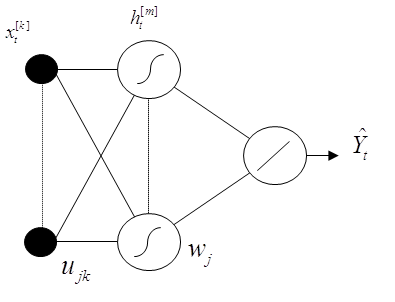
**Online Appendix**

**OA. Neural Networks and technical characteristics.**

In this section, short descriptions of the MLP, RNN and PSN are presented, along with their input selection and parametrization for each ETF return series under study. Firstly, the typical MLP model is shown in the following figure.

**Figure OA.1: A single output, fully connected MLP model**



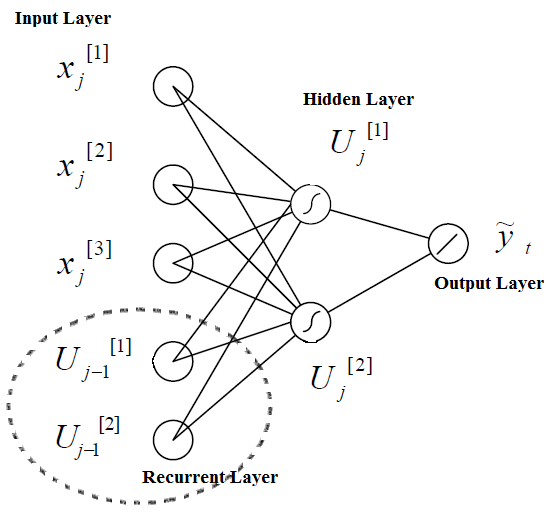
where:

*  are the inputs (including the input bias node) at time *t*
*  are the hidden nodes outputs (including the hidden bias node) at time *t*
*  is the MLP output
* *ujk*, *wj*  are the network weights
* is the transfer sigmoid function 
* is a linear function 

The Error Function to be minimized is, where  is the target value.

The second NN applied in this study is the RNN. A simple illustration its architecture is presented below.

**Figure OA.2: RNN with two nodes in the hidden layer**



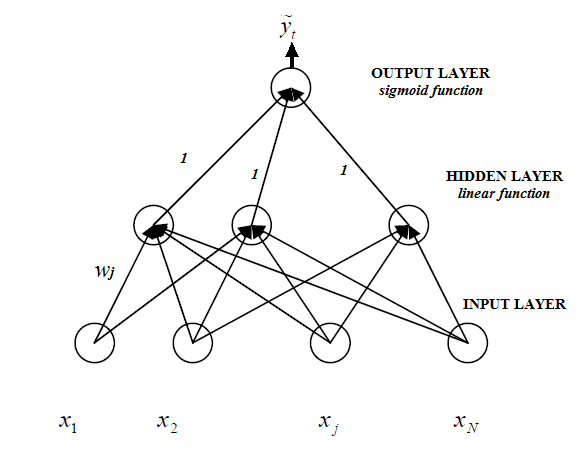
where:

*  are the RNN inputs at time *t* (including bias node)
* is the output of the RNN
* and are the weights of the network
* is the output of the hidden nodes at time *t*
* is the transfer sigmoid function : 
* is a linear function: 

The Error Function to be minimized is  , where  is the target value. In short, the RNN architecture can provide more accurate outputs because the inputs are (potentially) taken from all previous values (see  and ). For an exact specification of recurrent networks, see Elman (1990).

The third model is the PSN architecture, as shown in the figure below.

**Figure A.3: A PSN with one output layer**



where:

* *xt (n=1,2,…,k+1)* are the model inputs (including the input bias node)
*  are the PSN input and output respectively
* *wj* *(j=1,2..,k)* are the adjustable weights (*k* is the desired order of the network)
* The hidden layer activation function 
* The output sigmoid activation function (*c* the adjustable term): 

The Error Function minimized in this case, where  is the target value. More details on the PSN model are given by Ghosh and Shin (1991).

