Modeling First-day Returns of Initial Public Offerings with Neural Networks

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Outline

- Introduction
- Data Sets and Variable Generation
- Modeling the Initial Returns of IPOs
- Future Work

Introduction

- We construct three models for predicting IPO initial returns.

  One regression model

  OLS linear regression

  Two ANN models

  Brainmaker

  Maryland Network Code (MNC)

Introduction -- continued

- We compare the performance of the ANN models to the regression model.

- We hypothesize that the ANN models will produce lower MAE values than the regression model.

Data Sets and Variable Generation Overview

- We build models to predict the initial return for IPOs.
- Initial return is defined as percent change from final offer price to closing stock price at the end of first day of public trading.
- Database was compiled from the Global New Issues Database offered by Securities Data Company.

Data Sets and Variable Generation Overview -- continued

- Compiled data for 1,075 IPOs from January 1989 to December 1994.

- Based on Standard Industrial Classification (SIC) codes, each IPO was classified as a technology IPO or a non-technology IPO.

Dependent Variable

- The dependent variable (denoted RETURN) in each of our models is the initial return for each IPO.

- $RETURN = (P_C - P_F)/ P_F$

  $P_C =$ closing price of the stock on the first day of public trading

  $P_F =$ final offer price for IPO

Independent Variables

%CHGOFF	Percent change in final offer price
ABOVE	Equals 1 if the final offer price is greater than the highest price in the initial offer price range
BELOW	Equals 1 if the final offer price is less than the lowest price in the initial offer price range

Independent Variables -- continued

%CHGSHR	Percent change in final number of shares offered
INCREASE	Equals 1 if the final number of shares being offered is greater than the preliminary estimate of the number of shares to be offered
DECREASE	Equals 1 if the final number of shares being offered is less than the preliminary estimate of the number of shares to be offered

Independent Variables -- continued

ABV_INC	Equals ABOVE x INCREASE
BEL_DEC	Equals BELOW x DECREASE
AMT	Dollar size of offering
CHGMKT	Percent change in the stock market from file date to offer date
3MTHMKT	Percent change in the stock market for the three months prior to the offer date

Independent Variables -- continued

MKTSHR	Previous year's underwriting market share for book manager
QTY30	Number of offerings in the last 30 days
QTY90	Number of offerings in the last 90 days
RET30	Average IPO initial return in last 30 days
RET90	Average IPO initial return in last 90 days

Modeling the Initial Returns of IPOs

Data Sets

		Number of Offerings	
Data Set	Split	Technology	Non-technology
Training	4/9	196	282
Testing	2/9	98	141
Validating	3/9	147	211
Total	9/9	441	634

Regression Models

- Regression models built on the training set of IPO data.

  SPSS for Windows
  Stepwise algorithm

- Using estimated coefficients from the regression model built on the training set, we calculate the MAE of the model's predictions for the observations in the validating data set.

OLS Regression Model: Technology Offerings

R Square	0.295
Adjusted R Square	0.291
F statistic	81.535
Observations	196

	Coefficient	t statistic	p-value	VIF
Intercept	0.124	12.330	0.000	
% CHGOFF	0.506	9.030	0.000	1.000

RETURN = 0.124 + 0.506 %CHGOFF

Validating Data Set MAE = 0.0983

Neural Network Models

- Network training performed on training data set.
- Testing is performed on testing data set.
- A fractional factorial experiment is used to systematically find the best parameter settings.
  - Results of experiment used in OLS regression model to find parameters that have greatest impact on testing data set MAE.
  - Additional experimentation is performed with parameters found to be statistically significant.

Neural Network Models -- continued

- After the best parameter settings have been identified, the model's MAE is calculated using the validating data set.

Brainmaker Models

Initial parameter settings

Architecture	16 input nodes, 8 hidden nodes, 1 output node
Sigmoid slope	0.7 begin, 0.4 end
Learning rate	0.5 begin, 0.1 end
Momentum	0.5 begin, 0.1 end
Error threshold	0.125 begin, 0 end
Stopping criteria	1500 iterations
Procedure	Reduce the parameters incrementally in a stepwise fashion when either of the following criteria are met: 1) 200 additional iterations have elapsed or 2) MAE for the testing set is not improving.

