



Optimizing a Moroccan Equity Portfolio with Monte Carlo Simulation and the Efficient Frontier:

Evaluating the performance of market-cap-weighted vs. optimized portfolios within the MASI20 universe (2015-2025)

Educational / non-investment advice disclaimer

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Introduction & Methodology:

Scope, assumptions, data source, sample period:

On 13th August 2025, the Casablanca Stock Exchange reached a total of 1 trillion MAD of capitalization, all shares combined. This number caught the attention of the Moroccan and foreign media, and it made the CSE as an interesting subject to study and watch closely from the investors. With an average of one IPO from 2018 to 2024, to 3 IPOs in 2025, even the biggest companies such as SGTM understood the interest of the retail Moroccan investor, willing to give their hard-earned savings to the Moroccan companies for growth and prosperity.

As a quantitative trader/analyst I want to study this phenomenon and build a stocks portfolio 100% based on the Moroccan shares & equities, no bonds, no currencies, no crypto (the BAM would not be happy if I do so 😊).

We will choose the MASI20, the Moroccan stock index, companies based on their market cap, their revenue and their presence in the Moroccan markets such as real state, banking, health, logistics, etc. We will analyze the essential metrics such as the daily returns, risk, variance, correlation between the shares, and finally apply a Monte Carlo simulation to optimize the studied portfolio.

-**Data source:** Casablanca Stock Exchange (Official Website), Yahoo Finance, & Investing.com

-**Sample Period:** 01/01/2010 – 01/12/2025

Market universe overview:

Chosen stocks, index weights, summary statistics:

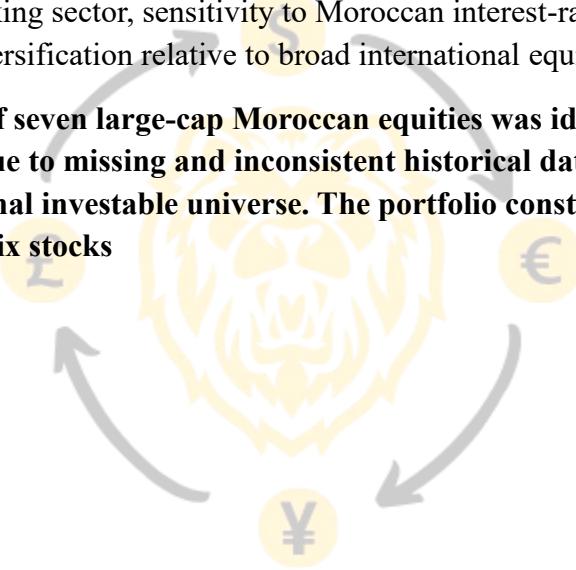
We assume that for day trading the Moroccan stocks might be a difficult activity due to the absence of data, liquidity and transparency in the markets as any other emerging market. So simply we have chosen the top 6 Moroccan stocks based on their biggest market cap and weight in the Moroccan stock indice. Also, the companies with the largest market caps tend to have more stable returns, lower tail risk and better data integrity compared to the ones with smaller caps. Market-cap weighting is a standard method used in global indices, it reflects investor preference for large, liquid companies, idiosyncratic risk, and ensures data availability for quantitative models.

Below, a simple table to display the market cap of the chosen companies and their weight in the universe, and their sector.

Stock	Market Cap (MAD)	Description
Attijariwafa Bank	155 740 453 352	Banking
Itissalat Al-Maghreb	98 282 859 012	Telecommunication
Managem	70 120 235 160	Mining
BCP	57 537 429 859	Banking
TAQA Morocco	54 230 058 058	Energy
Bank of Africa	50 697 874 912	Banking

The resulting portfolio will naturally show lower volatility compared to small caps, higher correlation within the banking sector, sensitivity to Moroccan interest-rate and credit cycle dynamics, and limited diversification relative to broad international equity markets.

NB: An initial universe of seven large-cap Moroccan equities was identified based on market capitalization. Due to missing and inconsistent historical data, Sodep-Marsa Maroc was excluded from the final investable universe. The portfolio construction is therefore based on the remaining six stocks