Regarding the selection of inputs, there is no formal theory behind the selection of the NN inputs and their characteristics, such as number of hidden neurons, learning rate, momentum and iterations. For that reason, we conduct NN experiments and a sensitivity analysis on a pool of autoregressive terms of the return series in the in-sample dataset. In terms of our iterations, our experimentation starts from 5.000 iterations and stops at the 100.000 iterations. In each experiment the number of iterations is increased by 5.000, following cornerstone studies on NN training such as Tenti (1996) and Zhang *et al.* (1998). Based on the above, we select the inputs that provide the higher trading performance for each network in the in-sample period. The final sets of inputs of the three NNs for the three forecasting exercises are presented in table OA.1 below:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SPY** | | | **DIA** | | | **QQQ** | | |
| **MLP** | **RNN** | **PSN** | **MLP** | **RNN** | **PSN** | **MLP** | **RNN** | **PSN** |
| SPY (1)\* | SPY (1) | SPY (1) | DIA (2) | DIA (1) | DIA (1) | QQQ (1) | QQQ (1) | QQQ (2) |
| SPY (3) | SPY (2) | SPY (4) | DIA (4) | DIA (3) | DIA (2) | QQQ (2) | QQQ (4) | QQQ (4) |
| SPY (5) | SPY (3) | SPY (5) | DIA (5) | DIA (4) | DIA (5) | QQQ (3) | QQQ (5) | QQQ (5) |
| SPY (7) | SPY (5) | SPY (6) | DIA (7) | DIA (6) | DIA (6) | QQQ (5) | QQQ (6) | QQQ (6) |
| SPY (8) | SPY (7) | SPY (7) | DIA (9) | DIA (7) | DIA (8) | QQQ (6) | QQQ (7) | QQQ (7) |
| SPY (9) | SPY (8) | SPY (9) | DIA (10) | DIA (8) | DIA (9) | QQQ (8) | QQQ (9) | QQQ (8) |
| SPY (12) | SPY (9) | SPY (10) | DIA (11) | DIA (9) | DIA (10) | QQQ (10) | QQQ (10) | QQQ (9) |
| - | SPY (10) | SPY (11) | - | DIA (10) | - | QQQ (11) | QQQ (12) | QQQ (10) |
| - | SPY (12) | SPY (12) | - | - | - | QQQ (12) | - | QQQ (11) |

**Table OA.1: Neural network inputs**

*Note: SPY(1) means that as input is used the SPY return series lagged by one day. Thus, today’s return is used to forecast the tomorrow’s one. The pool of potential inputs includes lags of daily returns running back to a month.*

Table OA.2 shows the training characteristics of all the above NN architectures for each forecasting exercise.

**Table OA.2: Neural network design and training characteristics**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Parameters** | **MLP** | **RNN** | **PSN** |
| **SPY** | Learning algorithm | Gradient descent | Gradient descent | Gradient descent |
| Learning rate | 0.003 | 0.003 | 0.4 |
| Momentum | 0.004 | 0.005 | 0.5 |
| Iteration steps | 30000 | 40000 | 40000 |
| Initialisation  of weights | N(0,1) | N(0,1) | N(0,1) |
| Input nodes | 7 | 9 | 7 |
| Hidden nodes | 6 | 6 | 5 |
| Output node | 1 | 1 | 1 |
| **DIA** | Learning algorithm | Gradient descent | Gradient descent | Gradient descent |
| Learning rate | 0.002 | 0.005 | 0.3 |
| Momentum | 0.005 | 0.006 | 0.5 |
| Iteration steps | 45000 | 35000 | 40000 |
| Initialisation  of weights | N(0,1) | N(0,1) | N(0,1) |
| Input nodes | 7 | 8 | 7 |
| Hidden nodes | 9 | 7 | 6 |
| Output node | 1 | 1 | 1 |
| **QQQ** | Learning algorithm | Gradient descent | Gradient descent | Gradient descent |
| Learning rate | 0.003 | 0.002 | 0.3 |
| Momentum | 0.005 | 0.005 | 0.4 |
| Iteration steps | 30000 | 35000 | 25000 |
| Initialisation  of weights | N(0,1) | N(0,1) | N(0,1) |
| Input nodes | 9 | 8 | 9 |
| Hidden nodes | 8 | 10 | 8 |
| Output node | 1 | 1 | 1 |

