



Infrastructure Finance

Risk–Return Analysis and Predictability of Infrastructure Assets in India, the US and Europe

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MTP I

INTRODUCTION

A brief overview of the evolution of infrastructure as a financial asset class

- Infrastructure has moved from a pure public good to a financial asset class.
- Roads, power lines, pipelines, data centres etc. generate long-lived, contract-backed cash flows.
- Governments face fiscal constraints and large funding gaps, especially in emerging economies.
- As a result, policymakers increasingly use capital markets (not just budgets/banks) to finance infrastructure.
- Listed vehicles like InvITs and REITs are central to this shift:
 - a. Monetise operating assets and recycle capital into new projects.
 - b. Offer investors units backed by infrastructure cash flows.
- In India, InvITs/REITs are relatively new; the framework has evolved only in the last decade, and market depth is limited.
- The US and Europe have longer histories and deeper markets for listed infra-like instruments (REITs, energy/infrastructure partnerships).

INTRODUCTION

Market Size: India, USA and Europe

India

- Listed InvIT + REIT market size: USD ~35–40 billion
- Infrastructure pipeline (NIP 2019–25): USD ~1.8 trillion
- India's infra market is fast-growing but still small compared to developed markets.

United States

- Listed REIT market capitalisation: USD ~1.5–1.6 trillion
- MLPs + energy infrastructure partnerships: USD ~400–450 billion
- Combined listed infra/REIT ecosystem: ~USD 2 trillion+ (largest globally)

Europe

- European listed infrastructure & utilities: USD ~600–700 billion
- European REIT sector: USD ~300–350 billion
- Total listed infra-related market: ~USD 900 billion–1 trillion

RELATED RESEARCH

- **InvITs/REITs as policy innovations:** Indian studies show that InvITs and REITs were introduced to deepen capital markets and mobilise long-term infrastructure funding, but the market remains small and still developing.
- **Risk-return behaviour:** Empirical work finds that Indian InvITs/REITs have lower volatility and steadier returns than equities, but offer diversification benefits rather than consistent risk-adjusted outperformance.
- **Machine-learning prediction of REIT/infra returns:** ML models, especially non-linear ones using technical indicators often outperform traditional econometric models in forecasting REIT and infra return patterns.
- **Financial time-series forecasting architectures:** Recent work shows that well-designed MLP-based models can match or outperform more complex RNN/Transformer architectures in financial prediction tasks.
- **Gap in literature:** Few studies combine cross-market comparison of infra assets (India-US-Europe) with systematic ML-based prediction; this thesis fills that gap.

OBJECTIVE

This study aims to understand how infrastructure assets behave as financial instruments across India, the US and Europe, and to test whether modern machine-learning models can predict short-term movements in Indian infrastructure returns.

Build a Cross-Country Dataset

- Collect daily price data for InvITs, REITs/MLPs, infra stocks and market indices.
- Clean and align the data, and convert prices into total-return series.

Analyse Risk–Return Behaviour

- Measure returns, volatility, drawdowns and Sharpe-type ratios for each asset group.
- Compare “average” InvIT, REIT and infra-stock performance within and across regions.

Evaluate Beta, Alpha & Diversification

- Estimate CAPM alpha and beta for each instrument type.
- Study variations across India, the US and Europe to understand co-movement and diversification.

Test Predictability Using ML Models

- Build linear (Granger) and ML models (MLP, LSTM) for return prediction.
- Compare statistical performance and simple trading-rule outcomes and assess their practical implications.

METHODOLOGY

Overall Research Design

Two-Part Analytical Framework

The study is structured in two major components:

- a cross-sectional analysis comparing infrastructure instruments across India, the US and Europe,
- a predictive modelling exercise focused on short-horizon return forecasting for the Indian infrastructure index. This allows both a broad market comparison and a deeper look at return dynamics.

Using Daily Market Data

- All instruments: InvITs, REITs/MLPs, infra stocks and indices are analyzed using daily return series.
- Using a uniform frequency ensures comparability across regions and facilitates both risk-return analysis and machine-learning model construction.

Consistent Approach for Comparison & Prediction

- The same cleaned dataset is used to study risk-return patterns, CAPM alpha-beta behaviour, co-movement across regions, and later to train forecasting models. This creates a consistent pipeline from raw data to empirical and predictive insights.

METHODOLOGY

Data & Return Construction

- **Cross-Country Dataset of Instruments:** The dataset includes representative InvITs/MLPs, REITs, infrastructure stocks, and relevant indices from India, the US and Europe. Instruments were selected based on trading consistency and availability of historical data to ensure meaningful comparisons.
- **Data Cleaning and Alignment:** Daily adjusted-close prices were collected using Python and standard APIs. Trading holidays were aligned across markets, missing values were treated cautiously, and corporate actions were handled through adjusted prices. This ensures a smooth and reliable time series.
- **Construction of Return and Total-Return Series:** Daily simple returns were computed from adjusted prices. Where distribution data existed, total-return series were built to reflect reinvested dividends and payouts. Five-day cumulative returns were constructed as prediction targets for the machine-learning models.
- **Type-Level Equal-Weighted Portfolios:** To reduce noise from individual instruments, equal-weighted portfolios were created for each type: InvIT/MLP, REIT and infra stock in each region. Annualized returns and volatilities were computed for consistent cross-country comparison.