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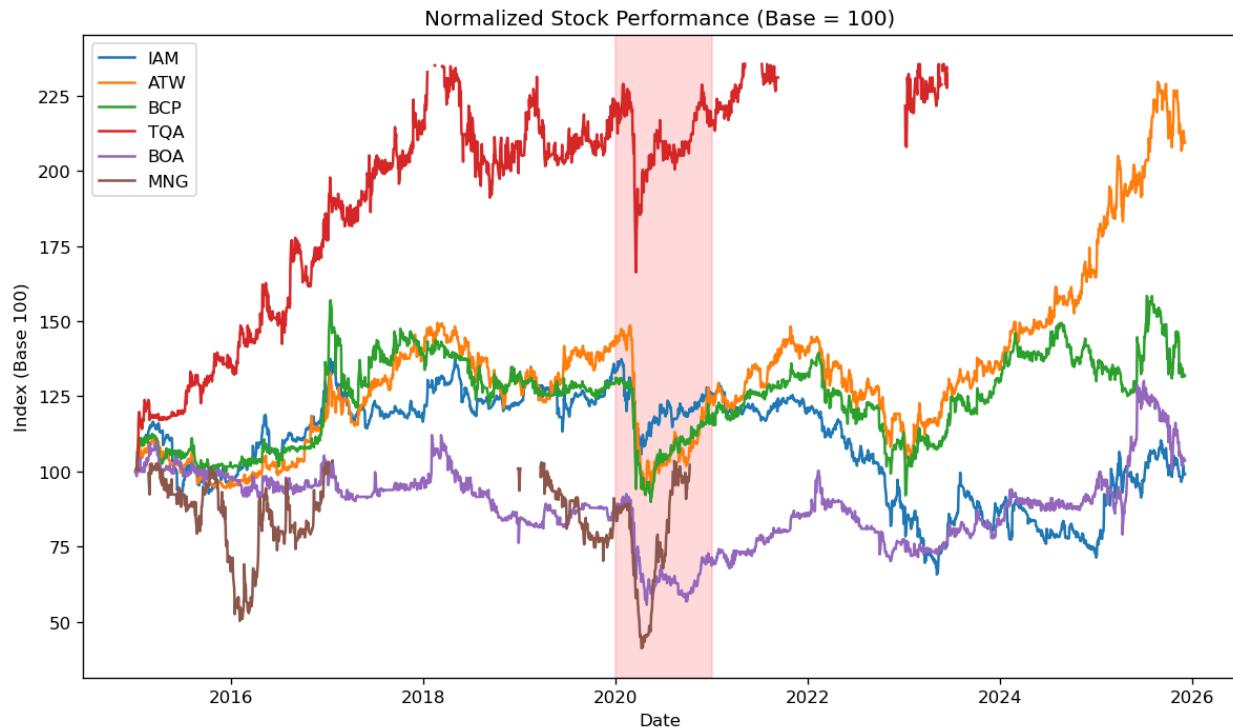
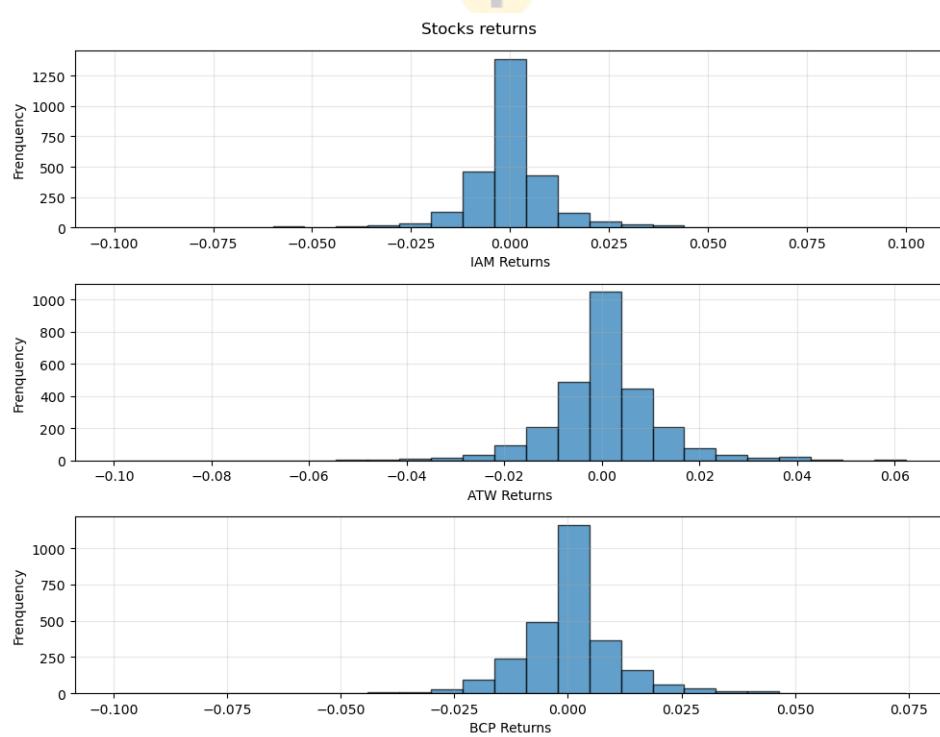


Figure 1: Stock Performance from 2015 to 12/2025

Visually by plotting the stocks price we can see heterogeneous price dynamics in a way that every stock follows its proper behavior (it will be confirmed by the Correlation Matrix in the next section). As the developed markets, the chosen stocks have reacted the same during the Covid-19 crisis losing approximately 35% of their value.