Brainmaker Models -- continued

Parameter changes for fractional factorial experiment

Parameter	+	-
Number of hidden nodes	10	6
Sigmoid slope	0.9 begin, 0.6 end	0.5 begin, 0.2 end
Learning rate	0.7 begin, 0.3 end	0.3 begin, 0.1 end
Momentum	0.7 begin, 0.3 end	0.3 begin, 0.1 end
Error threshold	0.25 begin, 0 end	0.075 begin, 0 end

Brainmaker Models: Technology Offerings

Hidden nodes	Sigmoid slope	Learning rate	Momentum	Error threshold	MAE
-	-	-	-	+	0.1083
+	-	-	-	-	0.0961
-	+	-	-	-	0.1007
+	+	-	-	+	0.0974
-	-	+	-	-	0.0994
+	-	+	-	+	0.0977
-	+	+	-	+	0.1101
+	+	+	-	-	0.1019
-	-	-	+	-	0.0991
+	-	-	+	+	**0.0928**
-	+	-	+	+	0.0988
+	+	-	+	-	0.0954
-	-	+	+	+	0.0979
+	-	+	+	-	0.0954
-	+	+	+	-	0.1027
+	+	+	+	+	0.0969

Brainmaker Models: Technology Offerings

R^2	0.696		
Adjusted R^2	0.544		
Observations	16		
	Coefficient	t statistic	P-value
Intercept	0.099	128.562	0.000
Hidden nodes	-0.002	-3.508	0.005
Sigmoid slope	0.001	1.390	0.195
Learning rate	0.008	1.083	0.304
Momentum	0.001	1.445	0.183
Error threshold	0.000	0.744	0.474

Number of hidden nodes	MAE
10	0.0928
11	0.0924
12	0.0924

Brainmaker Models: Technology Offerings

- Number of hidden nodes found to be statistically significant in regression model.
- Increasing hidden nodes to 11 produces best testing set MAE value.

Architecture	16 input nodes
	11 hidden nodes
	1 output node
Sigmoid slope	0.5
Learning rate	0.3
Momentum	0.7
Error threshold	0.25

- Validating data set MAE = 0.0922

MNC Models

Initial parameter settings

Architecture	16 input nodes, 8 hidden nodes, 1 output node
Hidden layer	
Sigmoid slopes	0.15 node 1, 0.20 node 2, 0.25 node 3, 0.30 node 4, 0.35 node 5, 0.40 node 6, 0.45 node 7, 0.50 node 8 begin; Incremented by 0.2 after 100 iterations
Output node	
Sigmoid slope	0.5
Learning rate	0.2
Momentum	0.4
Error threshold	0
Stopping criteria	200 iterations
Procedure	Increase sigmoid slope after 100 iterations.

MNC Models -- continued

Parameter changes for fractional factorial experiment

Parameter	+	-
Number of hidden nodes	10	6
Output node sigmoid slope	0.6	0.4
Learning rate	0.3	0.1
Momentum	0.4	0.2
Pruning	On	Off

MNC Model: Technology Offerings

Hidden nodes	Sigmoid slope	Learning rate	Momentum	Pruning	MAE
-	-	-	-	+	0.0928
+	-	-	-	-	0.0921
-	+	-	-	-	0.0994
+	+	-	-	+	0.0910
-	-	+	-	-	0.1018
+	-	+	-	+	0.0927
-	+	+	-	+	0.0930
+	+	+	-	-	0.0910
-	-	-	+	-	0.0991
+	-	-	+	+	**0.0904**
-	+	-	+	+	0.0942
+	+	-	+	-	0.0944
-	-	+	+	+	0.0958
+	-	+	+	-	0.0912
-	+	+	+	-	0.0938
+	+	+	+	+	0.0907

MNC Models: Technology Offerings

R^2	0.677		
Adjusted R^2	0.516		
Observations	16		
	Coefficient	t statistic	p-value
Intercept	0.095	115.9111	0.000
Hidden nodes	-0.003	-3.810	0.034
Sigmoid slope	-0.001	-0.879	0.400
Learning rate	-0.000	-0.360	0.729
Momentum	-0.000	-0.439	0.670
Pruning	-0.003	-2.324	0.043

Number of hidden nodes	MAE
10	0.0904
11	0.0899
12	0.0898
13	0.0898

MNC Models:
Technology Offerings -- continued

- Number of hidden nodes and pruning found to be statistically significant in regression model.
- Increasing hidden nodes to 12 produces best testing set MAE value

Architecture	16 input nodes
	12 hidden nodes
	1 output node
Output node sigmoid slope	0.4
Learning rate	0.1
Momentum	0.4
Pruning	On

- Validating data set MAE = 0.0903

Summary of Results

Technology IPOs

Model	Validating Data Set MAE	Percent Improvement Over OLS Linear Regression MAE
OLS Regression	0.0983	0.00
Brainmaker	0.0922	6.21
MNC	0.0903	8.14

Summary of Results--continued

Non-technology IPOs

Model	Validating Data Set MAE	Percent Improvement Over OLS Linear Regression MAE
OLS Regression	0.0962	0.00
Brainmaker	0.0936	2.70
MNC	0.0907	5.72

- MNC neural network models perform the best with about 8% (6%) improvement over the results of the technology (non-technology) OLS regression model.

Future Work

- Classify rather than predict initial returns.
  - IPOs with negative initial returns
  - IPOs with average initial returns
  - IPOs with large positive initial returns

- Segment IPOs further
  - Health care
  - Biotechnology
  - Software makers

Future Work -- continued

- Design the ANN experiments to ensure a more comprehensive search is performed to find optimal or near-optimal parameter settings.