**OB. Two-asset portfolio optimization**

This section summarizes the equivalent results obtained for two-asset portfolios formed by the respective ETFs. Table OB.1 presents the performance of the three two-asset portfolios (equally weighted).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table OB.1: Equally weighted two-asset portfolios** | | | | |
|  | Realized return | Sharpe ratio | Sortino ratio | Max drawdown |
| SPY-DIA | 8.765% | 0.7602 | 1.0479 | 7.391% |
| SPY-QQQ | 13.565% | 1.0788 | 1.6217 | 8.281% |
| DIA-QQQ | 11.899% | 0.9733 | 1.4239 | 7.760% |

The following tables present the optimization results for these portfolios. The results follow the same trend as in the case of the 1/N portfolio presented in the main text.

**Table OB.2: Performances of different trading strategies (Traditional M-V, two asset portfolios)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Panel A: Mean-Variance optimization without short-selling** | | | | | |
|  |  | Realized return | Sharpe ratio | Sortino ratio | Max drawdown |
| **SPY-DIA** | ARMA-DCC | 9.94% | 0.8989 | 1.3181 | 7.04% |
| ARMA-ADCC | 10.11% | 0.9171 | 1.3391 | 7.04% |
| ARMA-GAS | 10.13% | 0.9183 | 1.3338 | 7.04% |
| RNN-DCC | 14.09% | 1.2222 | 1.8107 | 7.83% |
| RNN-ADCC | 14.11% | 1.2254 | 1.8241 | 7.83% |
| RNN-GAS | 14.22% | 1.2313 | 1.8274 | 7.83% |
| PSN-DCC | 14.24% | 1.2325 | 1.8419 | 7.81% |
| PSN-ADCC | 14.25% | 1.2338 | 1.8363 | 7.81% |
| PSN-GAS | 14.23% | 1.2356 | 1.8542 | 7.81% |
| **SPY-QQQ** | ARMA-DCC | 12.66% | 1.0403 | 1.6595 | 7.60% |
| ARMA-ADCC | 12.64% | 1.0406 | 1.6585 | 7.59% |
| ARMA-GAS | 12.82% | 1.0686 | 1.698 | 7.59% |
| RNN-DCC | 22.77% | 1.9217 | 3.0146 | 7.18% |
| RNN-ADCC | 22.79% | 1.9218 | 3.0148 | 7.18% |
| RNN-GAS | 23.36% | 1.959 | 3.0933 | 7.18% |
| PSN-DCC | 23.15% | 1.9554 | 3.1586 | 7.86% |
| PSN-ADCC | 24.60% | 2.0118 | 3.3553 | 7.74% |
| PSN-GAS | 24.75% | 2.0088 | 3.3764 | 7.81% |