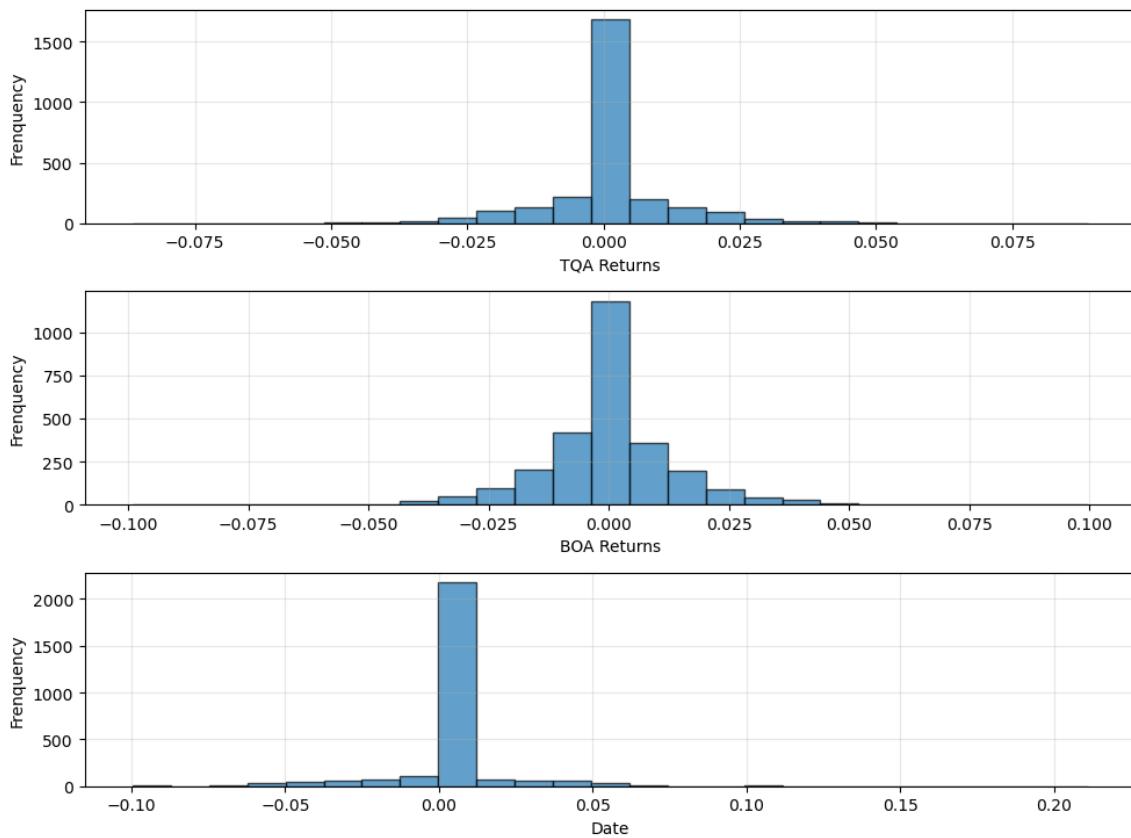


Figure 2: Stock Returns from 2015 to 12/2025

Mean returns are very close to zero for all stocks, which is typical for daily data in emerging markets. **Volatility ranges** from 1.1% to 1.7% per day, with **MNG** and **BOA** being the most volatile. All stocks exhibit **fat tails (kurtosis > 4)**, meaning the probability of extreme returns is significantly higher than in a normal distribution. **Skewness varies by stock:** some show slight negative bias (ATW, BOA), while others exhibit upward asymmetry (TQA, MNG). **MNG** stands out with the highest volatility and extreme outliers, which increases risk but also potential return contributions in portfolio construction.

NB: This quantitative profile confirms that risk management and diversification are essential and justifies later steps such as efficient frontier optimization.

Risk & correlation analysis:

Daily returns, volatility & correlation heatmap:

We decide to calculate the daily returns for our 6 chosen stocks, their daily volatility and the correlation between the shares to have a better idea of how the stocks behave on a daily basis.

	Mean daily return	Std daily return	Annualized return	Annualized volatility	Min daily return	Max daily return
IAM_price	0.0001	0.0116	0.016	0.1839	-0.0999	0.0999
ATW_price	0.0003	0.0114	0.085	0.181	-0.0999	0.0623
BCP_price	0.0002	0.012	0.044	0.1906	-0.0998	0.0744
TQA_price	0.0004	0.012	0.0973	0.1904	-0.0864	0.0889
BOA_price	0.0001	0.0142	0.0286	0.2252	-0.0991	0.0997
MNG_price	0.0002	0.0169	0.0386	0.2683	-0.0996	0.2109

Table 1: Daily return and volatility summary for the selected Moroccan equities 2015 to 12/2025

In order to characterize the risk profile of the selected stocks, we compute daily returns and derive basic statistics such as mean, standard deviation, and annualized volatility (Table 1). Large-capitalization Moroccan equities show relatively moderate average daily moves, but with occasional extreme observations, which is consistent with the behavior of emerging equity markets.

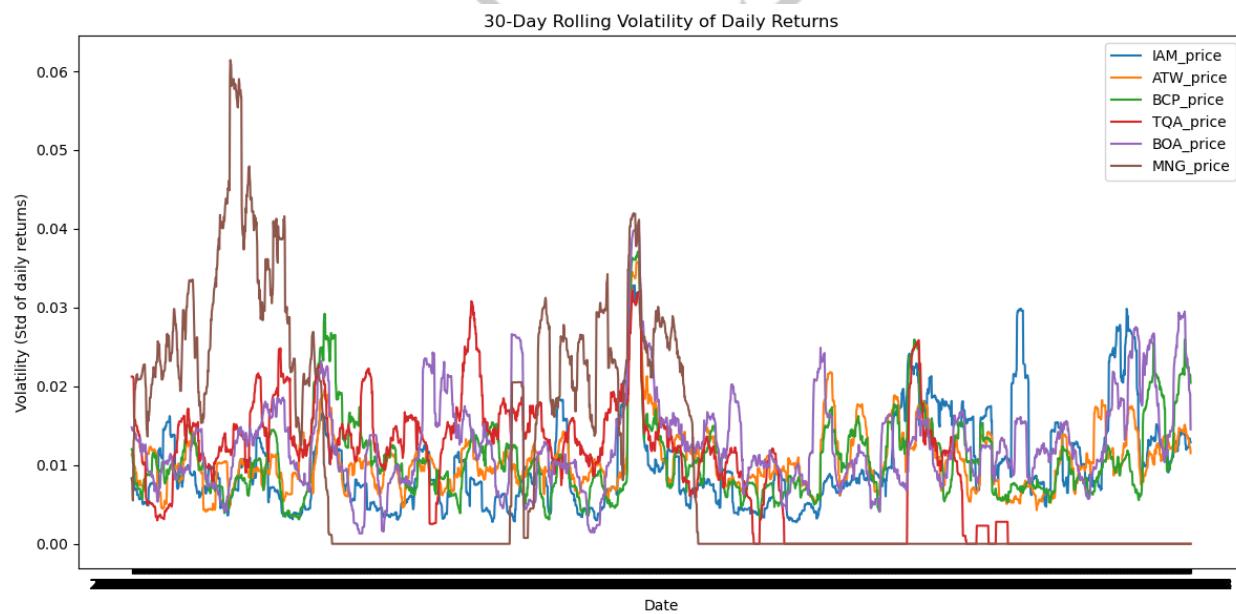


Figure 3: Daily return and volatility summary for the selected Moroccan equities 2015 to 12/2025

Figure 3 displays the 30-day rolling volatility of daily returns. Volatility is clearly not constant over time: periods of market stress are associated with sharp spikes in volatility, followed by mean-reversion towards calmer levels. This clustering of volatility has direct implications for portfolio construction and risk budgeting, as the same portfolio can exhibit very different risk levels across regimes.