METHODOLOGY

Risk-Return Analysis & Predictive Modelling

- **Risk-Return Metrics and CAPM Estimation:** For each instrument and portfolio, the study computes annualised returns, volatility, Sharpe-type ratios and drawdowns. CAPM regressions were used to estimate alpha and beta relative to appropriate benchmarks, providing insight into market sensitivity.
- **Diversification and Cross-Market Co-Movement:** Correlation matrices across India, the US and Europe help reveal whether infrastructure behaves as a global asset class or remains region-specific. This step identifies diversification opportunities and overlap across markets.
- **Prediction Setup for the Indian Infrastructure Index:** Short-horizon predictability is tested using 5-day cumulative returns as the target. Features include lagged returns of the Indian infra index and global indices, allowing the models to capture domestic momentum and international spillovers using chronological train-test splits.
- **Machine Learning Models and Evaluation:** Two models: an MLP and an LSTM are trained and compared with linear benchmarks. Performance is evaluated using RMSE, R² and directional accuracy. Various tests whether the prediction quality translates into meaningful economic gains.

RESULTS AND DISCUSSION

India: Universe & Instrument-Level Risk-Return

- **Indian infra universe and benchmark**

The Indian sample has one infra ETF (INFRABEES), three InvITs (IRBINVIT, INDIGRID, PGINVIT), three office REITs (BIRET, EMBASSY, MINDSPACE) and five infra-related stocks (Adani Ports, IRB, L&T, NTPC, Power Grid). INFRABEES acts as the infra-basket benchmark for all comparisons.

	Name	Type	Sector	Alpha_annual	Beta	t_alpha	t_beta	R2	N_obs
Ticker									
IRBINVIT.NS	IRB InvIT Fund	InvIT	Roads / Highways	-3.6800	0.1700	-0.2700	1.8700	0.0100	1044
INDIGRID.NS	IndiGrid (India Grid Trust)	InvIT	Power Transmission	7.7700	0.1000	1.7000	3.4700	0.0200	1044
PGINVIT.NS	POWERGRID InvIT	InvIT	Power Transmission	0.7300	0.0800	0.1200	2.9000	0.0100	1044
BIRET.NS	Brookfield India Real Estate Trust	REIT	Commercial Offices (REIT)	4.6000	0.1400	0.6500	3.9600	0.0200	1044
EMBASSY.NS	Embassy Office Parks REIT	REIT	Commercial Offices (REIT)	4.9200	0.0800	0.6300	1.6100	0.0000	1044
MINDSPACE.NS	Mindspace Business Parks REIT	REIT	Commercial Offices (REIT)	7.7200	0.0900	1.1600	2.7600	0.0100	1044
ADANIPORTS.NS	Adani Ports & SEZ	Stock	Ports / Logistics	0.2000	1.2300	0.0100	9.9400	0.2700	1044
IRB.NS	IRB Infrastructure Developers	Stock	Roads / BOT / EPC	23.9800	1.2400	1.1200	9.6100	0.1700	1044
LT.NS	Larsen & Toubro	Stock	Engineering & Construction (EPC)	8.3000	0.8800	0.9900	10.3200	0.3600	1044
NTPC.NS	NTPC Limited	Stock	Power Generation (PSU)	15.1800	0.8700	1.5800	11.0900	0.3000	1044
POWERGRID.NS	Power Grid Corporation	Stock	Power Transmission (PSU)	11.7000	0.7500	1.1200	8.3600	0.2200	1044

Table 1

RESULTS AND DISCUSSION

India: Universe & Instrument-Level Risk-Return

- **ETF and InvITs: mid returns, low risk:** On a total-return basis, the infra ETF earns ~20% per year with volatility around 16%, giving a Sharpe ratio a little above 0.8. Among InvITs, INDIGRID is the best-behaved name with ~16% annual return at only ~11% volatility (Sharpe \approx 0.83), while PGINVIT delivers lower returns and IRB InvIT shows a weak 5–6% return with relatively high volatility and a slightly negative Sharpe.
- **REITs lies “somewhere in the middle”:** The three office REITs cluster together with annual returns in the 13–16% range and volatility around 17–19%. Their Sharpe ratios (0.3–0.5) are slightly lower than the ETF and the strongest InvITs, but they sit close to the benchmark in risk–return space.
- **Infra stocks: higher return, much higher volatility:** Infra stocks are clearly more aggressive. IRB and NTPC deliver very high annual returns (\approx 47% and \approx 34%) but with volatilities close to 50% and 26%. L&T and Power Grid also show strong returns with mid-20s volatility. In the scatter plot, stock points fan out to the top-right, while InvITs, REITs and the ETF sit in a compact mid-risk, mid-return cluster.

