
WMT	100.0	59.1	52.5	89.0	-11.0	5109.6
BEN	100.0	13.7	11.9	87.0	-13.0	5196.6
WY	100.0	15.6	23.3	149.2	49.2	5345.7
MMC	100.0	25.0	27.1	108.5	8.5	5454.3
PTC	100.0	8.1	2.2	27.7	-72.3	5482.0
CPB	100.0	25.5	30.5	119.6	19.6	5601.6

Initial Market Investment = \$5000.0

Final Market Portfolio Value = \$5601.6

Total Return on Market Investment = 12.0 percent

# Performance Results

The total market average ROI for this group of forecast test stocks was 12.0%

Monte Carlo testing was performed by generating 100 Neural Networks (for each Monte Carlo test), each of which was trained on the 50 training stocks and then forecast-tested on all of the 50 forecast test stocks. Each Neural Network would output a predicted price point for each of the 50 forecast test 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 each of the 50 forecast test stocks) are shown below:

1. ?? % @ a threshold of 50%
2. ?? % @ a threshold of 50%
3. 18.2% @ a threshold of 50%
4. 18.5% @ a threshold of 50%
5. 19.4% @ a threshold of 50%

# Performance Results – Super Nets

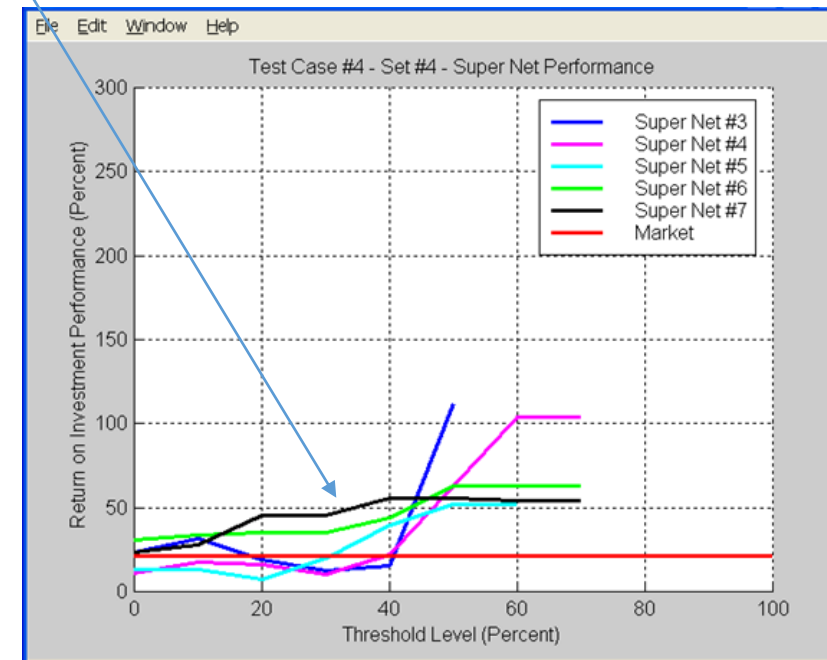
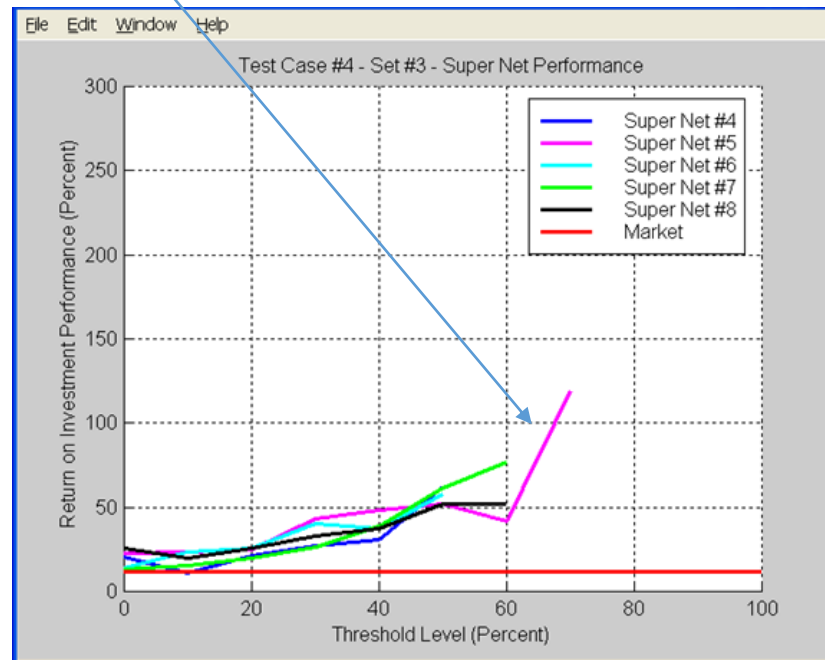
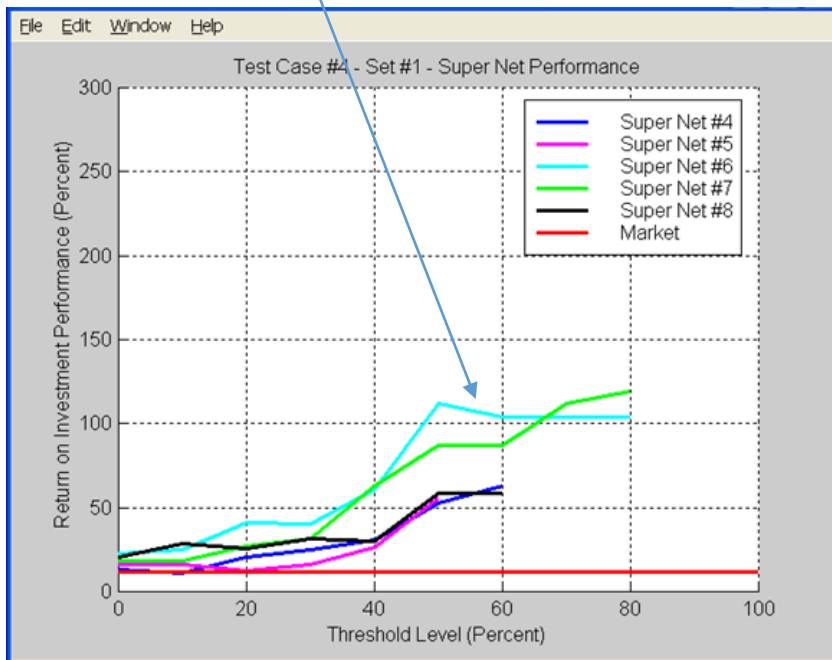
When performing forecast testing, a threshold can be set in the software such that only stocks, for which the Neural Network predicts a certain percentage ROI, will be purchased. For example, if the threshold is set at 50%, then only stocks for which the Neural Network predicts will have an ROI of 50%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