| **DIA-QQQ** | ARMA-DCC | 12.33% | 1.0441 | 1.7549 | 6.65% |
| ARMA-ADCC | 12.35% | 1.0481 | 1.7215 | 6.65% |
| ARMA-GAS | 12.42% | 1.052 | 1.7699 | 6.65% |
| RNN-DCC | 26.50% | 2.1949 | 3.5555 | 6.75% |
| RNN-ADCC | 26.52% | 2.196 | 3.5578 | 6.75% |
| RNN-GAS | 28.29% | 2.3181 | 3.8093 | 6.75% |
| PSN-DCC | 28.30% | 2.2244 | 3.8734 | 8.82% |
| PSN-ADCC | 28.43% | 2.212 | 3.9033 | 8.82% |
| PSN-GAS | 28.48% | 2.2145 | 3.9106 | 8.82% |
| **Panel B: Mean-Variance optimization with short-selling** | | | | | |
|  |  | Realized return | Sharpe ratio | Sortino ratio | Max drawdown |
| **SPY-DIA** | ARMA-DCC | 11.46% | 1.0218 | 1.5845 | 7.52% |
| ARMA-ADCC | 11.63% | 1.0373 | 1.5939 | 7.52% |
| ARMA-GAS | 11.64% | 1.0387 | 1.5955 | 7.52% |
| RNN-DCC | 19.42% | 1.6116 | 2.5722 | 8.72% |
| RNN-ADCC | 19.83% | 1.6436 | 2.6235 | 8.72% |
| RNN-GAS | 19.97% | 1.6541 | 2.6414 | 8.72% |
| PSN-DCC | 19.68% | 1.624 | 2.6008 | 8.70% |
| PSN-ADCC | 20.05% | 1.6501 | 2.6499 | 8.70% |
| PSN-GAS | 20.08% | 1.652 | 2.6535 | 8.70% |
|  | ARMA-DCC | 13.51% | 1.0436 | 1.6472 | 9.77% |
|  | ARMA-ADCC | 13.53% | 1.0358 | 1.5882 | 9.83% |
|  | ARMA-GAS | 14.31% | 1.0896 | 1.744 | 9.71% |
| **SPY-QQQ** | RNN-DCC | 32.38% | 2.6126 | 4.0333 | 7.41% |
|  | RNN-ADCC | 32.82% | 2.6422 | 4.0887 | 7.41% |
|  | RNN-GAS | 33.25% | 2.6648 | 4.1425 | 7.41% |
|  | PSN-DCC | 32.93% | 2.6713 | 4.3888 | 7.40% |
|  | PSN-ADCC | 34.95% | 2.7242 | 4.6567 | 7.48% |
|  | PSN-GAS | 35.05% | 2.7119 | 4.6709 | 7.45% |
| **DIA-QQQ** | ARMA-DCC | 12.82% | 1.0803 | 1.8199 | 7.93% |
| ARMA-ADCC | 12.93% | 1.1357 | 1.8279 | 7.93% |
| ARMA-GAS | 12.92% | 1.1432 | 1.8456 | 7.93% |
| RNN-DCC | 41.76% | 3.0091 | 5.505 | 8.30% |
| RNN-ADCC | 42.35% | 2.9617 | 5.6068 | 8.52% |
| RNN-GAS | 42.37% | 2.9627 | 5.6095 | 8.52% |
| PSN-DCC | 41.34% | 3.069 | 5.6375 | 7.78% |
| PSN-ADCC | 42.36% | 3.0892 | 5.6402 | 7.78% |
| PSN-GAS | 42.85% | 3.1891 | 5.6378 | 7.78% |

