# Online-Appendix

„Predicting Stock Returns With Machine Learning: Global Versus Sector Models“

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# Appendix

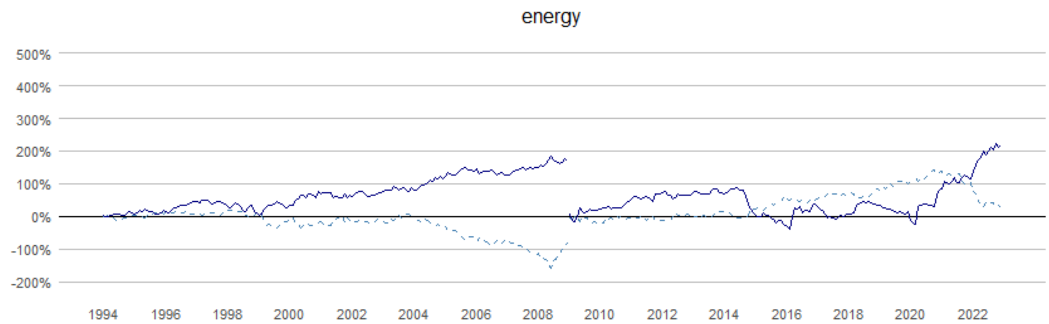
## A1 Performance of sector-specific neural network long-short portfolios

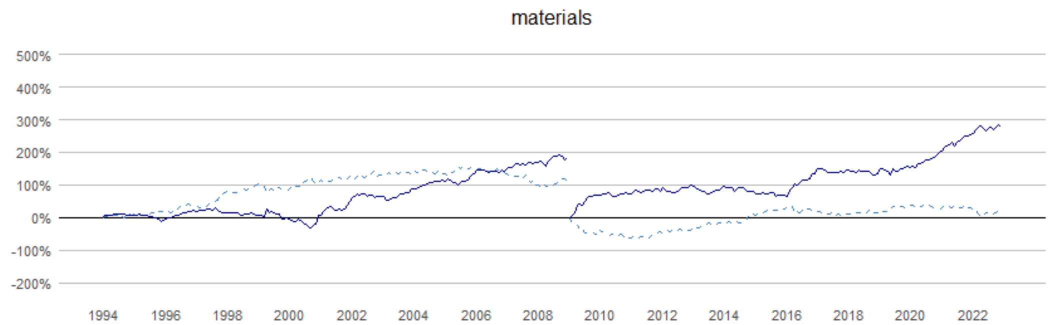
This table summarizes the out-of-sample statistics of the value-weighted long-short portfolios formed from different sector-specific neural network model return predictions. All stocks are sorted into decile portfolios based on their predicted returns for the next month. A long-short portfolio buys the highest expected return stocks (decile 10) and sells the lowest (decile 1). Results are reported for the 10 GICS sectors (excluding Real Estate, which is included in the sector Financials). The table presents the average value-weighted monthly full sample mean return (in %) and average monthly sub-sample mean returns (in %) with associated t-statistics (*t-stat*). The sample consists of US CRSP stocks, excluding microcap stocks with a market capitalization smaller than the 20th percentile of stocks listed on the NYSE. The sample runs from January 1994 to December 2022.

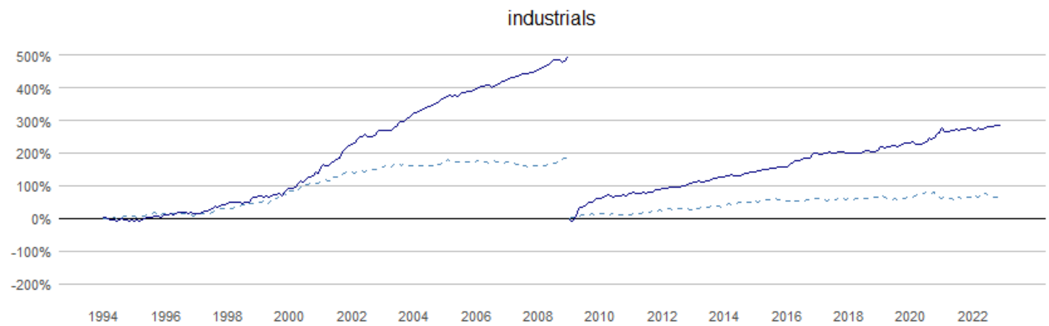
| **Sector** | Mean 1994-2022 | *t-stat* | Mean 1994-2008 | *t-stat* | Mean 2009-2022 | *t-stat* |
|---|---|---|---|---|---|---|
| Energy | 1.58 | *3.89* | 0.92 | *2.09* | 2.28 | *3.30* |
| Materials | 2.03 | *5.85* | 1.96 | *4.17* | 2.10 | *4.10* |
| Industrials | 3.10 | *11.49* | 3.94 | *9.63* | 2.19 | *6.59* |
| Consumer Discretionary | 3.69 | *9.93* | 3.79 | *8.51* | 3.58 | *5.91* |
| Consumer Staples | 0.97 | *2.98* | 0.35 | *0.85* | 1.64 | *3.22* |
| Health Care | 1.25 | *3.72* | 0.48 | *0.88* | 2.08 | *5.55* |
| Financials | 1.98 | *6.21* | 2.45 | *5.83* | 1.47 | *3.07* |
| Information Technology | 2.22 | *5.79* | 1.25 | *2.30* | 3.27 | *6.14* |
| Communication Services | -0.18 | *-0.43* | -0.60 | *-1.03* | 0.28 | *0.50* |
| Utilities | 0.32 | *1.21* | 0.32 | *0.76* | 0.32 | *1.02* |

