Dividend portfolio – multi-period performance of portfolio selection based solely on dividend yields
(DRAFT)

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Abstract: What will happen to your investment if you ignore change of share prices while calculating both returns and risk during stocks portfolio selection? Is it profitable in long term to sell a share when its price has started to skyrocket? Backtesting of a decade-long investment with periodic portfolio rebalancing shows a continuous advantage of such radical and unintuitive approach over the classic formula of return-on-investment. The idea to concentrate on dividend yield in portfolio selection theory, *contrarian* to popular models, is at least thirty years old, here it is tested and some practical aspects are analyzed. With the help of a computer simulation it is possible to show the impact of both different frequencies of portfolio rebalance, which was huge, and different risk levels. All simulations have been logged to files so that it is possible to trace changes in portfolios including dividends paid and splits without running the simulator, which is published on GitHub as open-source with an instruction manual and can easily be run by anyone.

Keywords: dividend contrarian dynamic portfolio selection computer simulation backtesting

Key Takeaways:
- historical prices of stocks, their past performance might not be the best hint on how to invest
- a naive method to pick out the best stocks for a portfolio (opposed to nonlinear programming) can provide very good results
- the naive method gives better results in low risk strategies, risk-return tradeoff has not been observed,
- there is no evidence that portfolio selection based on dividend yield performs worse in bearish or bullish periods. Yields were quite consistent throughout decades.

Introduction

Harry Markowitz' work (1959) contributed vastly to the development of financial economics and established underpinnings for Modern Portfolio Theory – a framework for the construction of investment portfolios. There were many followers, new models and theories, both *normative* ones describing how investors should behave and *positive* ones like CAPM, which proposes hypothesizes how markets actually behave. MPT[1] includes numerous implicit and explicit assumptions about markets and investors, and criticisms emerged soon after the theory got its audience. For example asset returns have shown to be far from the normal distribution, with fat tails and high kurtosis. Even Markowitz pointed out limitations of his own work by warning us that *when past performances of securities are used as inputs, the outputs of the analysis are portfolios which performed particularly well in the past*.

One of criticisms refers to risk-return tradeoff. Haugen and Heins (1975) found that risk might not generate a special reward. Murphy (1977) cited several studies, which concluded that there might not be any stable relationship between return and risk. Fama and French stated after having examined 9500 stocks across three decades that risk measured by beta was not able to predict performance. It has to be noted that despite scientific evidence, much wider than mentioned

1 This acronym will be used later on to refer to the initial Markowitz's model. Modern Portfolio Theory contains a much wider spectrum of models and ideas.

above, one can still find books on investment which state without deeper reflection or any reservation that «*there is a risk-return trade-off*» *(*like Bradford, 2009, p. 208). Fama and French also found that shares with lower P/E ratios and price to book ratios provided the highest returns, stocks are more bound to these measurements than to beta. Similar observations were made among others by Basu (1977), Rosenberg (1985), Bhandari (1988). But you could find such claims already in Graham and Dodd (1934). The alleged risk-return tradeoff can however be observed in some results of simulations presented below.

A fundamental and still debated question is how risk ought to be measured. The original variance approach began to be troublesome as markets were becoming more volatile. It has forced scientists and financial institutions to invent other risk measures, like for example JPMorgan's Value-at-Risk or copula proposed by Sklar (1973). Although variance will be used here, techniques used for simulations allow for further research on the impact of different risk definitions on portfolio performance.

While estimating risks and returns using the historical performance of stocks it has to be decided which time frame should be used to get the sample. It was seen as MPT's drawback by Fabozzi (2002) and the results of simulations presented here show a vast impact of this decision. Estimation error attracted attention of many researchers, a good overview was given by DeMiguel (2009). DeMiguel's work is worth mentioning not only because it similar to what is proposed in this article – the 1/N, naive strategy is used as a benchmark for other approaches. It *shows that the estimation window needed for the sample-based mean-variance strategy and its extensions to outperform the 1/N benchmark is around 3000 months for a portfolio with 25 assets and about 6000 months for a portfolio with 50 assets*. Estimation errors were claimed to be the cause of poor performance of sample-based portfolios. The results shown below contradict such claims in long term – MPT portfolios performed much better than S&P index. Another contradiction found is that there have been claims that MPT portfolios tend to have large quantities of individual assets, Affleck-Graves (1996) found that weights are limited to about 40 percent. But many risky portfolios produced by model solver did contain just one asset during backtesting.

