Case №1: Algorithmic Trading

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1 Intro

In this essay I am going to present my solution of the first case on algorithmic trading[1]. The rest of the paper is organized as follows: in section 2 I present chosen strategy – dual moving average crossover: its traditional application and improvement, suggested by authors of the article. In section 3 results of work will be demonstrated. In section 4 I present performance of my best strategy on the train&validation and test data.

2 Trading strategy

I have chosen the article[2], where authors propose a modified version of moving average crossover trading strategy (they also use this upgrade for price cross-over, but we will not consider it in this work). Let's start from description of traditional variant without the modification (it will be called the **«traditional»** or **«standard»** strategy further).

[1] Full and detailed information can be found in IPython Jupyter notebook.

[2] Papailias F., Thomakos D. D. An improved moving average technical trading rule //Physica A: Statistical Mechanics and its Applications. – 2015. – T. 428. – C. 458-469.

First of all, we calculate moving averages of prices with different window sizes (denote «short» and «long» sizes s and l respectively, where $s < l$). Thus, we get two new time series $(MA)_i^s$ and $(MA)_i^l$, $i = 1,...,n-1$. When the short MA crosses and rises above the long one, it is a signal to buy stocks (long position). Opposite situation is a signal to sell stocks (short position). So trading actions take place only in the moments of intersection, change of time-series' positions relative to each other.

Papailias, Thomakos suggest such **modification**: in order to stay in the market (don't sell owned stocks) the current price should be greater or equal than the entry price (the price which last time we buy stocks for). It will be called the **«upgraded»** strategy further. In my opinion, it makes strategy more secure but also more conservative. However, in the article this strategy outperforms traditional one, using ETF DJIA, ETF SP 500 prices for a long-run period of 80 and 60 years or prices of EUR/USD exchange rate for 10 years for trading. So I will try to analyze this fact for short-run period (2019-2020) in my work.

Thus, both strategies (traditional and upgraded) had been tested on ETF S&P 500 with the help of two time-series: filtered by ARMA-GARCH returns and original prices time-series. Also I had tested different variations of my improvement of authors' rule: in order to stay in the market (don't sell owned stocks) the current price should be greater or equal than (**1/up** * the entry price), where **up** > 1, to make strategy more risk taking.

3 Results

Simulations show that implementing strategies on prices is not a good idea, using filtered time-series is much better.

I assumed it would be like this and added extra parameter «up» to regulate strictness of improved trading rule. But it wasn't helpful. The two best strategies by «Cum return» maximization criteria (traditional and upgraded) are the following (for both strategies daily maximum drawdown doesn't exceed 0.5%):

- **traditional**: short window = 20, long window = 140
  - Cum return over MDD = 58.37
  - Cummulative return = 24.07%
  - Maximum drawdown (% from capital) = 0.45%
  - Sharpe ratio = 0.163
  - Rachev ratio = 0.978
  - Value at risk (5%) = -0.61%
  - Expected shortfall (5%) = -0.99%
  - Market beta = 0.326

- **upgraded**: short window = 20, long window = 250, up = 1
  - Cum return over MDD = 32.07
  - Cummulative return = 22.18%
  - Maximum drawdown (% from capital) = 0.59%
  - Sharpe ratio = 0.133
  - Rachev ratio = 0.828
  - Value at risk (5%) = -0.71%
  - Expected shortfall (5%) = -1.20%
  - Market beta = 0.410

All information above tells us to choose traditional strategy (all indicators are much better) on filtered data. Market beta is not so small as we want. However, ETF copies dynamics of market index, so maybe it's one of the reasons for such results.

4 Final test

Final run had been done on filtered time-series and the best of the best models had been chosen for this mission (traditional strategy with short window = 20 and long window = 140).

Let's start from evaluating the strategy on train+val sample (figure 1). Our strategy had a big fall in 2011-2012 and it took about 5 years to recover losses. Maybe, this instability relates to the way parameters were tuned (only on validation sample). Since 2016 the strategy shew the growth and achieved 40% in the end of the period under review. Sharpe ratio says that our strategy is a little bit better than risk-free return. To sum it up, the strategy shows acceptable results. Now let's look at more interesting test period.