RESULTS AND DISCUSSION

India: Universe & Instrument-Level Risk-Return

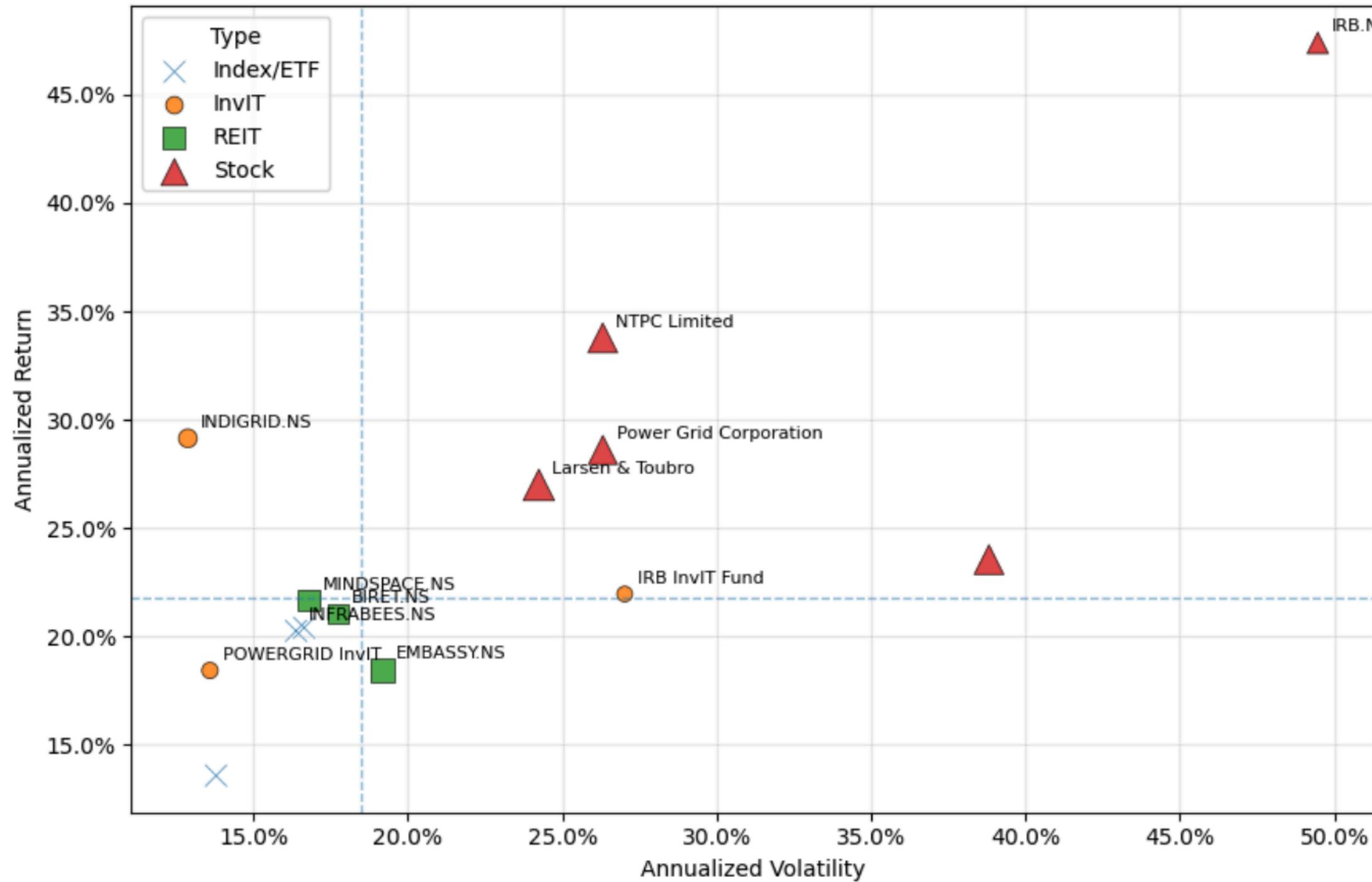


Fig.1 (Risk-Return)

RESULTS AND DISCUSSION

India: Type-Level Averages (InvIT vs REIT vs Stock)

- **Average risk-return by type:** When we average across names, InvITs earn about 23% per year with volatility near 18%, REITs earn about 20% with similar volatility, and infra stocks earn the highest average return, around 32%, but with volatility above 33%.
- **Sharpe ratios and trade-offs:** Despite lower raw returns, InvITs have the highest average Sharpe ratio (~1.0) because they combine decent returns with relatively low volatility. Stocks have a slightly lower Sharpe (~0.78) as their extra return comes with a big jump in risk. REITs sit in between, with mid-20s returns and Sharpe ratios around 0.75.
- **Interpretation for Indian investors:** For a domestic equity investor, InvITs and REITs effectively act as a lower-volatility equity sleeve. Stocks offer more upside but also much larger drawdowns and price swings. Over the sample, InvITs give the best balance of return per unit risk, while REITs and the infra ETF provide steady, income-oriented exposure around the middle of the risk-return spectrum.

RESULTS AND DISCUSSION

India: Type-Level Averages (InvIT vs REIT vs Stock)

Type	Count	Ann. Return (avg) %	Ann. Return (median) %	Ann. Vol (avg) %	Sharpe (avg)	Alpha (avg) %	Beta (avg)	R ² (avg)
InvIT	3	23.1800	21.9600	17.8300	1.0400	14.4900	0.1300	0.0100
REIT	3	20.3900	21.0600	17.9100	0.7500	12.0300	0.1000	0.0100
Stock	5	32.0600	28.6100	33.0300	0.7800	11.8700	0.9900	0.2600