*Note: The table presents the out-of-sample performances over the period January 2014 to March 2015 (68 weekly observations). Panel A reports performances of different M-V portfolios without short-selling. All the portfolios are weekly rebalanced tangency portfolios obtained by the M-V optimization based on various model combinations. For example, ARMA-DCC refers to the performance of the tangency portfolio of the efficient frontier of the three ETF assets, where the expected returns are obtained through ARMA forecasts, while the variance-covariance matrix is predicted by DCC. Panel B reports performances of different M-V portfolios with short-selling. ‘-S’ denotes optimizations allowing short-selling.*

**Table OB.3: Performances of different trading strategies (Mean-95% CVaR, two asset portfolios)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Panel A: Mean-CVaR optimization without short-selling** | | | | | |
|  |  | Realized return | Return/CVaR | Sortino ratio | Max drawdown |
| **SPY-DIA** | ARMA-DCC | 11.43% | 3.7593 | 1.5361 | 7.04% |
| ARMA-ADCC | 10.95% | 3.6442 | 1.4451 | 7.04% |
| ARMA-GAS | 12.07% | 3.8522 | 1.5516 | 7.04% |
| RNN-DCC | 15.52% | 5.2265 | 1.936 | 7.59% |
| RNN-ADCC | 15.61% | 5.2449 | 2.1182 | 7.59% |
| RNN-GAS | 15.93% | 5.4406 | 2.0632 | 7.59% |
| PSN-DCC | 16.19% | 5.4931 | 2.1039 | 7.74% |
| PSN-ADCC | 16.25% | 5.4176 | 2.1042 | 7.74% |
| PSN-GAS | 16.78% | 5.6334 | 2.1945 | 7.79% |
| **SPY-QQQ** | ARMA-DCC | 14.56% | 4.3505 | 1.9341 | 7.60% |
| ARMA-ADCC | 14.53% | 4.3512 | 1.8877 | 7.60% |
| ARMA-GAS | 14.56% | 4.4526 | 1.9316 | 7.67% |
| RNN-DCC | 25.58% | 8.3827 | 3.2877 | 7.10% |
| RNN-ADCC | 25.61% | 8.4723 | 3.6059 | 7.11% |
| RNN-GAS | 25.68% | 8.4913 | 3.4259 | 7.09% |
| PSN-DCC | 26.31% | 8.5562 | 3.6079 | 8.09% |
| PSN-ADCC | 28.04% | 8.8336 | 3.8447 | 8.06% |
| PSN-GAS | 28.35% | 8.8972 | 3.8817 | 8.32% |
| **DIA-QQQ** | ARMA-DCC | 13.51% | 4.1587 | 1.8478 | 6.63% |
| ARMA-ADCC | 13.51% | 4.1736 | 1.8661 | 6.65% |
| ARMA-GAS | 13.53% | 4.1749 | 1.9175 | 6.65% |
| RNN-DCC | 29.19% | 9.3864 | 3.8015 | 6.54% |
| RNN-ADCC | 29.16% | 9.587 | 3.9141 | 6.54% |
| RNN-GAS | 30.19% | 9.7552 | 4.096 | 6.44% |
| PSN-DCC | 32.16% | 9.7333 | 4.4244 | 7.21% |
| PSN-ADCC | 32.41% | 9.7125 | 4.4726 | 7.21% |
| PSN-GAS | 32.57% | 9.7971 | 4.4875 | 7.23% |
| **Panel B: Mean-CVaR optimization with short-selling** | | | | | |
|  |  | Realized return | Return/CVaR | Sortino ratio | Max drawdown |
| **SPY-DIA** | ARMA-DCC | 13.64% | 4.4741 | 1.8801 | 7.67% |
| ARMA-ADCC | 13.94% | 4.5896 | 1.8746 | 7.67% |
| ARMA-GAS | 14.41% | 4.7466 | 1.9429 | 7.67% |
| RNN-DCC | 20.93% | 7.2314 | 2.738 | 8.30% |
| RNN-ADCC | 21.33% | 7.446 | 2.6547 | 8.30% |
| RNN-GAS | 21.27% | 7.3368 | 2.8372 | 8.30% |
| PSN-DCC | 21.52% | 7.2268 | 2.8935 | 8.14% |
| PSN-ADCC | 21.93% | 7.4467 | 2.9224 | 8.16% |
| PSN-GAS | 22.37% | 7.4565 | 3.045 | 8.16% |
| **SPY-QQQ** | ARMA-DCC | 15.77% | 4.4802 | 1.9161 | 9.77% |
| ARMA-ADCC | 16.22% | 4.583 | 1.8679 | 9.83% |
| ARMA-GAS | 17.72% | 4.9791 | 2.1237 | 9.92% |
| RNN-DCC | 34.89% | 11.7233 | 4.2933 | 7.05% |
| RNN-ADCC | 35.31% | 11.9701 | 4.1373 | 7.05% |
| RNN-GAS | 35.42% | 11.82 | 4.4496 | 7.05% |
| PSN-DCC | 35.29% | 11.6545 | 4.787 | 7.46% |
| PSN-ADCC | 37.47% | 12.0527 | 5.0349 | 7.47% |
| PSN-GAS | 38.28% | 12.1199 | 5.2549 | 7.44% |
| **DIA-QQQ** | ARMA-DCC | 14.96% | 4.6376 | 2.117 | 7.93% |
| ARMA-ADCC | 15.51% | 4.8249 | 2.1498 | 7.93% |
| ARMA-GAS | 15.69% | 4.924 | 2.2474 | 7.93% |
| RNN-DCC | 45.00% | 13.5023 | 5.8598 | 7.90% |
| RNN-ADCC | 45.56% | 13.418 | 5.6734 | 7.20% |
| RNN-GAS | 45.13% | 13.1415 | 6.0254 | 7.52% |
| PSN-DCC | 45.19% | 13.6571 | 6.2721 | 7.97% |
| PSN-ADCC | 46.33% | 13.941 | 6.2202 | 7.94% |
| PSN-GAS | 47.74% | 13.9975 | 6.4695 | 7.91% |