## A2 Cumulative performance of top and bottom decile portfolios from sector-specific models

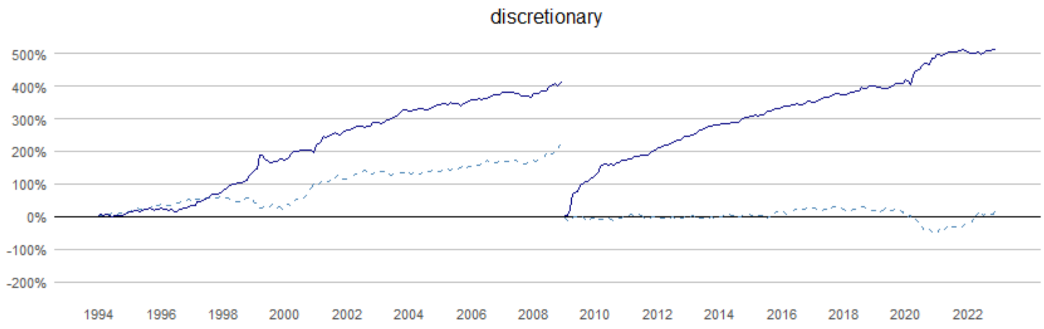
The figure plots the cumulative log returns of top and bottom decile portfolios. The portfolios are sorted on the out-of-sample return forecasts of individual sector-specific neural network models. Each month, stocks are sorted into value-weighted decile portfolios based on the predicted returns from the sector-specific machine learning strategies. The solid and dash lines represent long (top decile) and short (bottom decile) positions, respectively. The figure includes plots for the cumulative returns of the 10 GICS sectors: Energy (*energy*), Materials (*materials*), Industrials (*industrials*), Consumer Discretionary (*discretionary*), Consumer Staples (*staples*), Health Care (*health*), Financials (*financials*), Information Technology (*tech*), Communication Services (*comm*) and Utilities (*utilities*). The sample consists of US CRSP stocks, excluding microcap stocks with a market capitalization smaller than the 20th percentile of stocks listed on the NYSE. The sample runs from January 1994 to December 2022. The cumulative performance is cut off in December 2008 and restarted in January 2009 to present differences in cumulative returns between the two sub-samples.