Concentration on dividends as the main source of wealth and on other «value» strategies based on different intrinsic properties was one of the mainstream ideas at least since Fama and French published their studies on the power of dividends yield to explain stock returns. Their findings suggested that it increases with return horizon. Two decades later Bekaert (2006) wrote that *the ability of the dividend yield to predict excess returns is best visible at short horizons*. Another contribution was provided by Lakonishok (1994) who postulated that *over longer horizons, value strategies have outperformed glamour*[2] *strategies quite consistently*. He also considered possible explanations for this extraordinary performance – value strategies were *contrarian*[3] *to naive* strategies based on past earnings, investors get overly excited by past and are irrespectful to mean reversion (Kahneman, 1982, p. 417). Lakonishok's evidence does not support the hypothesis that value strategies are fundamentally riskier. Let us mention a few more researchers interested in value portfolios. A study done by Keppler (1991), which examined the link between price-to-cash flow and investment returns found that the most profitable strategy was investment in the lowest price-to-cash flow quartile. Arnott (2003) examined different components of equity returns in 200 years. His conclusion was that dividends were responsible for most of returns «dwarfing» rise of prices. Interestingly some studies independently found that the ninth decile outperforms the highest yielding one.

2 fast-growing

3 Because this term is used not only for portfolios controlled by dividend yields «dividend portfolio» will be used instead

MPT is a single-period, static theory on the choice of portfolio. But Markowitz also tried to extend his optimization criterion with the expected utility of wealth after many reinvestment periods and used SIMSCRIPT for simulations (Rubinstein, 2002). This approach of a repeated game between the nature and the investor, sometimes called «dynamic hedging» or backtesting, is used during simulations here[4].

Two models will be compared – the classic MPT and a model based solely on dividend yields, ignoring changes in asset valuations and even ignoring optimization – weights will be split evenly. Portfolios will be continuously adjusted (rebalanced) by buying and selling shares in response to variations of prices and dividends. The terminal wealth will be compared.

To sum up what needs to be addressed:
- does ignoring changes in stock valuations bring extra benefit over MPT?
- is this benefit consistent trough-out decades?
- does taking risk reward an investor, is there any risk-profit tradeoff?
- what is the impact of different sampling methods, different period lengths?
- what is the structure of MPT portfolios, does a weight exceed 50 percent and when?
- what values of strategy attributes (preferred risk, rebalance frequency) give best results?
- does the number of assets in dividend portfolio make a difference?

Classic mean-variance model

In order to help recognize the model used for simulations in the source code and help understand the flow of the simulation let us sum up some widely known formulas for sample-based Markowitz's model. In order to invest in stocks one would choose a period of time in recent history, divide this period into smaller parts and calculate returns on investment of a chosen set of stocks:

$$ROI = \frac{FinalPrice - InitialPrice + DividendsPayouts - TransactionCosts}{InitialPrice}$$

Then an optimal portfolio would be found, which would require making some assumptions – is it the expected return that should be maximized with an assumed, maximum level of accepted risk or the risk that should be minimized with an assumed, minimum level of return? Having estimated the mean values and the covariance matrix we can construct the classic model proposed by Markowitz:

$$E = \sum_{i=1}^{N} x_i \widehat{\mu_i}$$

$$V = \sum_{i=1}^{N} \sum_{j=1}^{N} \widehat{\sigma_{ij}} x_i x_j$$

$$\sum_{i=1}^{N} x_i = 1$$

$$x_i \geq 0 \; for \; i = 1..N$$

Depending on investors preferences (e_{min} or v_{max}) you can have two variants of the model to solve:

$$V \rightarrow MIN$$
$$E \geq e_{min}$$

4 The simulator with a short manual is available on GitHub: https://github.com/boguszjelinski/stocks

or

$$E \to MAX$$
$$V \le v_{max}$$

The latter will be used in simulations. No short sale, dividends will be reinvested. As transaction costs are negligible in a large scale, they will not be calculated.

Dividend portfolio

The dividend portfolio will be constructed differently. The ROI will ignore the change of valuation:

$$\text{ROI} = \frac{DividendsPayouts - TransactionCosts}{InitialPrice}$$

The variance will be estimated for each stock, stocks exceeding v_{max} will be ignored, the rest will be sorted by mean dividend yield. The best scoring 'n' stocks will be picked up and evenly split in the portfolio.