*Note: The table presents the out-of-sample performances over the period January 2014 to March 2015 (68 weekly observations). Panel A reports performances of different mean-CVaR portfolios without short-selling. All the portfolios are weekly rebalanced tangency portfolios obtained by the different mean-CVaR optimization based on various model combinations. For example, ARMA-DCC refers to the performance of the tangency portfolio of the efficient frontier of the two ETF assets, where the expected returns are obtained through ARMA forecasts, while the variance-covariance matrix is predicted by DCC. Panel B reports performances of different mean-CVaR portfolios with short-selling.* *‘SKT’ represents that the 95% CVaR is predicted using a Monte-Carlo simulation with the skewed t copulas to allow for asymmetric tail dependence ‘-S’ denotes optimizations allowing short-selling.*

**Table OB.4: Performances of different trading strategies (Mean-99% CVaR, two asset portfolios)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Panel A: Mean-CVaR optimization without short-selling** | | | | | |
|  |  | Realized return | Return/CVaR | Sortino ratio | Max drawdown |
| **SPY-DIA** | ARMA-DCC | 11.78% | 3.4047 | 1.5734 | 7.04% |
| ARMA-ADCC | 11.70% | 3.4157 | 1.5434 | 7.04% |
| ARMA-GAS | 12.45% | 3.4658 | 1.5837 | 7.04% |
| RNN-DCC | 15.29% | 4.0588 | 1.9069 | 7.46% |
| RNN-ADCC | 15.93% | 4.2188 | 2.1139 | 7.60% |
| RNN-GAS | 16.24% | 4.3146 | 2.057 | 7.54% |
| PSN-DCC | 16.14% | 4.3732 | 2.0984 | 6.75% |
| PSN-ADCC | 16.16% | 4.2995 | 2.0921 | 6.70% |
| PSN-GAS | 16.65% | 4.4627 | 2.1779 | 6.66% |
| **SPY-QQQ** | ARMA-DCC | 15.01% | 3.9402 | 1.9809 | 7.60% |
| ARMA-ADCC | 15.52% | 4.0784 | 2.0161 | 7.60% |
| ARMA-GAS | 15.02% | 4.006 | 1.9716 | 7.67% |
| RNN-DCC | 25.20% | 6.5098 | 3.2382 | 6.98% |
| RNN-ADCC | 26.13% | 6.8149 | 3.5987 | 7.12% |
| RNN-GAS | 26.17% | 6.734 | 3.4156 | 7.04% |
| PSN-DCC | 26.48% | 6.6134 | 3.4937 | 6.85% |
| PSN-ADCC | 27.07% | 6.8062 | 3.7114 | 6.77% |
| PSN-GAS | 27.32% | 6.843 | 3.7402 | 6.90% |
| **DIA-QQQ** | ARMA-DCC | 13.92% | 3.7665 | 1.8926 | 6.63% |
| ARMA-ADCC | 14.44% | 3.9119 | 1.993 | 6.65% |
| ARMA-GAS | 13.96% | 3.7561 | 1.9572 | 6.65% |
| RNN-DCC | 28.76% | 7.2893 | 3.7443 | 6.43% |
| RNN-ADCC | 29.75% | 7.7115 | 3.9063 | 6.55% |
| RNN-GAS | 30.77% | 7.7363 | 4.0838 | 6.40% |
| PSN-DCC | 31.15% | 7.5232 | 4.2842 | 6.10% |