# Performance Results – Super Nets

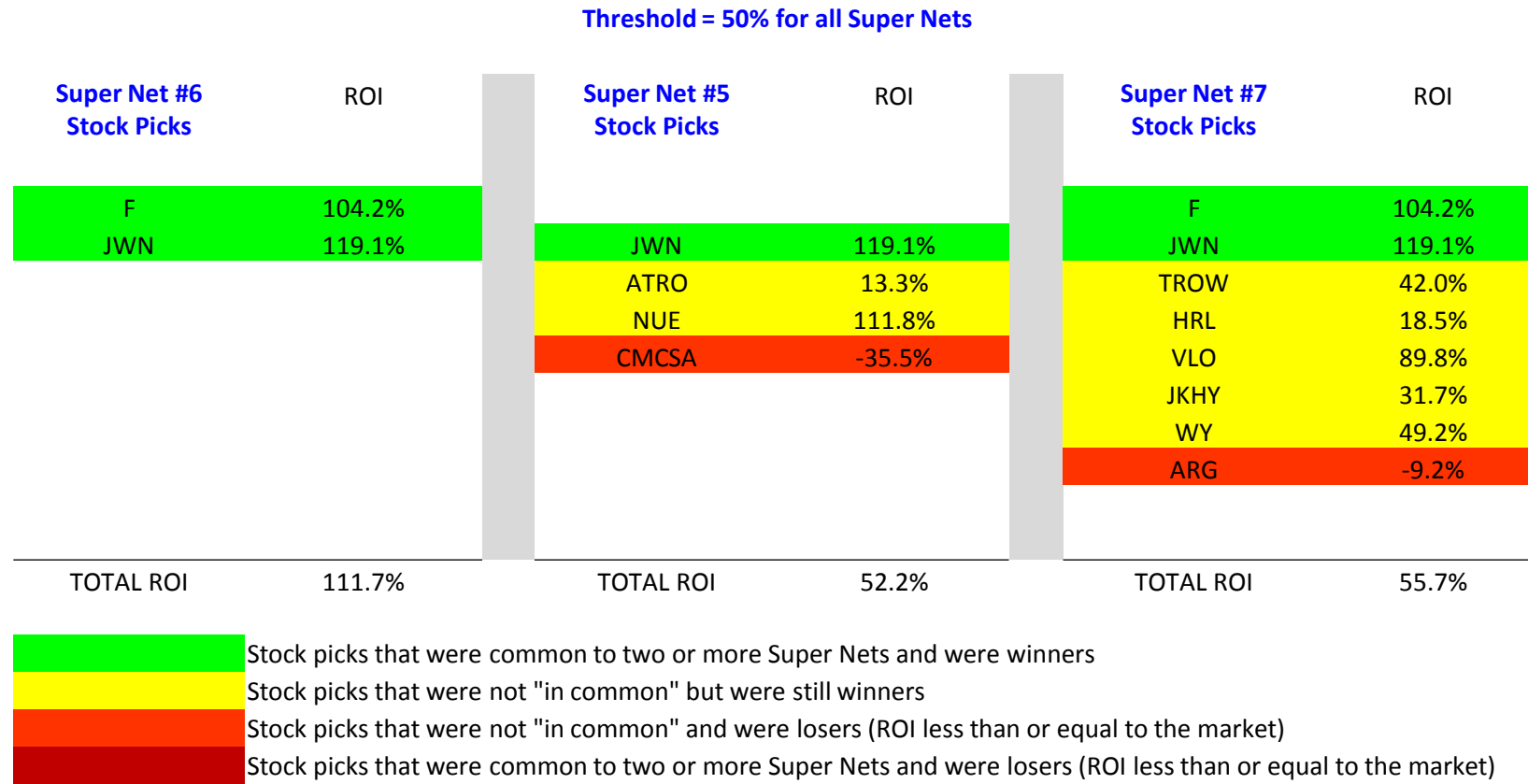
The plots on this page show Super Net ROI performance for threshold levels varying from 0% to 100%. The market ROI (aggregate return of all forecast test companies) of **12.0%** is shown in red for comparison purposes.

Super Net 6 (Set 1, below left), Super Net 5 (Set 3, below middle), and Super Net 7 (Set 4, below right) were selected to demonstrate performance on subsequent 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 two of the Super Nets also picked several more winners as well. 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 #6 Performance

The performance of Super Net #6 (Set 1) 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 ROI (12.0% in this case) or below.

# Super Net #6 Performance

Neural Network Rule Set Threshold = 70.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
F	100.0	5.5	11.3	204.2	104.2

The threshold is lowered to 50% and the Super Net picks 1 more company which is a big winner.