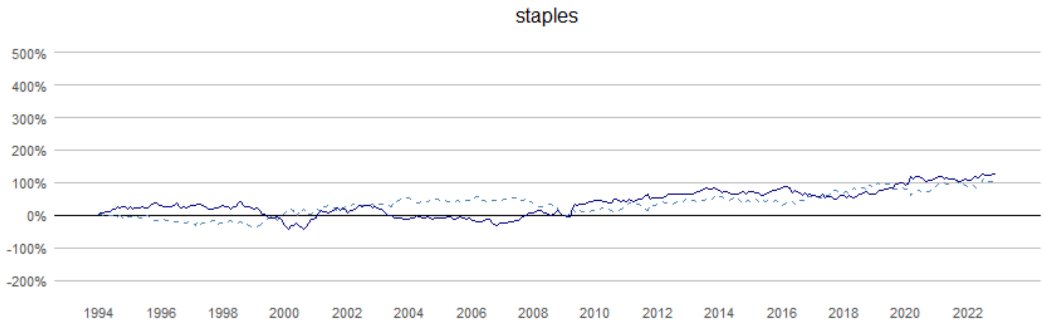


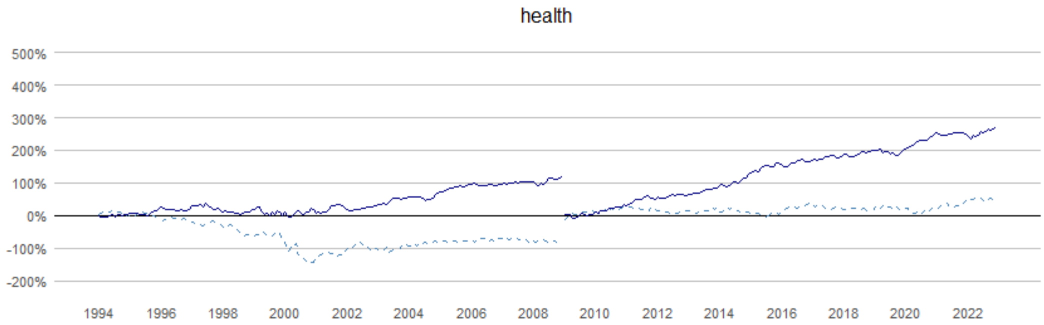



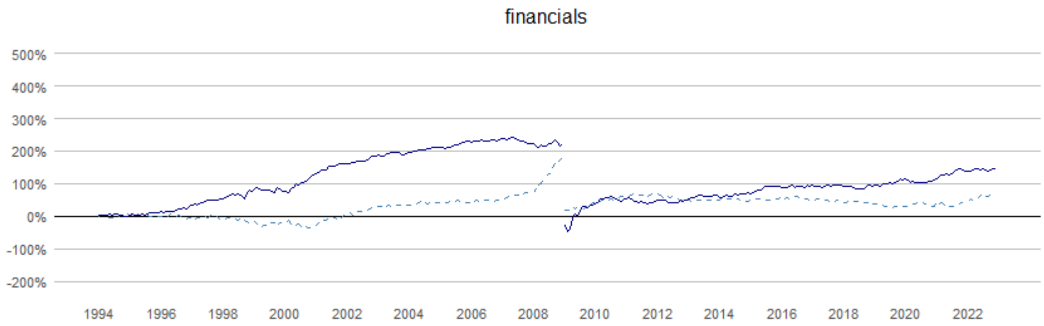



**A2** (continued)



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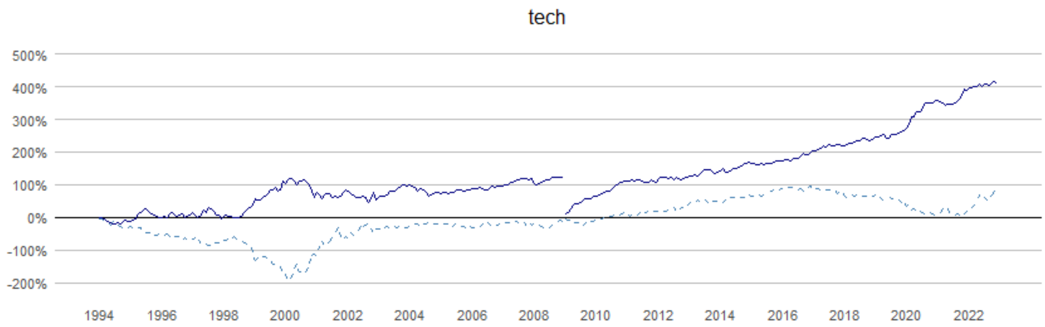