| PSN-ADCC | 31.29% | 7.4834 | 4.3175 | 6.06% |
| PSN-GAS | 31.38% | 7.5351 | 4.3238 | 6.09% |
| **Panel B: Mean-CVaR optimization with short-selling** | | | | | |
|  |  | Realized return | Return/CVaR | Sortino ratio | Max drawdown |
| **SPY-DIA** | ARMA-DCC | 13.76% | 3.7428 | 1.8935 | 7.67% |
| ARMA-ADCC | 14.08% | 3.8401 | 1.8995 | 7.67% |
| ARMA-GAS | 14.27% | 3.9107 | 1.9195 | 7.67% |
| RNN-DCC | 20.67% | 4.9938 | 2.6985 | 8.15% |
| RNN-ADCC | 20.62% | 5.0647 | 2.564 | 8.16% |
| RNN-GAS | 20.83% | 4.9179 | 2.7181 | 8.14% |
| PSN-DCC | 21.03% | 4.9702 | 2.8289 | 7.05% |
| PSN-ADCC | 21.55% | 5.1152 | 2.8587 | 7.11% |
| PSN-GAS | 21.58% | 5.1323 | 2.9847 | 7.03% |
| **SPY-QQQ** | ARMA-DCC | 15.90% | 3.7479 | 1.9297 | 9.77% |
| ARMA-ADCC | 16.39% | 3.8346 | 1.8927 | 9.83% |
| ARMA-GAS | 17.55% | 4.1023 | 2.0981 | 9.92% |
| RNN-DCC | 34.47% | 8.0958 | 4.2313 | 6.92% |
| RNN-ADCC | 34.12% | 8.1419 | 3.9961 | 6.95% |
| RNN-GAS | 34.68% | 8.123 | 4.2628 | 6.91% |
| PSN-DCC | 34.49% | 8.0153 | 4.68 | 6.37% |
| PSN-ADCC | 36.82% | 8.2791 | 4.9251 | 6.42% |
| PSN-GAS | 36.93% | 8.2796 | 5.151 | 6.42% |
| **DIA-QQQ** | ARMA-DCC | 15.08% | 3.8795 | 2.132 | 7.93% |
| ARMA-ADCC | 15.67% | 4.037 | 2.1784 | 7.93% |
| ARMA-GAS | 15.54% | 4.0569 | 2.2204 | 7.93% |
| RNN-DCC | 43.46% | 9.3243 | 5.7753 | 7.75% |
| RNN-ADCC | 44.03% | 9.1267 | 5.4797 | 6.28% |
| RNN-GAS | 44.19% | 9.2088 | 5.7724 | 6.37% |
| PSN-DCC | 44.16% | 9.3926 | 6.1319 | 6.81% |
| PSN-ADCC | 45.53% | 9.5763 | 6.0846 | 6.90% |
| PSN-GAS | 46.05% | 9.4468 | 6.3416 | 6.82% |

*Note: The table presents the out-of-sample performances over the period January 2014 to March 2015 (68 weekly observations). Panel A reports performances of different mean-CVaR portfolios without short-selling. All the portfolios are weekly rebalanced tangency portfolios obtained by the different mean-CVaR optimization based on various model combinations. For example, ARMA-DCC refers to the performance of the tangency portfolio of the efficient frontier of the two ETF assets, where the expected returns are obtained through ARMA forecasts, while the variance-covariance matrix is predicted by DCC. Panel B reports performances of different mean-CVaR portfolios with short-selling.* *‘SKT’ represents that the 95% CVaR is predicted using a Monte-Carlo simulation with the skewed t copulas to allow for asymmetric tail dependence ‘-S’ denotes optimizations allowing short-selling.*