Initial NNet Investment = \$100.0

Final NNet Portfolio Value = \$204.2

Total Return on NNet Investment = 104.2 percent

50.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
F	100.0	5.5	11.3	204.2	104.2
JWN	100.0	9.1	20.0	219.1	119.1

The threshold is lowered to 30% and the Super Net picks 6 more companies – three are big winners, one is a minor winner, one is a significant loser and one is a minor loser.

Initial NNet Investment = \$200.0

Final NNet Portfolio Value = \$423.3

Total Return on NNet Investment = 111.7 percent

Neural Network Rule Set Threshold = 30.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
TROW	100.0	32.5	46.1	142.2	42.2
ETN	100.0	22.9	16.5	72.1	-27.9
HSY	100.0	69.3	97.6	140.8	40.8
F	100.0	5.5	11.3	204.2	104.2
ATRO	100.0	16.1	18.2	113.3	13.3
JKHY	100.0	5.8	7.6	131.7	31.7
CAH	100.0	32.1	31.5	98.1	-1.9
JWN	100.0	9.1	20.0	219.1	119.1

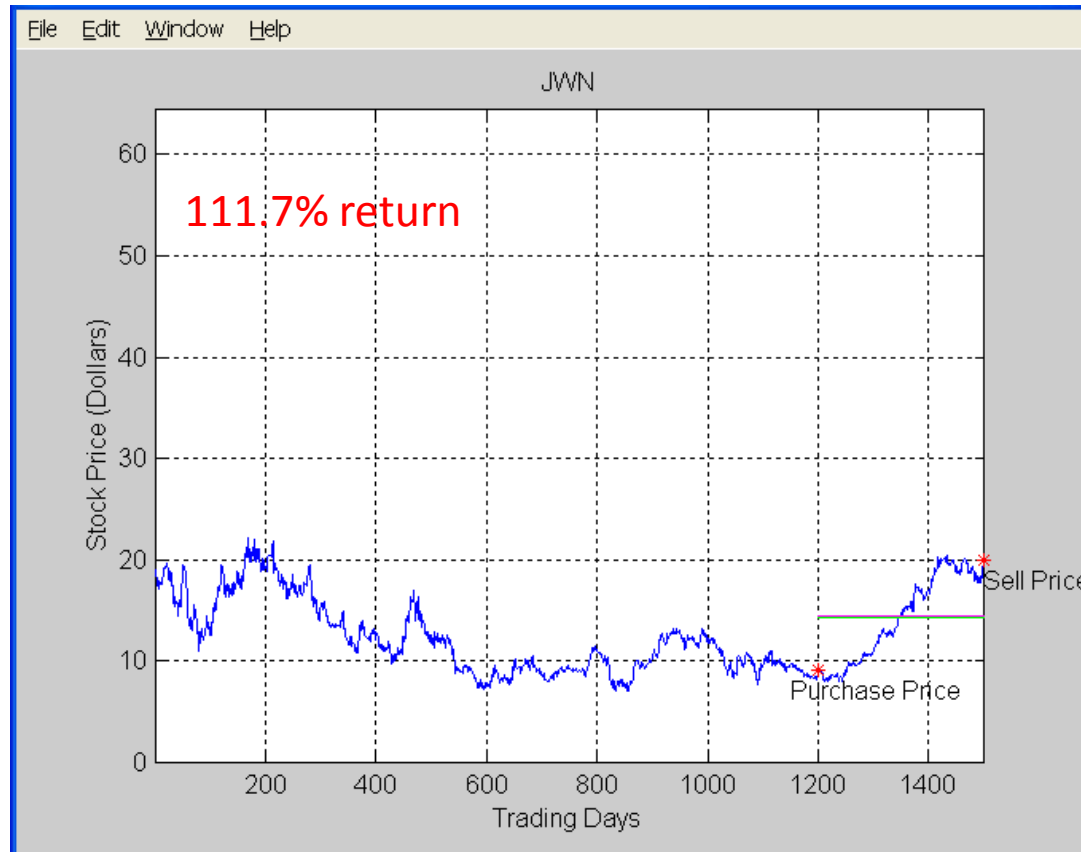
Initial NNet Investment = \$800.0

Final NNet Portfolio Value = \$1121.4

Total Return on NNet Investment = 40.2 percent

# Super Net #6 Performance

The following plot is of the one company that was added to the mix for the 50% threshold level.