Table 2

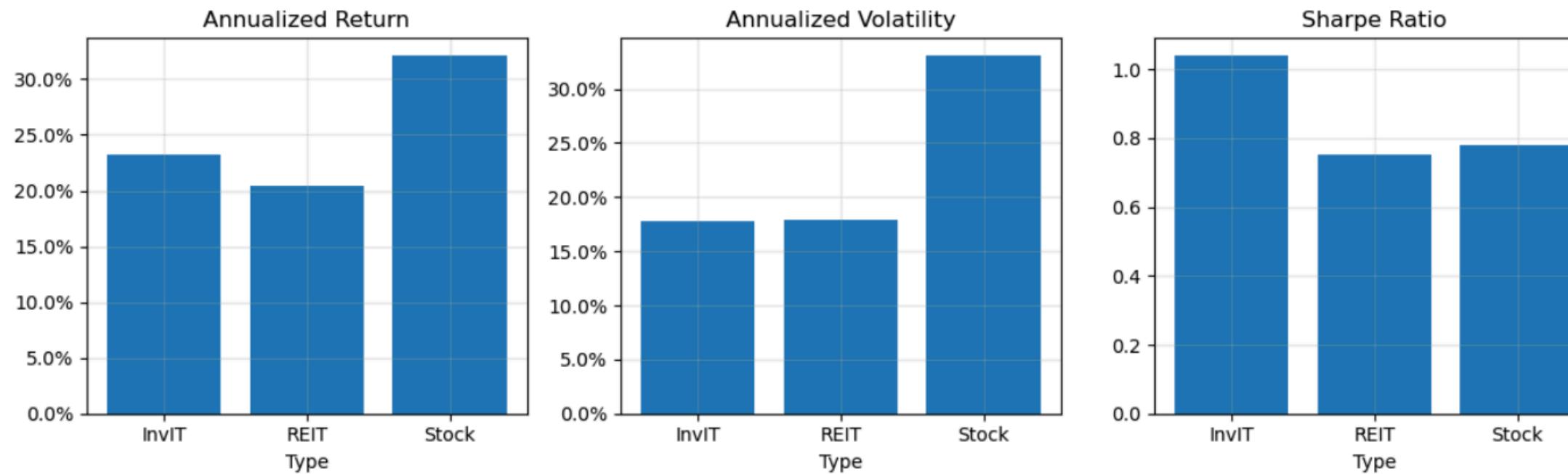


Fig.2

RESULTS AND DISCUSSION

India: CAPM Alpha, Beta and Rolling Betas

- **InvITs and REITs: very low beta:** CAPM results show betas around 0.1 and very low R² for InvITs and REITs. Their returns move only slightly with the infra ETF, and alphas are small and only weakly significant.
- **Infra stocks: market-driven and high beta:** Infra stocks have betas close to or above 1 with much higher R². They move strongly with the infra ETF, and some (like IRB and NTPC) also earn sizeable positive alphas.
- **Type averages: defensive trusts vs equity-like stocks:** On average, InvITs and REITs both sit near 0.1 beta, while the stock bucket is near 1.0. All three types have positive average alphas, but only stocks show a strong link to the benchmark index.
- **Rolling betas over time:** Rolling 90-day betas keep this pattern: stock beta stays around or above 1, while InvIT and REIT betas remain in a low 0–0.4 band. By the end of the sample they are roughly 0.26 (InvITs), 0.03 (REITs) and 1.06 (stocks), confirming trusts/REITs as low-beta infra exposure.

RESULTS AND DISCUSSION

India: CAPM Alpha, Beta and Rolling Betas



Fig.3 (Rolling 90-Day Beta)

RESULTS AND DISCUSSION

USA: Instrument-Level Risk-Return

Type	Count	Ann. Return (avg) %	Ann. Return (median) %	Ann. Vol (avg) %	Sharpe (avg)	Alpha (avg) %	Beta (avg)	R ² (avg)
MLPS	3	18.0400	18.4100	31.7600	0.5000	6.7500	0.7900	0.3100
REIT	4	15.6100	15.6100	28.6200	0.4700	6.3000	0.6200	0.2300
Stock	3	12.8300	12.5300	26.8200	0.4100	2.2500	0.7300	0.3600