Simulation results

Let us assume we have 100000 USD, investment horizon is 16 years starting Jan 1st 2000. This spans over two periods of both decline and growth, and gives a good insight in performance in different market conditions – see Figure 2. We would like to invest in S&P 100 stocks. We can rebalance portfolio every month or once a year, or somewhere in between. It means we have 12*16 rebalances when one month has been chosen, or 16 rebalances with period length of one year. We can have different risk preferences. While gathering the sample (for assessing risk and return) let us look into twelve preceding periods of the same length as the chosen rebalance period – a rolling window sample. It sounds quite natural – someone interested in long-term investments would not perceive a short-term fluctuations as a valuable information. Sampling approaches are not in scope of this work although impact of different sampling periods have been analyzed – see tables 2 and 3. We ignore the possibility of estimation error.

With MPT we maximize expected return, we use a SCS solver to find the optimal portfolio[5]. Figure 1 shows the achieved terminal wealth depending on how often portfolios are rebuilt (in months) and how high the acceptable risk is.

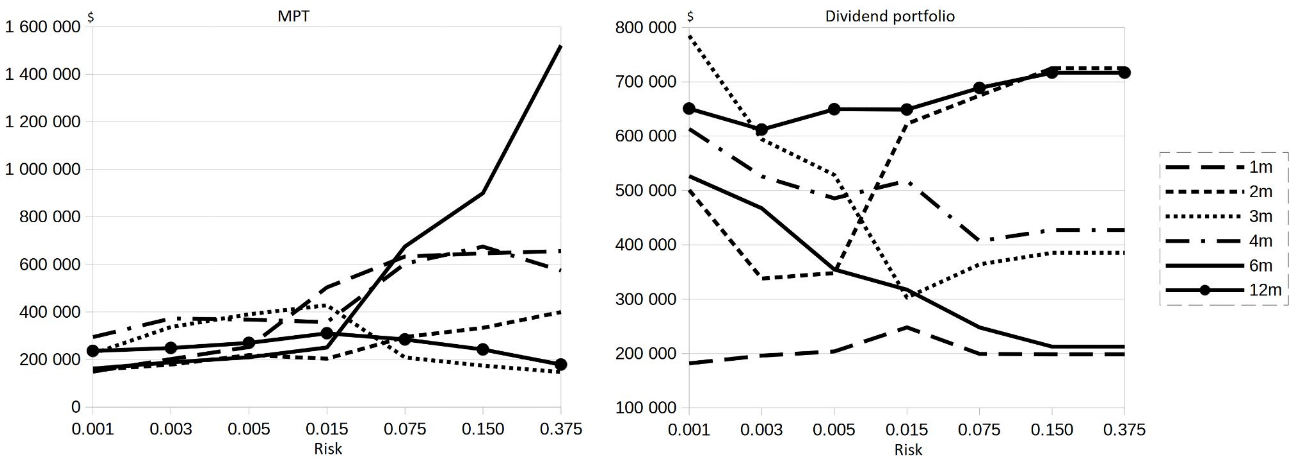

Figure 1. Terminal wealth of 42 strategies achieved with MPT and dividend portfolio.

5 https://github.com/cvxgrp/scs/

Dividend portfolios contained four best scoring assets. Simulations with two and ten assets showed that four is a better choice, but differences were small.
It is clearly visible that these two portfolios react differently to risk. In MPT one could see the risk-return tradeoff while in “dividend portfolio” the lowest risk prevails. The average wealth of 42 strategies is significantly higher in “dividend portfolio” (372884 vs 455621). Both MPT and dividend portfolios outperformed S&P100 in 16 year period – see Figure 2. A more detailed analysis of investment «trajectories» shows that the dividend portfolios coped with the 2000-2002 decline, but were not resistant to that in 2008 and 2009. Similar conclusion could be drawn for the 1990-2000 decade (not shown in the chart).