# Super Net #5 Performance

The performance of Super Net #5 (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 (12.0% in this case) or below.

# Super Net #5 Performance

Neural Network Rule Set Threshold = 70.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
JWN	100.0	9.1	20.0	219.1	119.1

Initial NNet Investment = \$100.0

Final NNet Portfolio Value = \$219.1

Total Return on NNet Investment = 119.1 percent

The threshold is lowered to 50% and the Super Net picks 3 more companies – one is a big winner, one is a minor winner, and one is a significant loser.

Neural Network Rule Set Threshold = 50.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
ATRO	100.0	16.1	18.2	113.3	13.3 <span style="color: green;">■</span>
NUE	100.0	12.5	26.5	211.8	111.8 <span style="color: green;">■</span>
CMCSA	100.0	26.8	17.3	64.5	-35.5 <span style="color: red;">■</span>
JWN	100.0	9.1	20.0	219.1	119.1

Initial NNet Investment = \$400.0

Final NNet Portfolio Value = \$608.7

Total Return on NNet Investment = 52.2 percent

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

Threshold = 30.0 percent

		Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
ARG	100.0	6.2	5.6	90.8	-9.2 <span style="color: red;">■</span>
HD	100.0	36.5	50.3	137.8	37.8 <span style="color: green;">■</span>
HRL	100.0	7.7	9.1	118.5	18.5 <span style="color: green;">■</span>
F	100.0	5.5	11.3	204.2	104.2 <span style="color: green;">■</span>
ATRO	100.0	16.1	18.2	113.3	13.3
NUE	100.0	12.5	26.5	211.8	111.8
JKHY	100.0	5.8	7.6	131.7	31.7 <span style="color: green;">■</span>
CMCSA	100.0	26.8	17.3	64.5	-35.5
JWN	100.0	9.1	20.0	219.1	119.1

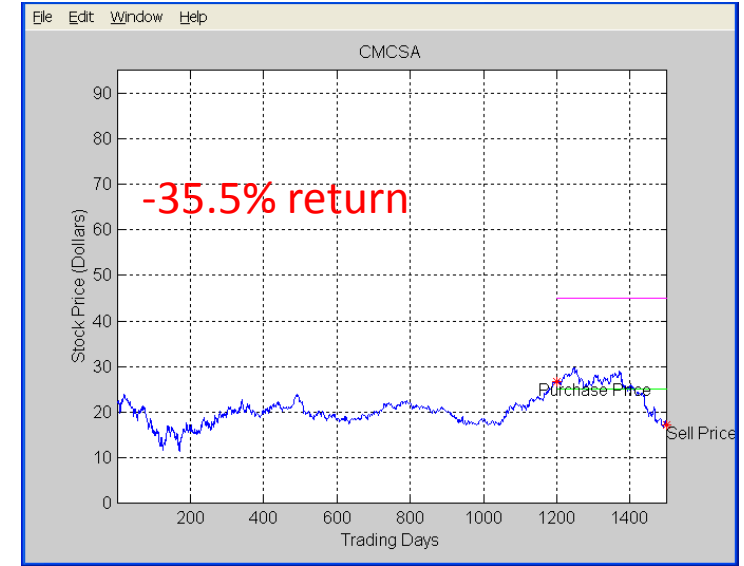
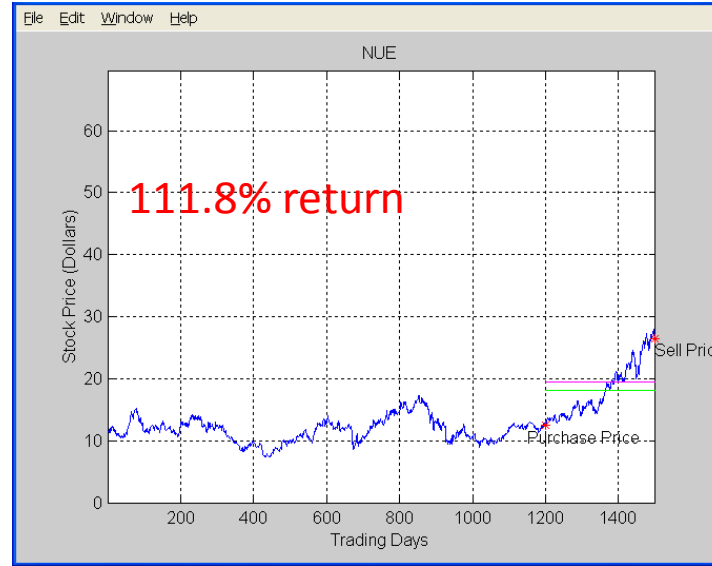
Initial NNet Investment = \$900.0