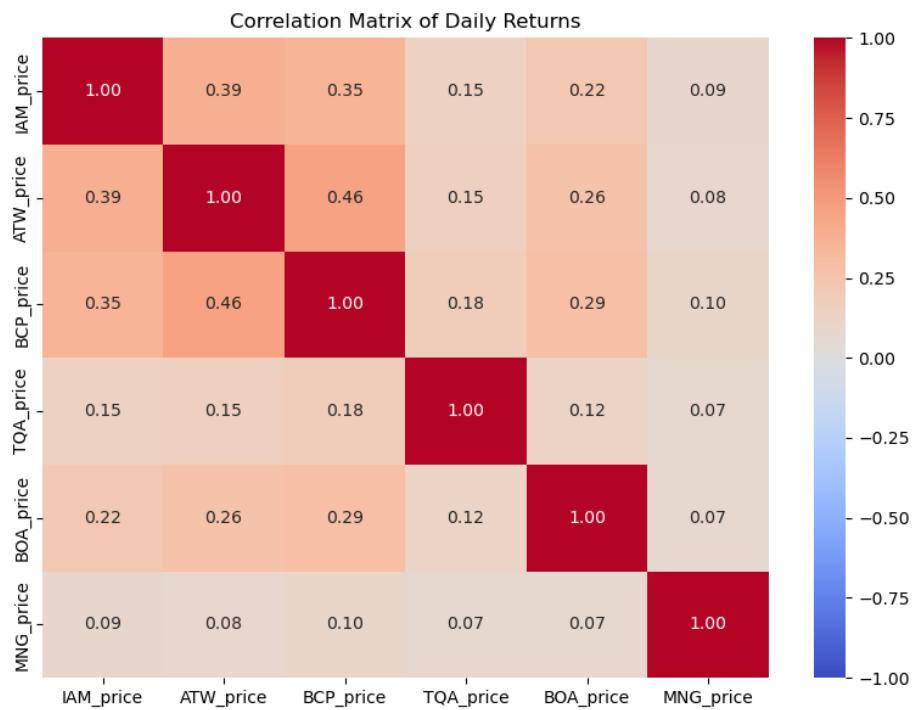


Figure 4: Correlation matrix of daily returns

The correlation matrix of daily returns is summarized in Figure 4. Overall, correlations between the six stocks are positive, reflecting exposure to common macro-economic and market factors. However, the strength of co-movement varies across pairs, suggesting that diversification benefits still exist within this small universe, especially when combining stocks from different sectors.

Benchmark Comparison (MASI20):

MASI20 Benchmark overview:

The MASI20 index is used as the benchmark for this study, as it represents the performance of the largest and most liquid equities listed on the Moroccan stock exchange. As a capitalization-weighted index, MASI20 reflects market consensus positioning and provides a relevant reference point for evaluating portfolio performance over the long term.

For consistency, daily returns of the MASI20 are computed over the same period as the selected equity universe, allowing for a direct and unbiased comparison of risk and return dynamics.

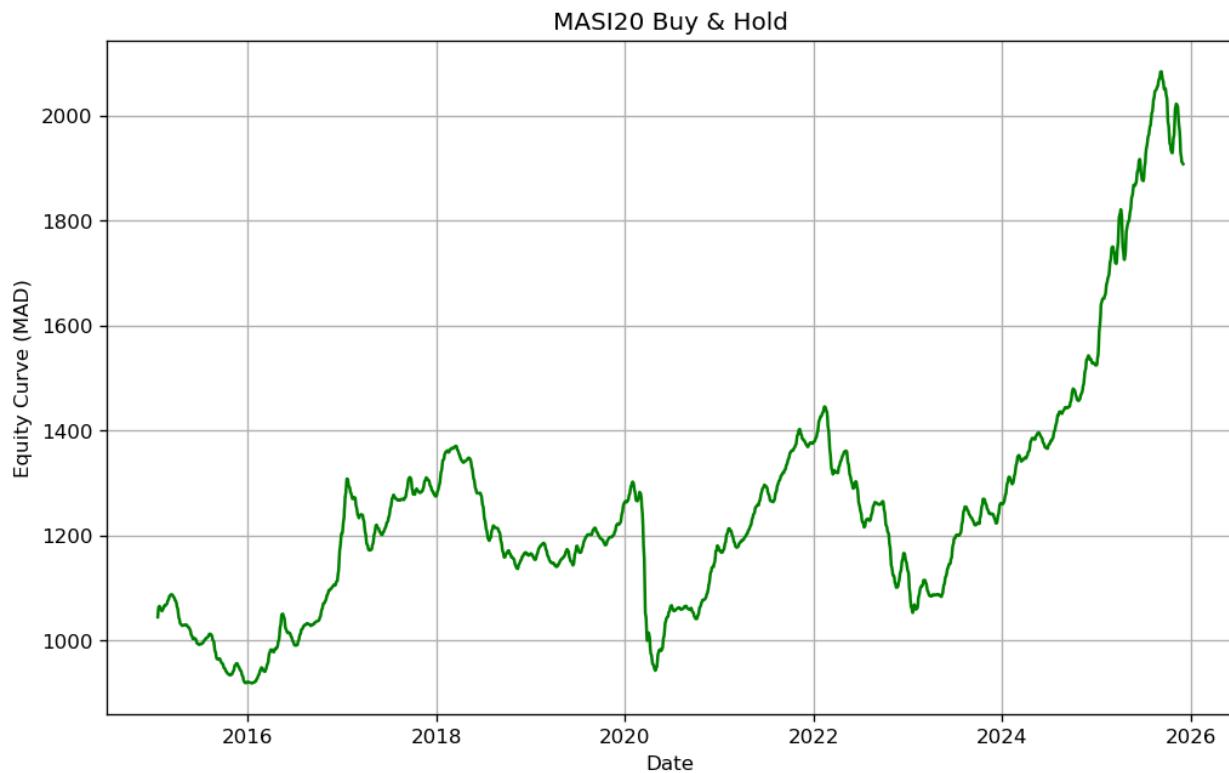


Figure 5: MASI20 10 years return for a 1000 MAD “buy and hold” strategy

Equal-weight portfolio construction:

Before applying any optimization techniques, a naïve equal-weight portfolio is constructed using the six selected stocks, with each asset allocated an identical weight of $\frac{1}{6}$. This portfolio serves as a neutral baseline, free from estimation bias and model assumptions, and allows us to isolate the value added by optimization techniques later in the study.