Table 3

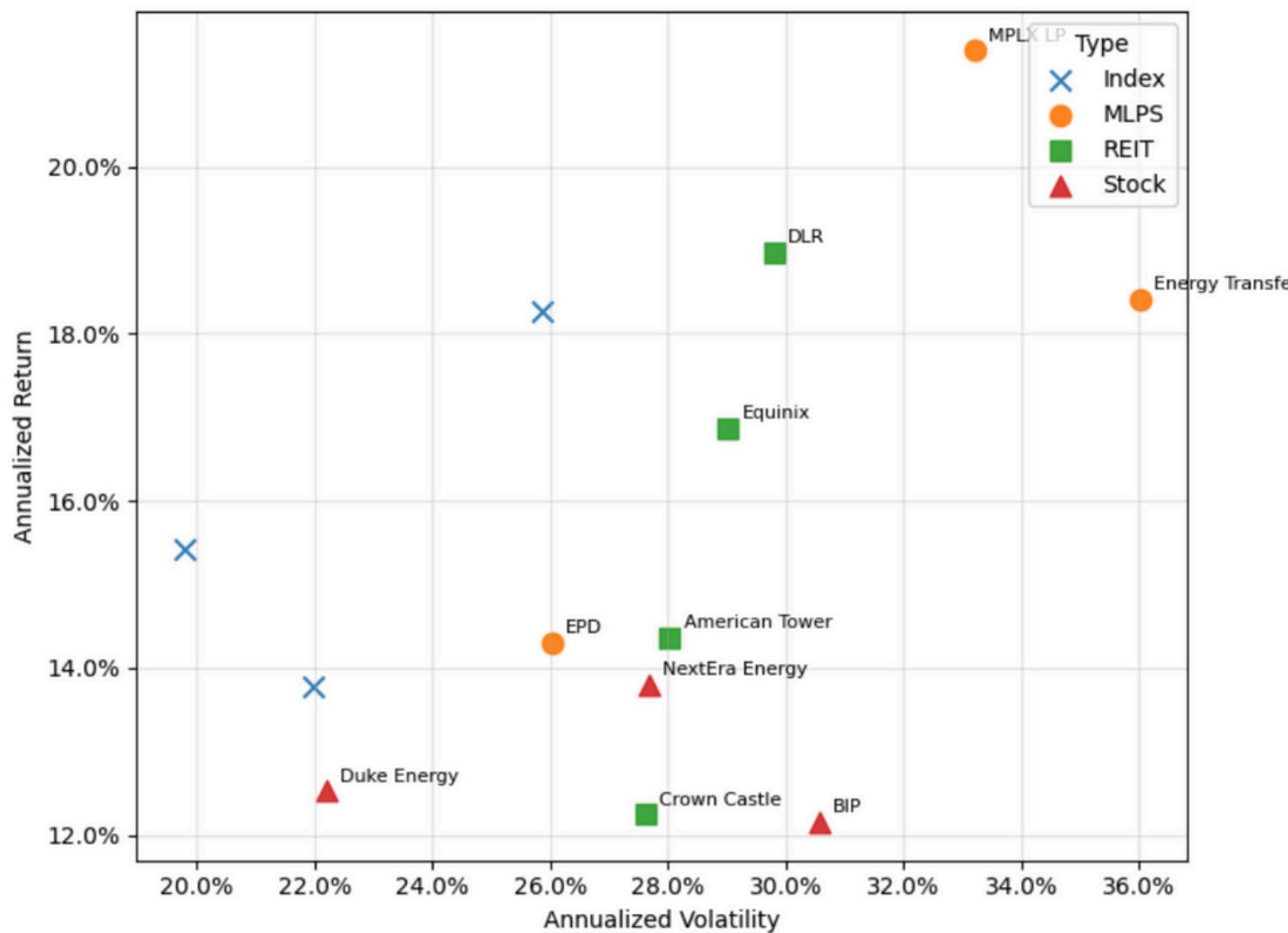


Fig.4 (Risk-Return)

RESULTS AND DISCUSSION

USA: Rolling 90-Day Beta



Fig.5

RESULTS AND DISCUSSION

Europe

Type	Count	Ann. Return (avg) %	Ann. Return (median) %	Ann. Vol (avg) %	Sharpe (avg)	Alpha (avg) %	Beta (avg)	R ² (avg)
Index	1	6.2800	6.2800	18.8500	0.2300	NaN	NaN	NaN
REIT	1	13.9700	13.9700	27.7100	0.4300	9.8600	0.4900	0.1100
Stock	6	10.8600	11.6800	24.8700	0.3600	5.9500	0.6800	0.2800

Table 4



Fig.6 (Rolling 90-Day Beta)

RESULTS AND DISCUSSION

Cross-Country Comparative Analysis

	Region	Type	AnnReturn	AnnVol	Beta	AlphaAnnual	Sharpe
0	Europe	Index	0.1065	0.1875	1.0000	0.0000	0.0306
1	Europe	REIT	0.1805	0.2847	0.4623	0.1138	0.0345
2	Europe	Stock	0.1703	0.2390	0.6177	0.0906	0.0386
3	India	Index	0.2245	0.1638	1.0000	0.0000	0.0549
4	India	InvIT	0.1085	0.1624	0.1207	0.0248	0.0241
5	India	REIT	0.1517	0.1745	0.1034	0.0665	0.0296
6	India	Stock	0.3826	0.3303	0.9946	0.1188	0.0513
7	US	Index	0.1477	0.2197	1.0000	0.0000	0.0338
8	US	MLPS	0.1981	0.3176	0.7876	0.0675	0.0318
9	US	REIT	0.1300	0.2858	0.6220	0.0285	0.0223
10	US	Stock	0.1369	0.2682	0.7282	0.0225	0.0259