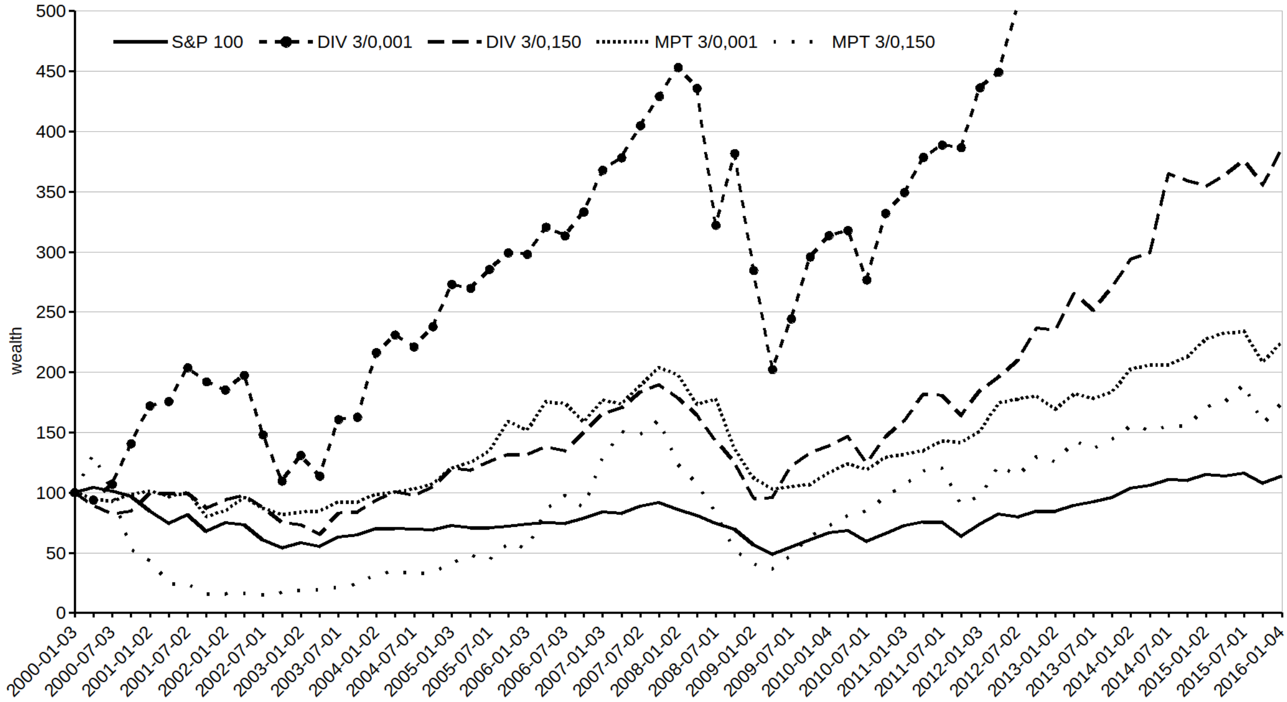

Figure. 2 MPT and dividend portfolios vs S&P100 – terminal wealth in thousands USD (from Jan 1st 2000 till Jan 1st 2016, rebalance after 3 months)

Table 1 shows how the maximum risk in the MPT model affects portfolio structure – it has not been observed that portfolios contain large quantities of individual assets, portfolios with just one asset were often proposed by the solver for more risky portfolios (vide Affleck-Graves).

Table 2 and Table 3 show how differences in sampling (different lengths of period's window) affects one chosen strategy (0.005/12) in MPT and dividend portfolios respectively. As you can see the impact on the terminal wealth may be vast, but table is not meant to provide any hint for investors due to probably significant estimation errors.

[%]	Number of different tickers in portfolios								
V≤	1	2	3	4	5	6	7	8	9
0.005	3.3	10.0	22.5	35.0	18.3	5.8	1.7	2.5	0.8
0.015	17.5	30.8	30.8	12.5	5.0	0.0	2.5	0.8	0.0
0.075	75.8	14.2	6.7	2.5	0.8	0.0	0.0	0.0	0.0
0.375	92.5	2.5	2.5	1.7	0.8	0.0	0.0	0.0	0.0

Table 1. Structure of MPT portfolios depending on maximum risk – frequencies of particular sizes in 120 rebalances, as a percentage (start on Jan 1st 2000, rebalance after 1 month)

		Number of periods in sample			
		6	12	18	24
Length of period in months	3	358	330	364	463
	6	453	207	258	315
	9	267	241	429	324
	12	340	270	303	286