Equal-weight portfolios tend to implicitly tilt towards smaller and more volatile assets compared to capitalization-weighted indices, which can lead to different risk and performance characteristics.

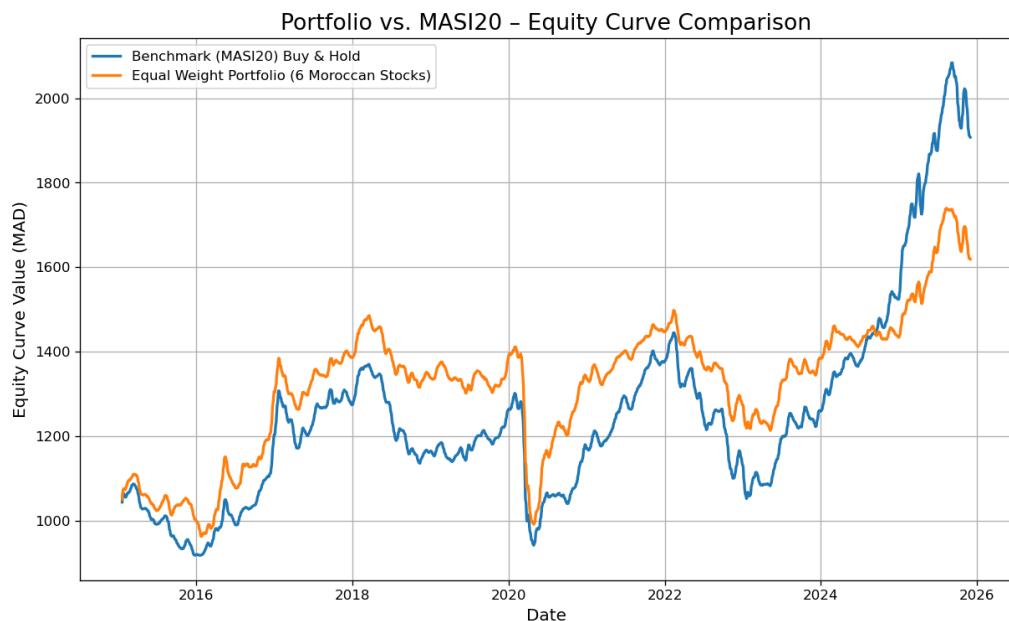


Figure 6: Buy & Hold strategy comparison (Equal weight market cap vs MASI20)

Figure 6 compares the cumulative returns of the equal-weight portfolio against the MASI20 benchmark. Over the sample period, the equal-weight portfolio exhibits periods of both outperformance and underperformance relative to the benchmark, reflecting differences in sector exposure and rebalancing effects.

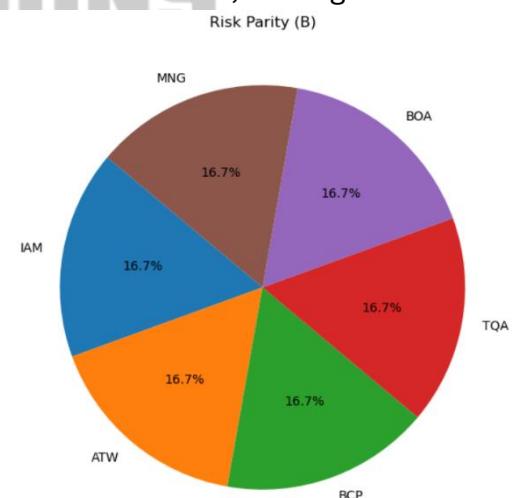
Building on this baseline analysis, the next section introduces the portfolio optimization framework used to systematically improve the risk-return trade-off beyond simple allocation rules.

Optimized portfolio strategy:

Equal-weight portfolio (Baseline):

The equal-weight portfolio allocates capital uniformly across the six stocks, serving as a simple and transparent benchmark. While this approach avoids estimation risk, it does not account for differences in volatility, correlation, or return expectations across assets.

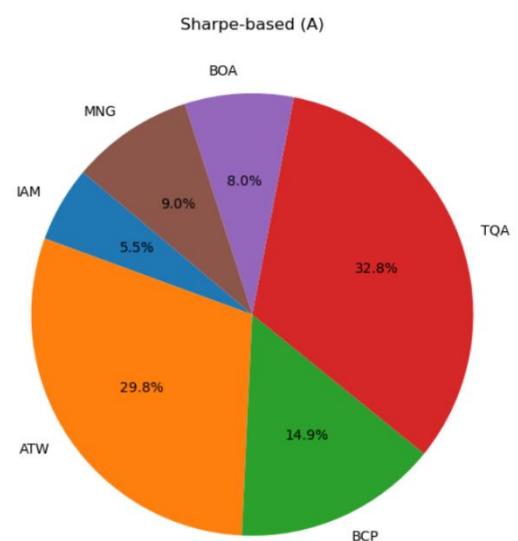
This portfolio is primarily used as a reference point to assess the value added by more sophisticated allocation methods.