Table 5

RESULTS AND DISCUSSION

Cross-Country Comparative Analysis

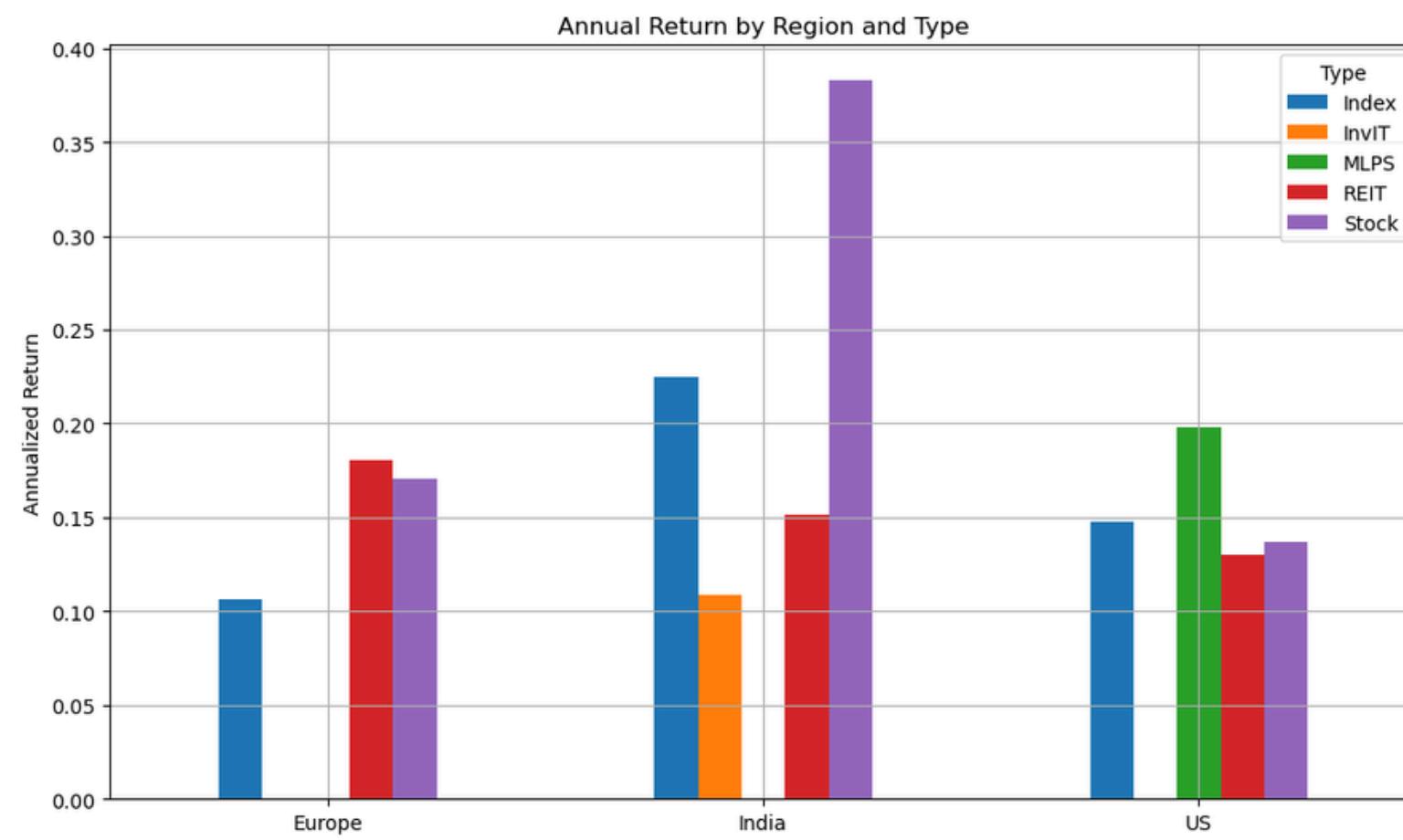


Fig.7

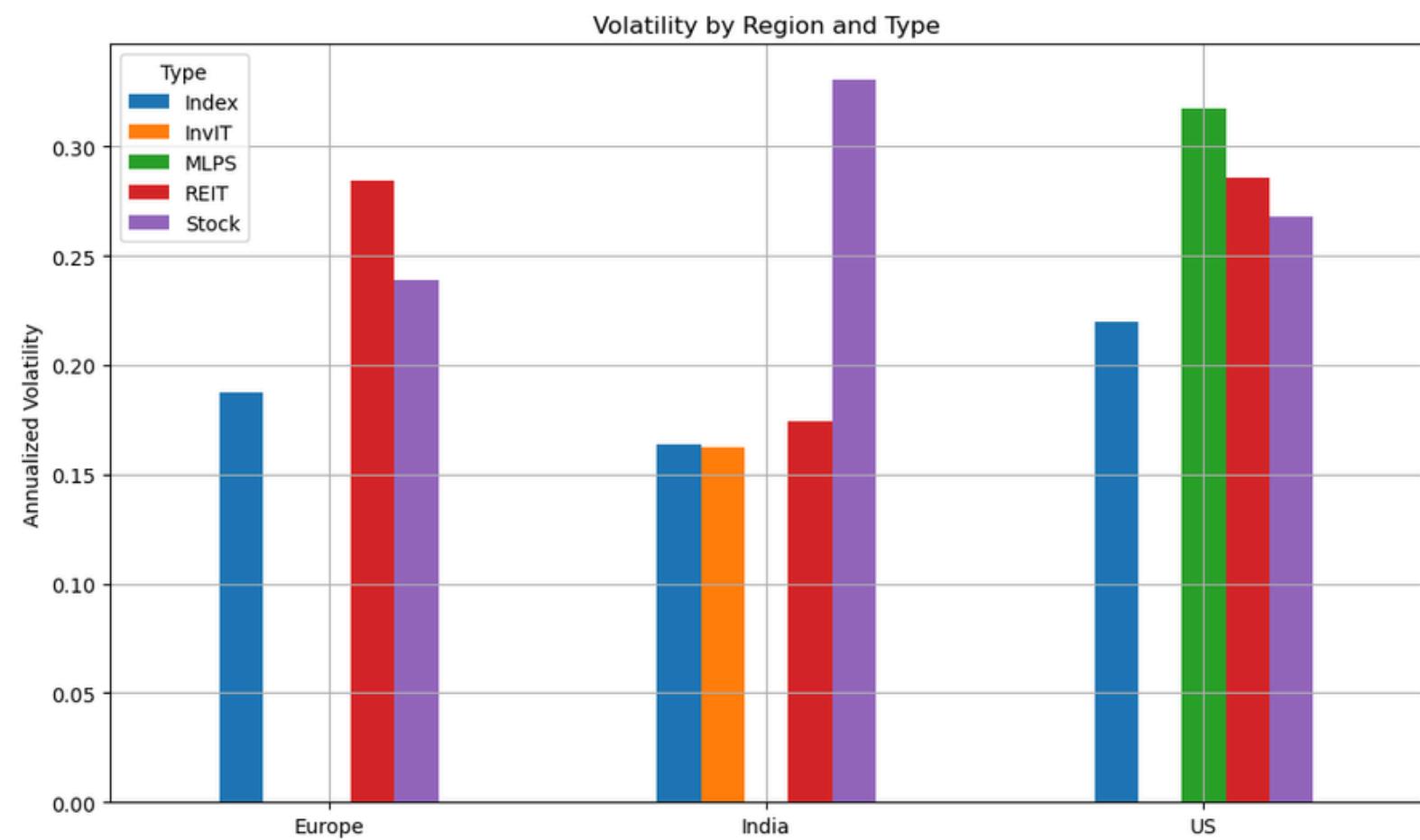