Table 2. Impact of different sampling methods on terminal wealth in MPT
(in thousands; start on Jan 1st 2000, V≤0.005, rebalance after 12 months, 16 rebalances)

		Number of periods in sample			
		6	12	18	24
Length of period in months	3	258	468	428	243
	6	420	251	317	657
	9	339	459	639	725
	12	358	649	766	438

Table 3. Impact of different sampling methods on terminal wealth, «dividend portfolio»
(in thousands; start on Jan 1st 2000, V≤0.005, rebalance after 12 months, 16 rebalances)

Figure 3 is an example of documentation generated by the simulator in order to examine its flow and correctness of historical data[6]. It shows a dividend portfolio purchased Jul 1st 2010 and its value three months later. A 1000000 / 937989 split was considered on VZ (Jul 2nd 2010).

6 Data downloaded from Yahoo had some missing or wrong data in dividends and splits. Output generated by Python simulator differs.

New portfolio:

Stock	W[%]	Vol.	Price	Total
T	25,0	4212	24,34	102520,08
VZ	25,0	3644	28,13	102505,33
EXC	25,0	2694	38,05	102506,70
SO	25,0	3072	33,37	102512,64

Portfolio value: 410044,74
Cash after stock purchase: 67,17

Portfolio rebuild on: 2010-10-01
Portfolio before rebuild:

Stock	Vol.	Price	Total	Dividend	Some more details
T	4212	28,81	121347,72	1769,04	2010-07-07, 0.420000;
VZ	3884	32,89	127744,76	1730,90	2010-07-07, 0.475000; SPLIT(s)
EXC	2694	43,03	115922,82	1414,35	2010-08-12, 0.525000;
SO	3072	37,14	114094,08	1397,76	2010-07-29, 0.455000;

Value of stock sold: 479109,37
Total dividends paid: 6312,05

Figure 3. Example of the simulator log

An obvious question would be if the dividend advantage is consistent throughout decades. Figures 4 and 5 show the realized yearly dividends from the «dividend portfolio» between Jan 1st 1980 and the end of 2015, for V≤0.005 and V≤0.375 scenarios respectively (arithmetic mean of four assets). Values tend to fluctuate around 5%, with some extraordinary positive deviations (mean=0.05, variance=0.0002 and mean=0.06 and variance=0.001 respectively). It looks like a trustworthy foundation for the dividend portfolio.

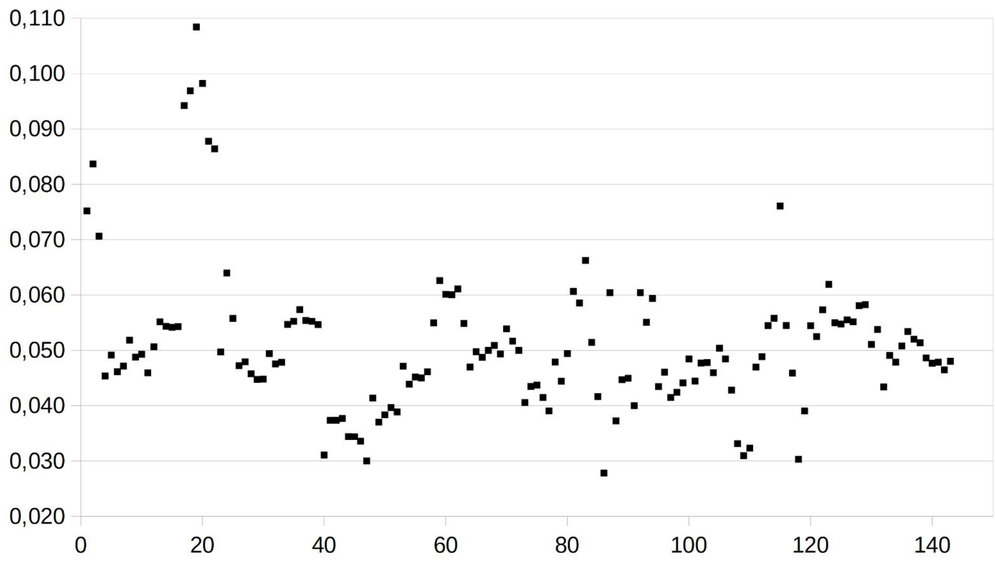

Figure 4. Dividend yields for V≤0.005 realized in 36 years - «dividend portfolio» strategy (yearly values, start on Jan 1st 1980, rebalance after 3 months)

