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Dynamic Quantile Regression Forest
Regression Forest Quantilica Dinamica

Mila Andreani[1] and Lea Petrella[2]

Abstract The potential of machine learning algorithms in the assessment of market risks has not been completely investigated in the literature, such as in the forecasting Value-at-Risk (VaR). In this paper we introduce the Dynamic Quantile Regression Forest, a model combining Quantile Regression Forests with a dynamic VaR. The model is dynamic as the quantile prediction of the previous random forest becomes part of the training set used to train the next random forest. Thus, it is possible to estimate the response variable conditional distribution by accounting for the evolution of the quantile over time among other covariates.

Abstract *Le potenzialità degli algoritmi di machine learning per la valutazione dei rischi di mercato sono ancora poco conosciute, in particolar modo per quel che concerne il calcolo del Value-at-Risk (VaR). Lo scopo di questo lavoro, dunque, è quello di introdurre la regression forest quantilica dinamica, un modello che unisce le regression forest con il calcolo dinamico del VaR, ossia tenendo conto dell'evoluzione del quantile nel tempo: in questo senso il modello è definito dinamico in quanto permette di stimare la distribuzione condizionata della variabile tenendo conto, fra le altre covariate, anche dell'evoluzione del quantile nel tempo.*

Key words: Value-at-Risk, Random Forest, Quantile Regression.

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1 Introduction

Numerous contributions in literature point out the high predictive accuracy of machine learning algorithms in the economic and financial fields [1,8]. However, it is necessary to account for the complexity of such tools when it comes to compare them to traditional econometric models in terms of computational effort. As a matter of fact, many machine learning models require a long time to be tuned before being implemented, whereas traditional models might deliver similar results in a more timely manner.

Yet, the Random Forest algorithm introduced by [4], represents an efficient compromise between predictive accuracy and computational effort. Random Forest is an ensemble machine learning tool composed of decorrelated decision trees. Each tree is trained with a subset of the training set sampled with replacement from the original dataset with a method called *bagging*. The term "random" is related not only to the random sampling of the training subset, but also on the randomly chosen variable used to make the splits in each decision tree. The final prediction is computed as the aggregation of each tree prediction. The main advantage of random forests is related to the high training speed and the low number of parameters to be tuned in order to deliver reliable predictions (*number of trees, node size, number of features to choose from for each split*).

Random forest can be used both for classification and regression tasks, and the latter model has been further developed by [6], who introduced the quantile regression forest. This model allows to predict quantiles by estimating the whole conditional distribution of the variable, and, in this sense, it is possible to use this model to forecast the Value-at-Risk, representing the quantile of the conditional distribution. However, other econometric models have been developed in order to compute the Value-at-Risk in a dynamic setting.

In particular, [7] proposed a model to compute the Conditional Autoregressive Value-at-Risk (CAViaR) via nonlinear quantile regression. This model is based on directly modelling the quantile as nonlinear function of its past values and other factors instead of estimating the entire conditional distribution of the variable. By doing so, it is possible to account for changes in the variable's distribution over time and to compute a dynamic Value-at-Risk. Despite the advantages of random forest, the state-of-the-art in the machine learning field doesn't account for the application of quantile random forests in computing VaR. Moreover, the only technique by which is possible to train machine learning tools in a dynamic setting is via "incremental learning". This method allows to train a model on several batches of a given dataset, but it doesn't allow to account for an autoregressive structure of the model, which is the idea behind the CAViaR model. For this reason, in this paper a new kind of random forest is proposed in order to account for a dynamic setting for forecasting Value-at-Risk. Moreover, the aim of this paper is also to design a model to compete with traditional econometric techniques in terms of predictive accuracy and computational effort.

2 The model

The main feature of machine learning is that the training phase is performed on a static training set. This means that a given dataset is divided into two parts, a training set and a test set. Subsequently, the algorithm is trained on the training set and tested on the test set. Thus, it is not possible to account for changes in the training set and, for instance, to consider an autoregressive structure in the model. Consequently, in order to forecast a dynamic quantile, it is necessary to change the way in which machine learning algorithms are trained and to develop a model that allows to update the training set each time a new prediction is made.

The dynamic quantile regression forest has been developed for this purpose: this model relies on updating the training set whenever the regression forest produces a prediction and subsequently training a new random forest on the updated training set. Thus, it is possible to account for an autoregressive structure as proposed by [7]. However, the random forest models the entire distribution instead of directly modelling the quantile. Specifically, given a set of observations Y_i with $i = 1, \dots, T$, and a set of regressors $X_{k1} \dots, X_{kT}$ with $k = 1, \dots, K$, a subset $Y_1 \dots, Y_t$ (in which t represents the window width) is used in order to initialize the random forest and to produce t quantile predictions via the CAViaR model. To do that consider one of the possible CAViaR models proposed by [5] i.e. the Symmetric Absolute Value:

$$q_t(\beta_1) = \beta_1 + \beta_2 q_{t-1}(\beta) + \beta_3 |y_{t-1}| \qquad (1)$$

The first random forest is trained on the subset $Y_1 \dots, Y_t$ using the $q_1 \dots, q_t$ estimated from the CAViaR in (1) with covariates given by $X_{k1}, \dots, X_{kt}$ with $k = 1, \dots, K$. The one-step-ahead q_{t+1} is computed implementing the quantile regression forest and added to the dataset. Subsequently, an additional quantile regression forest is fitted using $Y_1 \dots, Y_{t+1}$, q_{t+1} and $X_{k1} \dots, X_{k(t+1)}$ with $k = 1, \dots, K$. The procedure is repeated until the entire dataset $Y_1, \dots, Y_T$ is used to train the last random forest, which is fitted on the whole dataset comprehensive of the previous quantile predictions. Consequently, the one-step-ahead quantile prediction will be a nonlinear function of its past values and the regressors.