Fig.8

RESULTS AND DISCUSSION

Cross-Country Comparative Analysis

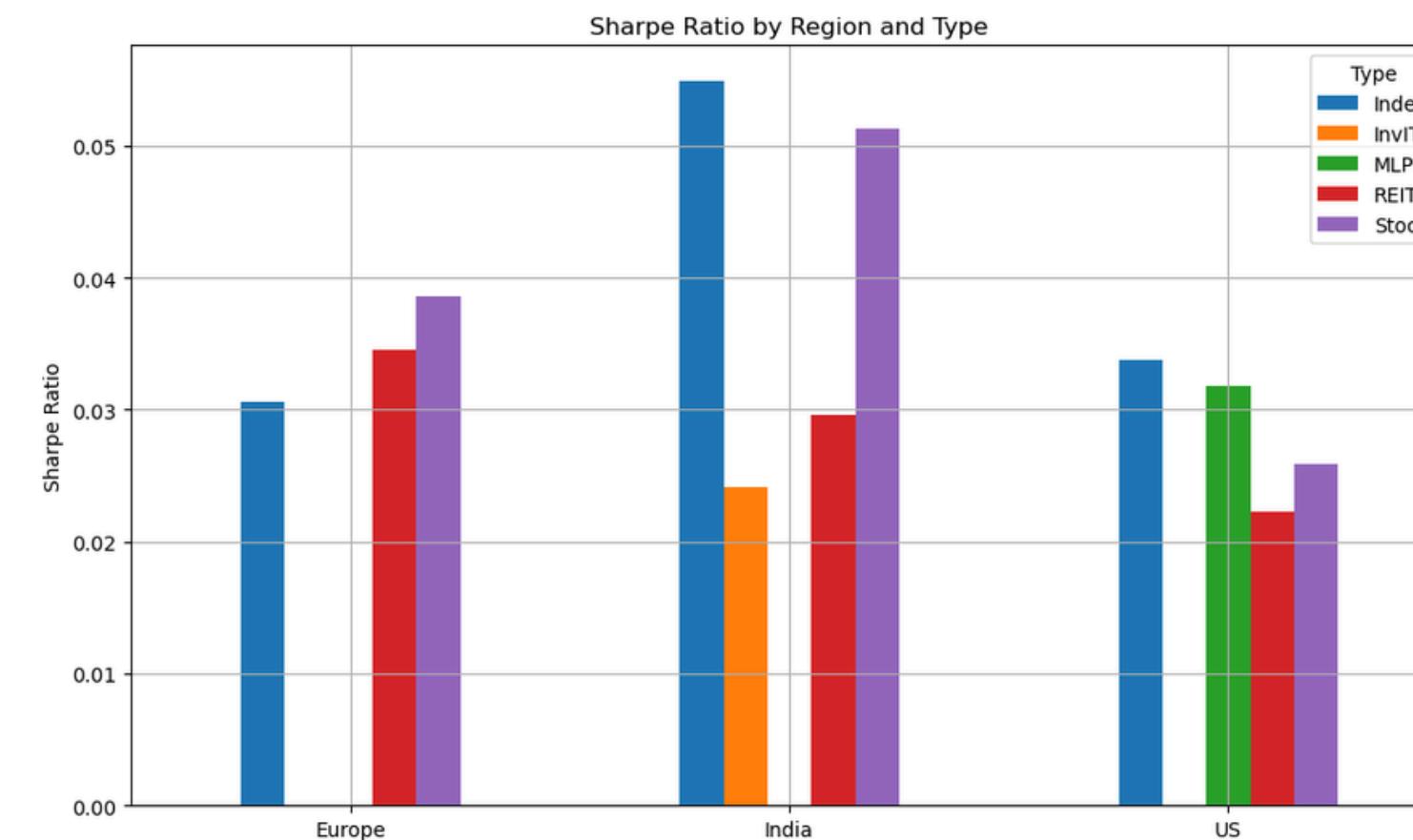


Fig.9