We get such good results:

- Sharpe ratio: 0.109 (> 0, so we exceeded the risk-free rate)
- Rachev ratio: 0.674
- Market beta: 0.186 (our strategy is not highly correlated with the market)
- Max drawdown (% from capital): 1.47%
- Cumulative return: 23.77%
- Cumulative return over Maximum Drawdown: 17.71

Also we can visualize our final results (figure 2):

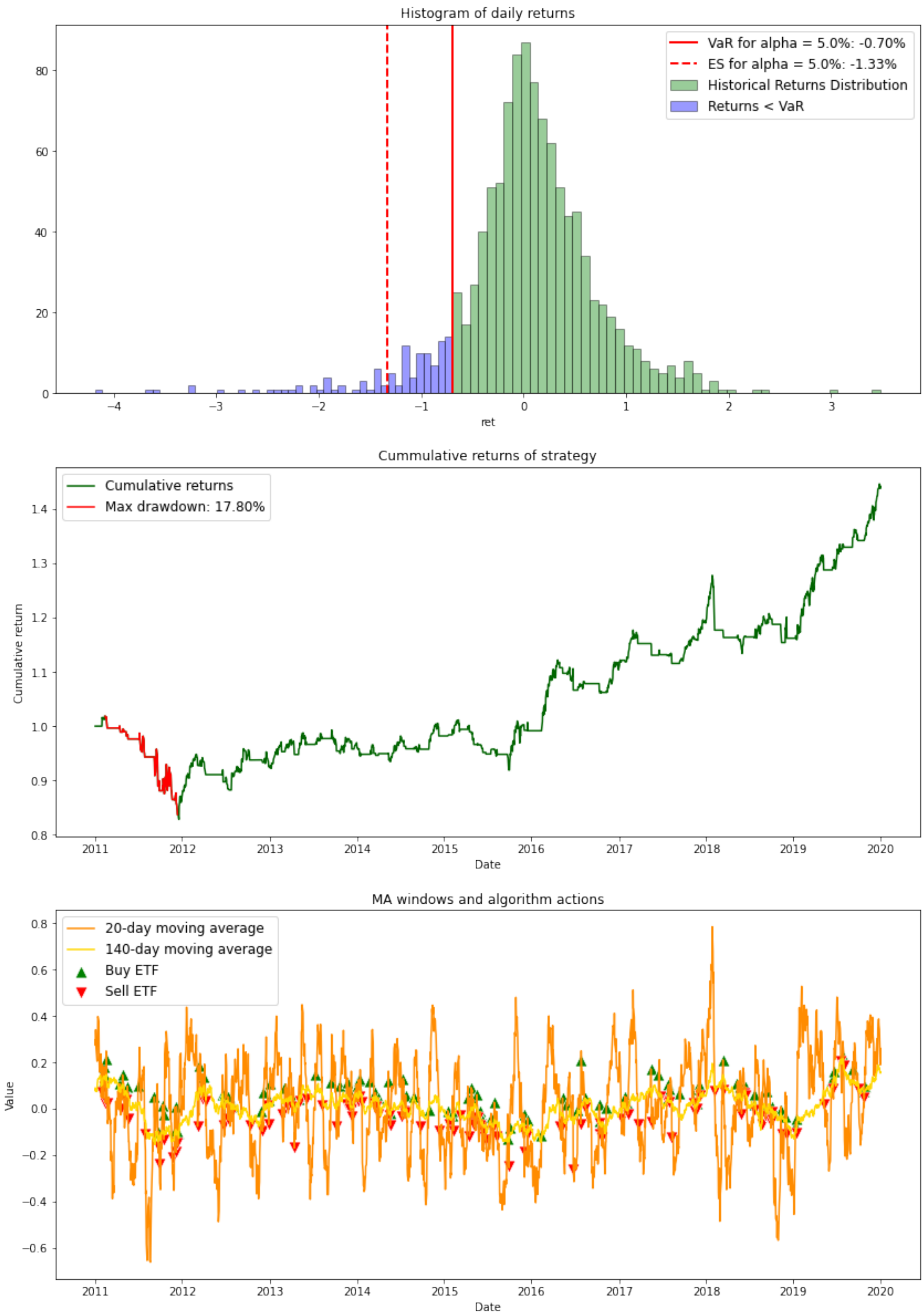

Figure 1. Strategy performance on train+val sample

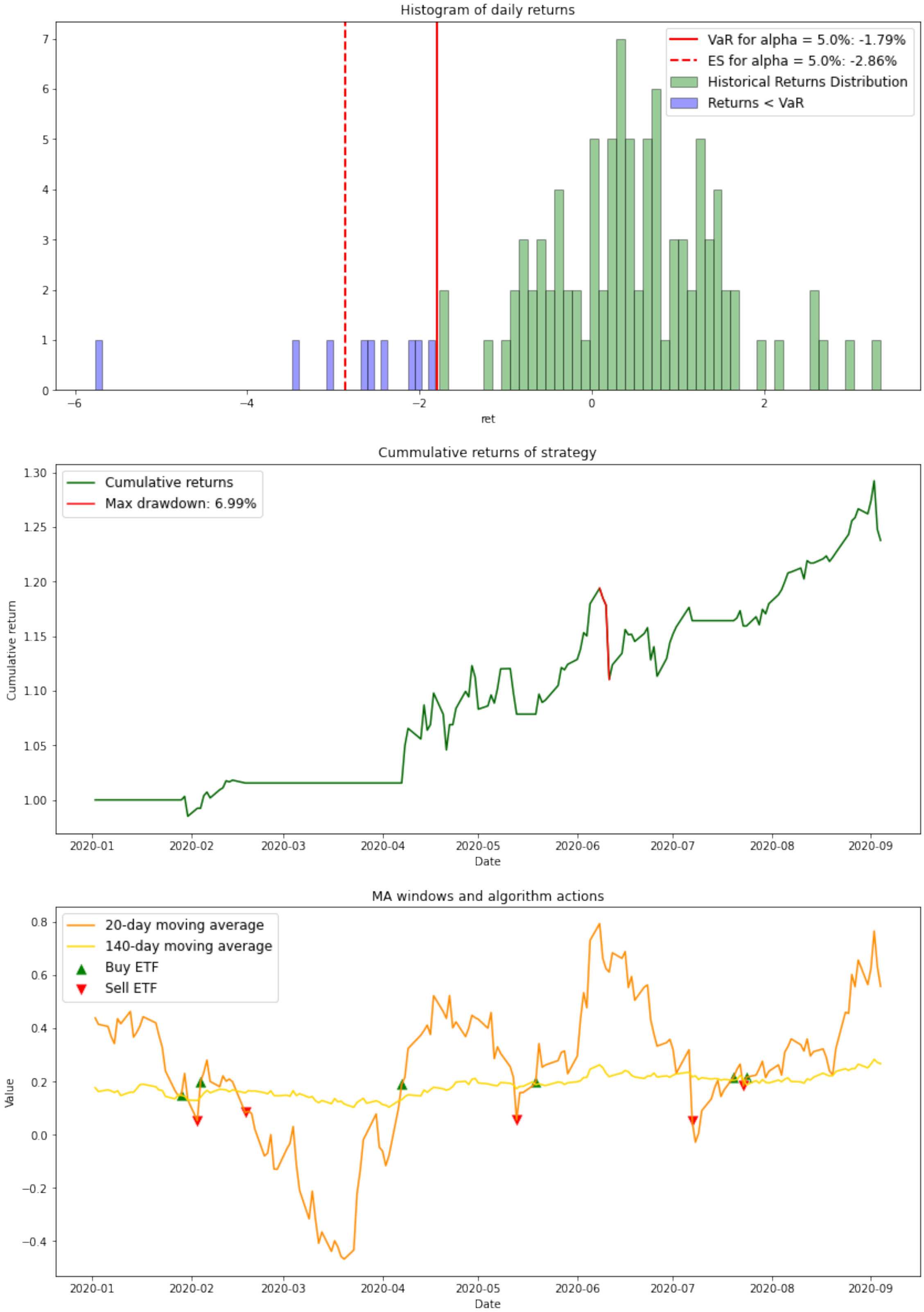

Figure 2. Strategy performance on test sample