3 Results

The model has been tested on T=1350 daily returns of the S&P 500 starting from 02-09-2010 and the VaR at 5% is predicted. The covariates are: Hang Seng index, CAC 40 index, FTSE 100 index, Dow Jones Index, NASDAQ 100 index, VIX, CBOE Equity VIX on Apple, CBOE Equity VIX on Amazon. The window width is equal to t=350 and the number of trees is set to 100. The first 350 observations are used to initialize the random forest using the CAViaR model in (1) and the remaining 1000

are used to estimate the quantile regression forest's predictions. The model proposed results to be:

-*accurate*: to measure the model accuracy in estimating the VaR, we use backtesting procedures like the conditional and unconditional coverage tests [2,3]. We show that our dynamic quantile regression forest produces both correct and independent exceedances, as shown in Table 1 (the expected exceedances are 50):

Table 1: Backtesting results

	Values
Actual exceedances	42
Unconditional coverage p-value	0.2304129
Conditional coverage p-value	0.1514733

-*competitive in terms of accuracy and computational effort:* the running time for our model is equal to 1 minute and 23 seconds and the prediction for the 1001-th quantile is equal to -0.023. Moreover, we compare the dynamic quantile regression forest with the four CAViaR models proposed in [7] (i.e., Symmetric absolute value, Asymmetric slope, Indirect GARCH (1,1), Adaptive) and the static quantile regression forest as proposed in [6]. The table below shows the quantile loss values for the models being compared and the ratio between our model's quantile loss, the CAViaR models' quantile loss and the static quantile regression forest quantile loss. Results show that our model produces a sensibly smaller quantile loss with respect to the Indirect GARCH (1,1) model and the static quantile regression forest, whereas it delivers similar results to the other three CAViaR models. Results are summarised in Table 2:

Table 2: Accuracy results

	% Loss	***Loss***
Dynamic quantile regression forest	-	0.0010227
Symmetric absolute value	108%	0.0009463
Asymmetric slope	107%	0.0009545
Indirect GARCH (1,1)	29%	0.0035005
Adaptive	108%	0.0009467
Static quantile regression forest	43%	0.0024011

4 Comparison with the static quantile regression forest

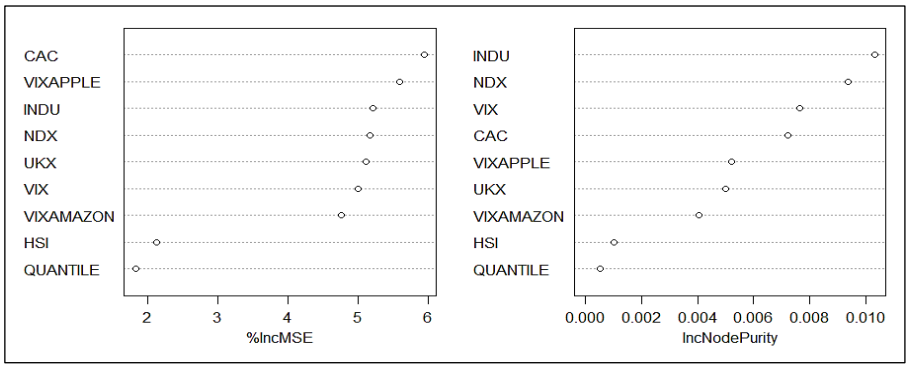
Moreover, according to the backtesting results the static quantile regression forest as proposed in [6] produces inaccurate estimates for the 5% VaR as shown in Table 3:

Table 3: Backtesting results for the static quantile regression forest

	Values
Actual exceedances	322
Unconditional coverage p-value	0
Conditional coverage p-value	0

As a matter of fact, Figure 1 highlights the relevance of introducing quantile predictions as regressors in the dynamic quantile regression forest. The figure shows that the quantile covariate positively affects the dynamic quantile regression forest's estimates in terms of Mean Squared Error and Node Impurity. As described in [5], the t-th node impurity measures the sum of squared errors between the observation value y_i and its mean in the t-th node $\mu(t)$ (i.e., the variance in the t-th node).

Figure 1: Dynamic Quantile Regression forest variable importance



References

1. A. E.Khandani, A. J.Kim, A. W.Lo , Consumer Credit-Risk Models Via Machine-Learning Algorithms , Journal of Banking and Finance 34 (2010): 2767-2787, 2010.
2. Christoffersen, P., Evaluating Interval Forecasts, International Economic Review, 39(4), 841-862, 1998.
3. Kupiec, P.H., 1995. Techniques for Verifying the Accuracy of Risk Management Models, The Journal of Derivatives 3(2), 73-84, 1995.
4. Leo Breinman, Random Forests, Machine Learning, 45, 5–32, 2001
5. M. Segal, Y. Xiao, Multivariate Random Forest, Data Mining and Knowledge Discovery, 2011.
6. Nicolai Meinshausen, Quantile Regression Forests, Journal of Machine Learning Research 7, 983–999, 2006.
7. R.F. Engle, S Manganelli, CAViaR: Conditional Autoregressive Value at Risk by Regression Quantiles, 2004.
8. S.I. Lee, S.J. Yoo, Multimodal deep learning for finance, The Journal of Supercomputing, 2019.