Individual Sharpe-Based Allocation:

In this approach, each stock is evaluated independently based on its historical Sharpe ratio. Capital is then allocated proportionally to the relative risk-adjusted performance of each asset.

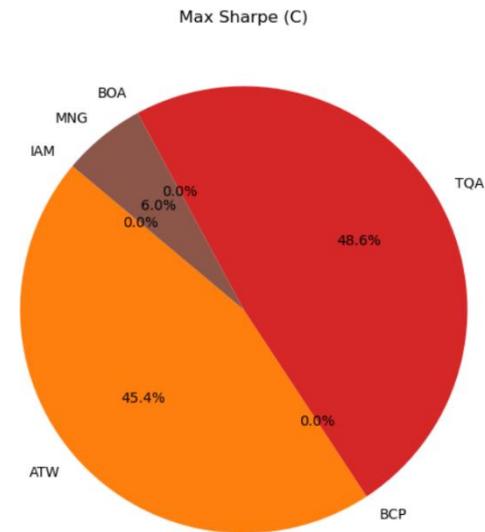
This method emphasizes stocks that have delivered superior standalone risk-adjusted returns, but it does not explicitly account for cross-asset correlations. As a result, it may lead to concentration in assets with similar risk drivers.



Maximum Sharpe portfolio (long-only):

The maximum Sharpe portfolio seeks to maximize the portfolio's risk-adjusted return subject to long-only constraints. This strategy balances expected returns against portfolio risk and diversification effects.

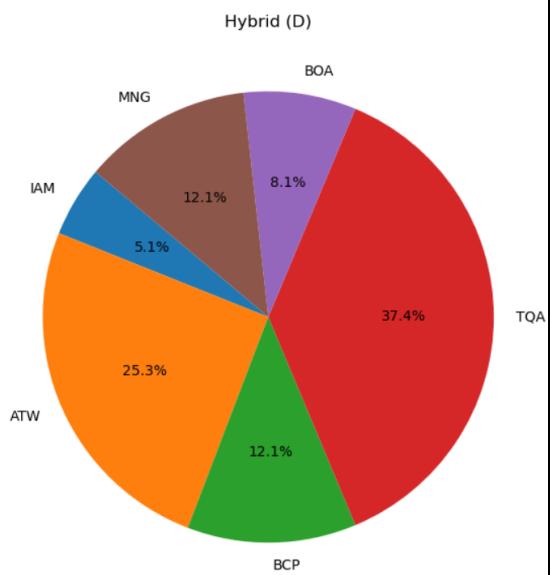
Compared to the minimum-variance portfolio, this approach typically exhibits higher volatility but offers improved return potential, making it more suitable for growth-oriented investors.



Hybrid portfolio strategy:

The hybrid portfolio combines elements of risk-parity and Sharpe optimization. Risk is first distributed evenly across assets, after which return, considerations are incorporated to enhance overall performance.

This approach aims to strike a balance between stability and return generation, producing a portfolio that is both diversified and performance oriented.



Efficient Frontier & Monte Carlo Optimization:

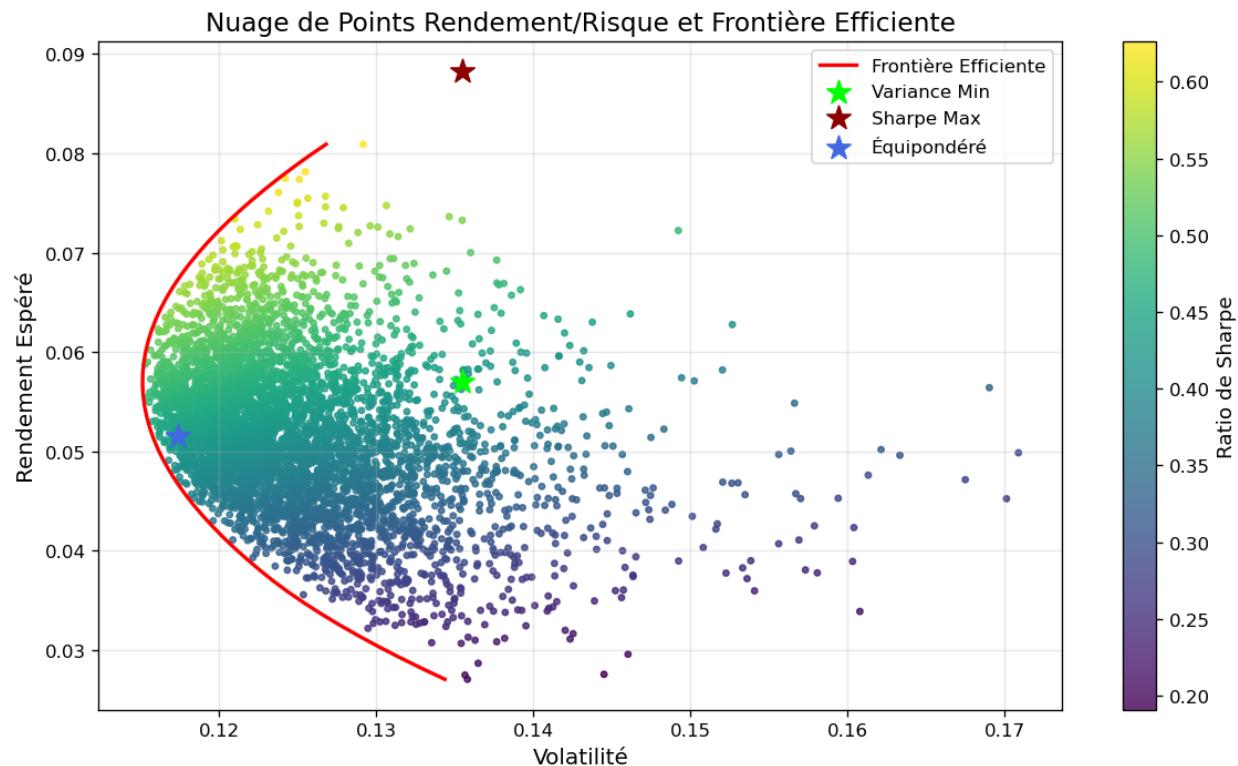


Figure 7: Efficient Frontier Graph

To move beyond naïve allocation rules, a Monte Carlo simulation is applied to generate a large number of random long-only portfolios using the six selected stocks. Each simulated portfolio differs in asset weights while respecting full investment and no short-selling constraints.