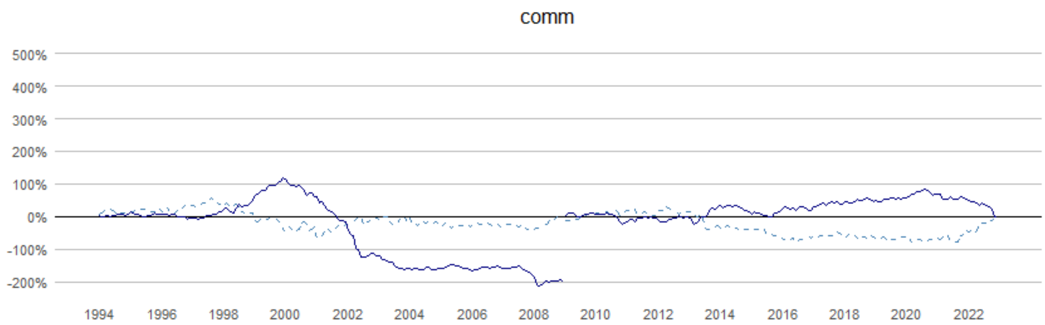


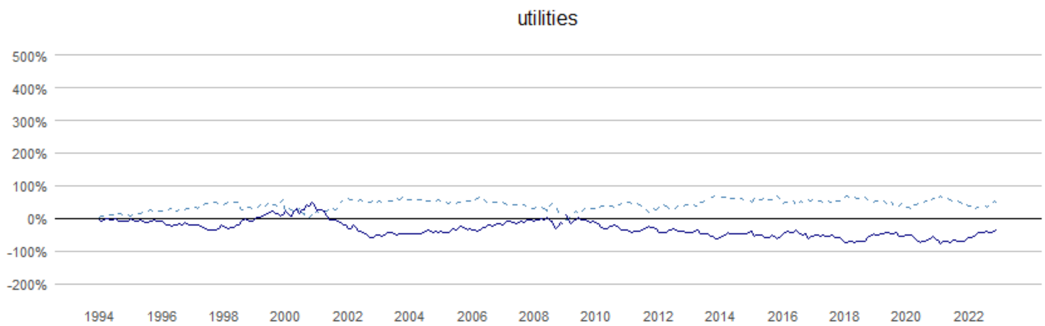

## A3 Performance of sector-specific OLS long-short portfolios

This table summarizes the out-of-sample statistics of the value-weighted long-short portfolios formed from different sector-specific OLS model return predictions. All stocks are sorted into decile portfolios based on their predicted returns for the next month. A long-short portfolio buys the highest expected return stocks (decile 10) and sells the lowest (decile 1). Results are reported for the 10 GICS sectors (excluding Real Estate, which is included in the sector Financials). The table presents the average value-weighted monthly full sample mean return (in %) and average monthly sub-sample mean returns (in %) with associated t-statistics (*t-stat*). The sample consists of US CRSP stocks, excluding microcap stocks with a market capitalization smaller than the 20th percentile of stocks listed on the NYSE. The sample runs from January 1994 to December 2022.

| **Sector** | Mean 1994-2022 | *t-stat* | Mean 1994-2008 | *t-stat* | Mean 2009-2022 | *t-stat* |
|---|---|---|---|---|---|---|
| Energy | 1.46 | *3.53* | 1.20 | *2.70* | 1.74 | *2.44* |
| Materials | 2.02 | *5.73* | 2.49 | *5.60* | 1.51 | *2.75* |
| Industrials | 2.55 | *9.92* | 3.11 | *9.14* | 1.95 | *5.08* |
| Consumer Discretionary | 2.62 | *8.89* | 3.13 | *8.10* | 2.08 | *4.65* |
| Consumer Staples | 1.28 | *4.19* | 1.66 | *4.20* | 0.88 | *1.87* |
| Health Care | 2.22 | *6.92* | 2.35 | *4.80* | 2.07 | *5.10* |
| Financials | 1.89 | *7.21* | 2.55 | *5.96* | 1.19 | *4.18* |
| Information Technology | 3.13 | *9.16* | 4.12 | *7.74* | 2.08 | *5.10* |
| Communication Services | 1.57 | *3.30* | 1.67 | *2.36* | 1.46 | *2.33* |
| Utilities | 0.09 | *0.29* | 0.09 | *0.19* | 0.09 | *0.23* |

## A4 Model architecture and hyperparameters for neural network models

This appendix summarizes the model architecture and hyperparameter values used to train the neural networks. All models have the same basic architecture with three hidden layers with 32, 16 and 8 neurons, respectively. All models use the rectified linear unit (ReLU) as the hidden layer activation functions and a linear activation function in the output layer. I use the Adam optimizer with default parameters and a mean squared error loss function. Batch normalization is used between each hidden layer and each layer uses an L1 penalty. I train the models with 100 epochs and early stopping with an early stopping patience of 5. The following table describes the remaining hyperparameter values and their potential ranges for hyperparameter tuning.

| Hyperparameter | Global model | Sector models |
|---|---|---|
| L1 penalty | $[10^{-5}, 10^{-4}]$ | $[10^{-5}, 10^{-4}]$ |
| Learning rate | [0.001,0.01] | [0.001,0.01] |
| Batch size | 10,000 | 5000 |