Final NNet Portfolio Value = \$1291.7

Total Return on NNet Investment = 43.5 percent

# Super Net #5 Performance

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







# Super Net #7 Performance

The performance of Super Net #7 (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 (12.0% in this case) or below.

# Super Net #7 Performance

Neural Network Rule Set Threshold = 70.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
TROW	100.0	32.5	46.1	142.2	42.2
ARG	100.0	6.2	5.6	90.8	-9.2
HRL	100.0	7.7	9.1	118.5	18.5
F	100.0	5.5	11.3	204.2	104.2
JWN	100.0	9.1	20.0	219.1	119.1
WY	100.0	15.6	23.3	149.2	49.2

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

Initial NNet Investment = \$600.0

Final NNet Portfolio Value = \$924.0

Total Return on NNet Investment = 54.0 percent

Neural Network Rule Set Threshold = 50.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
TROW	100.0	32.5	46.1	142.2	42.2
ARG	100.0	6.2	5.6	90.8	-9.2
HRL	100.0	7.7	9.1	118.5	18.5
VLO	100.0	9.1	17.2	189.8	89.8
F	100.0	5.5	11.3	204.2	104.2
JKHY	100.0	5.8	7.6	131.7	31.7
JWN	100.0	9.1	20.0	219.1	119.1
WY	100.0	15.6	23.3	149.2	49.2

Initial NNet Investment = \$800.0

Final NNet Portfolio Value = \$1245.5

Total Return on NNet Investment = 55.7 percent

The threshold is lowered to 30% and the Super Net picks 4 more companies – one is a major winner, one is a minor winner, one is a significant loser, and one is a minor loser.

Neural Network Rule Set Threshold = 30.0 percent

Company	Initial Investment (\$)	Purchase Price (\$)	Sell Price (\$)	Sell Value (\$)	ROI (percent)
TROW	100.0	32.5	46.1	142.2	42.2
ARG	100.0	6.2	5.6	90.8	-9.2
HRL	100.0	7.7	9.1	118.5	18.5
ETN	100.0	22.9	16.5	72.1	-27.9
VLO	100.0	9.1	17.2	189.8	89.8
F	100.0	5.5	11.3	204.2	104.2
ATRO	100.0	16.1	18.2	113.3	13.3
NUE	100.0	12.5	26.5	211.8	111.8
JKHY	100.0	5.8	7.6	131.7	31.7
CAH	100.0	32.1	31.5	98.1	-1.9
JWN	100.0	9.1	20.0	219.1	119.1
WY	100.0	15.6	23.3	149.2	49.2

Initial NNet Investment = \$1200.0

Final NNet Portfolio Value = \$1740.7

Total Return on NNet Investment = 45.1 percent

# Super Net #7 Performance

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