For each portfolio, expected return and volatility are computed, producing a cloud of feasible risk-return combinations. The upper envelope of this cloud forms the efficient frontier, representing portfolios that deliver the highest expected return for a given level of risk.

This framework allows the identification of optimal portfolios such as the minimum variance portfolio and the maximum Sharpe ratio portfolio, which serve as reference points for the optimized strategies analyzed in the following section.

The next section evaluates the out-of-sample performance of these portfolios, focusing on cumulative returns, drawdowns, and key risk-adjusted performance metrics.

Performance analysis of optimized portfolios:

This section evaluates the historical performance of the four portfolio strategies introduced previously: Individual Sharpe (A), Risk Parity (B), Maximum Sharpe (C), and Hybrid (D). Performance is assessed using cumulative returns, drawdown behavior, and standard risk-adjusted metrics.

Equity Curve analysis:

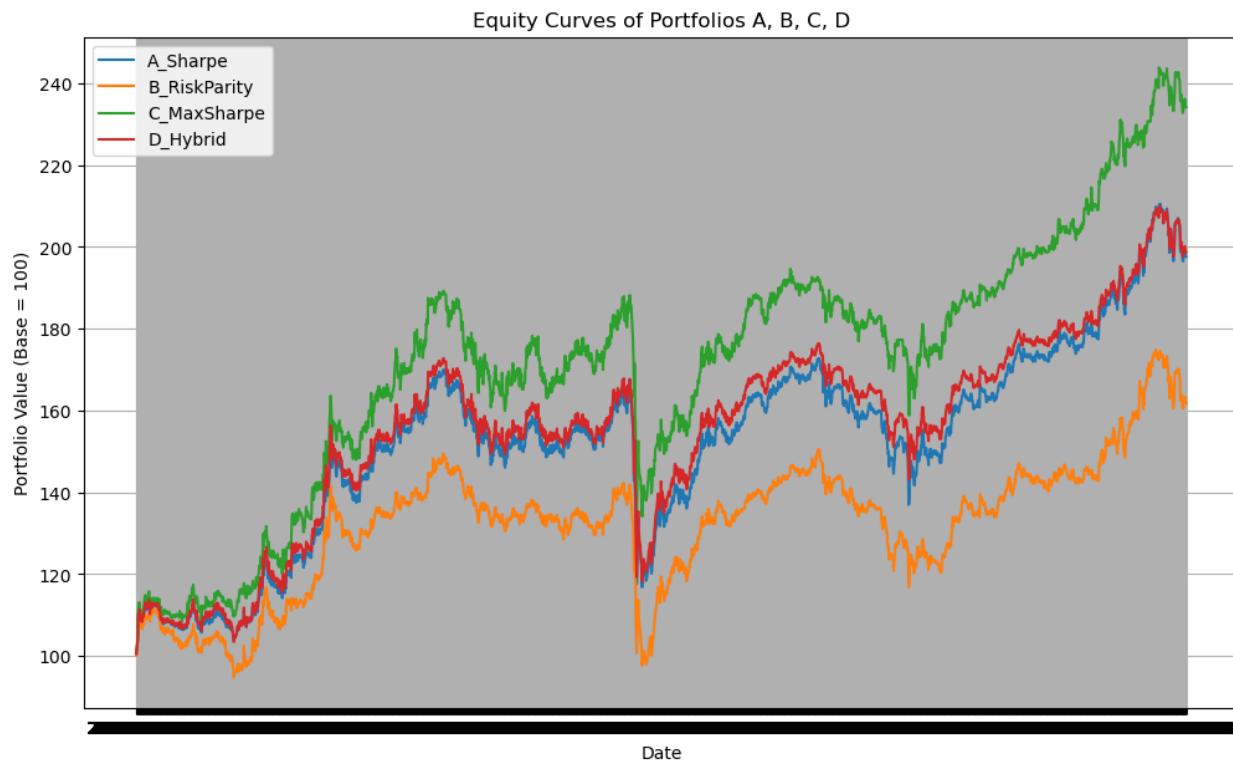


Figure 8: Equity Curve of Portfolios

- **The Maximum Sharpe portfolio (C)** clearly delivers the strongest long-term performance, ending the period with the highest portfolio value. This outcome reflects its explicit focus on maximizing risk-adjusted returns, albeit at the cost of higher volatility.
- **The Hybrid portfolio (D)** follows closely, offering a balanced trajectory that captures a significant portion of the upside while avoiding excessive concentration. This confirms the benefit of combining risk-based allocation with return optimization.

- **The Individual Sharpe portfolio (A)** delivers solid and stable growth, outperforming the Risk Parity approach while maintaining a smoother equity curve than the pure Maximum Sharpe strategy.
- **The Risk Parity portfolio (B)** exhibits the most conservative growth profile. While it underperforms in terms of cumulative return, its trajectory remains comparatively smoother during certain market phases, consistent with its volatility-balancing objective.