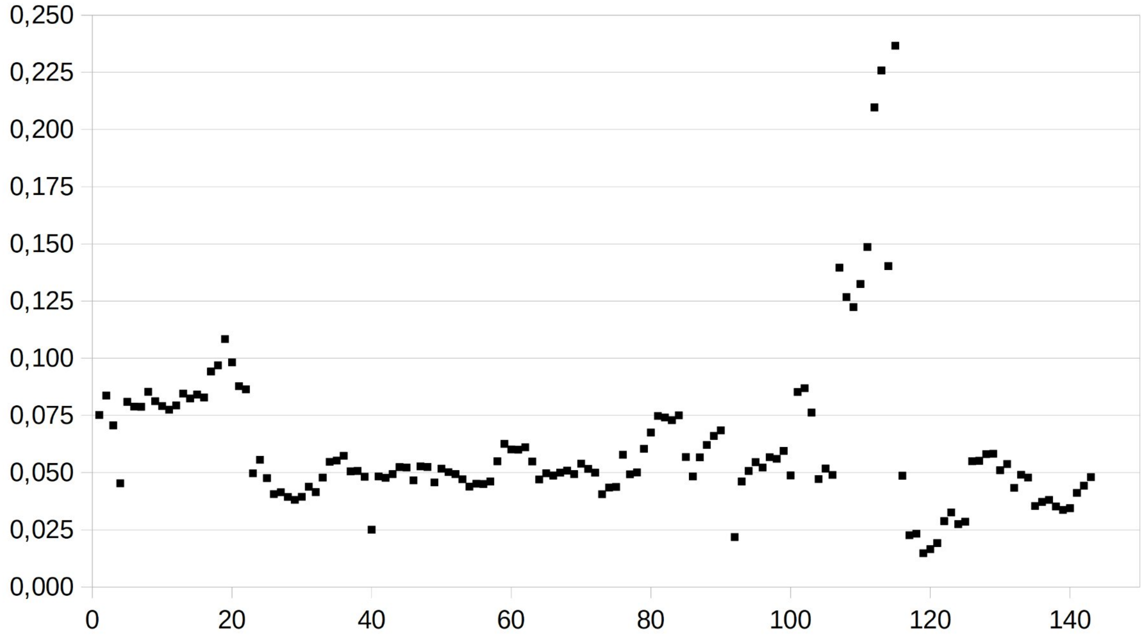

Figure 5. Dividend yields for V≤0.375 realized in 36 years - «dividend portfolio» strategy (yearly values, start on Jan 1st 1980, rebalance after 3 months)

Computational considerations and reproducibility

There are essential differences in datasets distributed freely in the Internet and these differences have had vital impact on terminal wealth. As an example – while comparing Yahoo and Tiingo datasets one third of paid dividends are different by more than 10 cents, 15% of splits are different by more than 0.1 (10%), there are differences in stock prices too. Differences are smaller when comparing Tiingo to Quandl, but still not negligible. The same effect was observed while running simulations in different languages (Python vs Java) – small differences in implementations have affected the terminal wealth quite significantly. All simulations are available in GitHub and these differences can be reviewed.

Conclusions

The dividend portfolio even in a primitive form (no solver) outperforms the classic portfolio theory quite consistently in low risk scenarios and it is generally a viable alternative to MPT. There is no evidence that the dividend portfolio performs worse in bearish or bullish periods. The contrary – achieved dividend yields were steady throughout decades and taking less risk did not punish the investor. The risk-return tradeoff is visible in results for MPT but the structure of risky MPT portfolios tends to contain few assets making such strategies unacceptable to most investors.

There are several topics that might need further research or improvements – reducing estimation errors, other risk measures and techniques like dividend arbitrage. Does semi-variance give better results? Does the ninth decile perform better than the last one? Why was there a difference in performance in two decline periods which were under scrutiny? Maybe the optimal parameters of strategies differ in bearish and bullish periods. This was not evident either which investment horizon (short or long) gives higher results. The simulator, which is available on GitHub as open-source, may also be used to continue research on MPT – a few contradictions to other research were found. Most importantly - sharing the source code on GitHub allows for cooperative research and easy reproducibility and verification of results.

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