Drawdown Analysis:

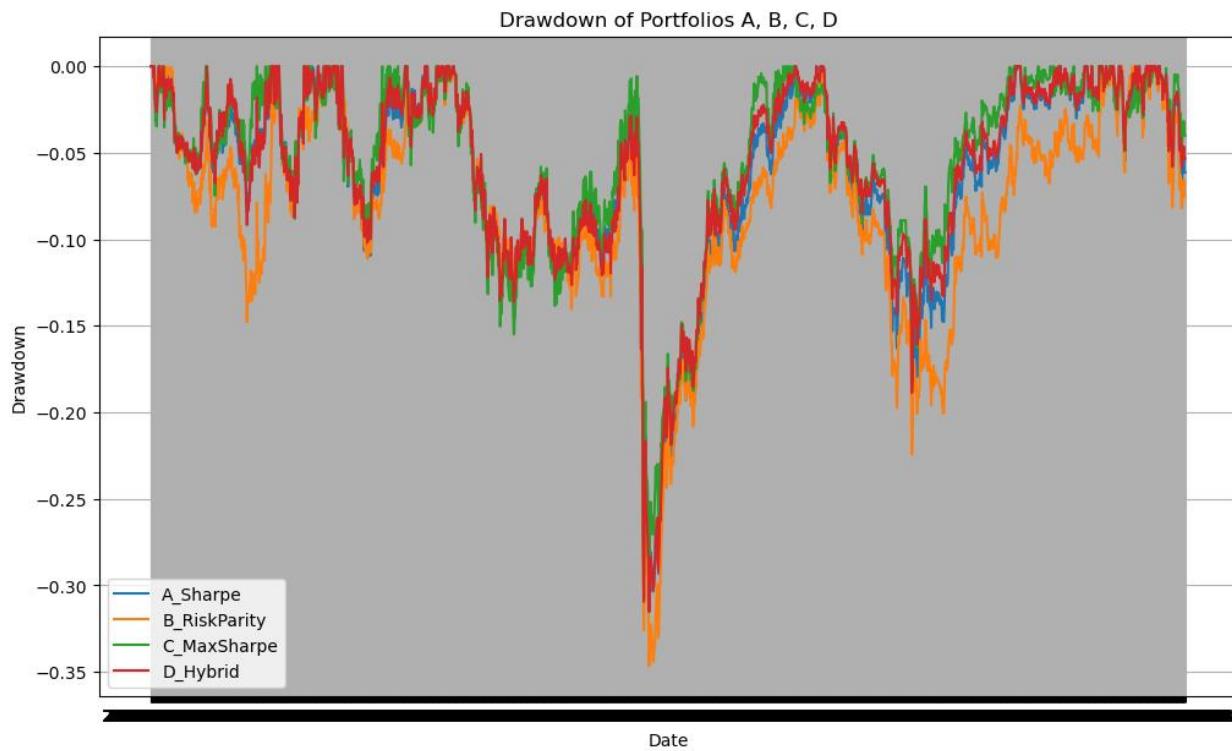


Figure 9: Drawdown of portfolios

All strategies experience pronounced drawdowns during periods of market stress, most notably during the **2020 COVID-19 crisis**, which represents the largest and most abrupt market dislocation in the sample. This episode highlights the high level of systemic risk embedded in the Moroccan equity market.

The **Risk Parity portfolio (B)** suffers the deepest drawdowns, exceeding -34%, indicating that volatility-based allocation alone does not provide sufficient protection during extreme, correlation-driven market events.

The **Maximum Sharpe portfolio (C)** records the shallowest maximum drawdown among the four portfolios, suggesting that stronger return dynamics facilitated a faster recovery despite higher volatility.

The **Individual Sharpe (A)** and **Hybrid (D)** portfolios exhibit intermediate drawdown behavior, offering a balance between downside exposure and recovery potential.

NB: The magnitude of observed drawdowns is largely attributable to the exceptional market conditions during the COVID-19 crisis, combined with the **passive nature of the portfolio management**. No dynamic risk controls, drawdown filters, or regime-based de-risking mechanisms were implemented, which naturally amplifies downside exposure during severe market shocks.

Risk-adjusted performance metrics:

Portfolio	CAGR	Volatility	Sharpe	Max Drawdown
A – Individual Sharpe	6.48%	11.98%	0.59	-31.28%
B – Risk Parity	4.55%	11.74%	0.44	-34.65%
C – Max Sharpe	8.15%	13.55%	0.65	-29.36%
D – Hybrid	6.53%	11.97%	0.59	-31.53%

The **Maximum Sharpe portfolio (C)** achieves the highest CAGR and Sharpe ratio, confirming its superior risk-adjusted performance over the sample period. The **Hybrid portfolio (D)** delivers competitive performance with lower volatility, reinforcing its role as a more balanced alternative.

The **Risk Parity portfolio (B)**, while theoretically appealing, underperforms across most metrics in this specific market context, suggesting limited diversification benefits within a concentrated equity universe.

Conclusion:

This study explored several practical portfolio construction approaches applied to a concentrated universe of large-cap Moroccan equities. By comparing equal-weight, Sharpe-based, risk-parity, maximum Sharpe, and hybrid strategies, the analysis highlights how different allocation philosophies translate into distinct risk-return profiles.

Among the tested strategies, the **Maximum Sharpe portfolio** delivers the strongest long-term performance and the highest risk-adjusted returns, while the **Hybrid portfolio** offers a more balanced alternative by combining diversification and return optimization. Defensive approaches such as risk parity appear less effective in this market context due to high systemic correlation and limited diversification opportunities.

Overall, the results confirm that **portfolio construction choices matter as much as asset selection**, especially in emerging and concentrated markets. While drawdowns remain significant under passive management, the framework provides a solid foundation for further enhancements, including dynamic risk management, regime detection, and more advanced allocation models.

This project demonstrates how quantitative portfolio techniques can be applied pragmatically to real market data, offering actionable insights while remaining transparent about limitations.

Future improvements:

- Dynamic volatility estimation (GARCH)
- Regime-based allocation
- Transaction costs and turnover
- Black-Litterman framework

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