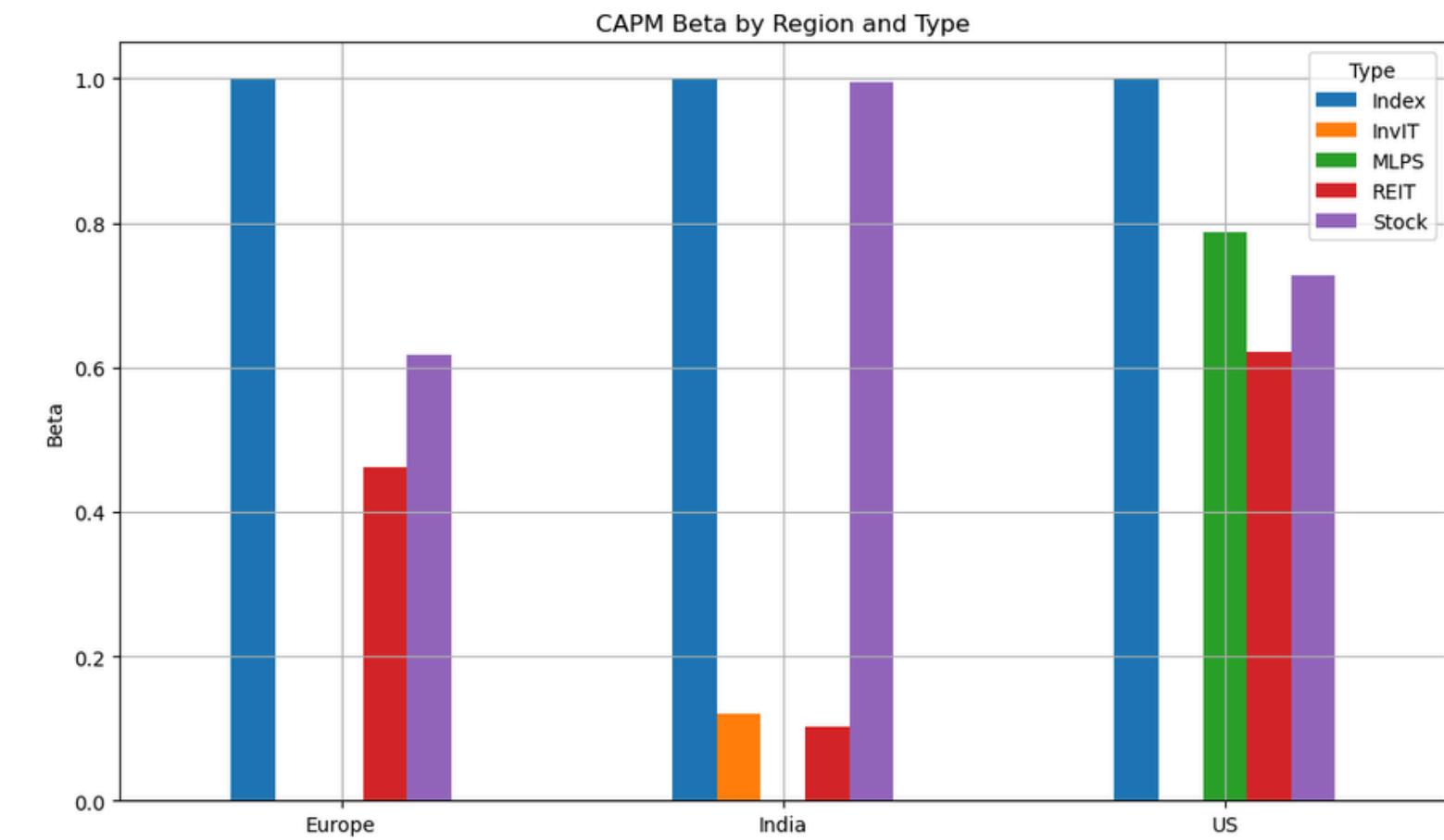


Fig.10

RESULTS AND DISCUSSION

Cross-Country Comparative Analysis

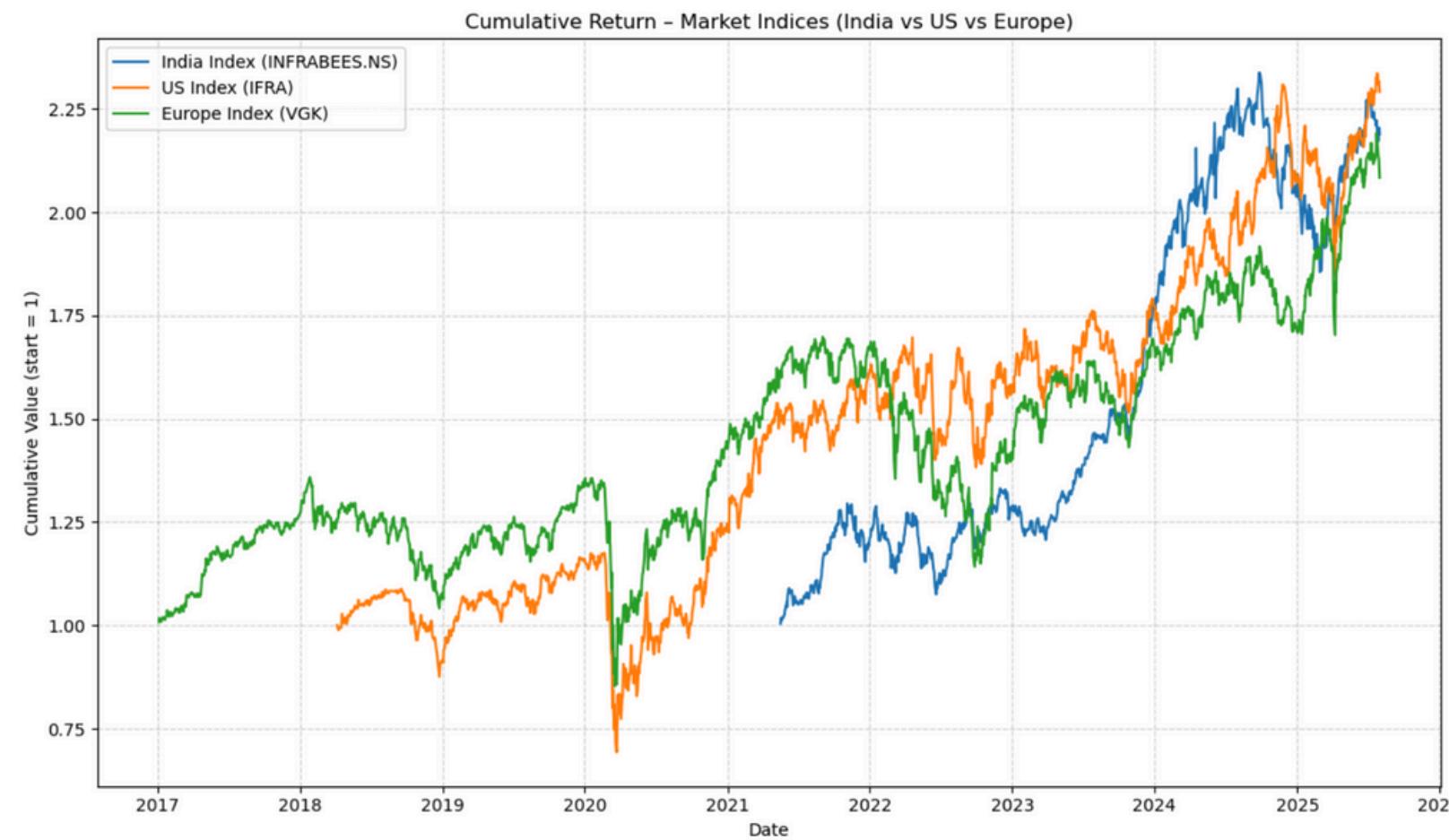


Fig.11

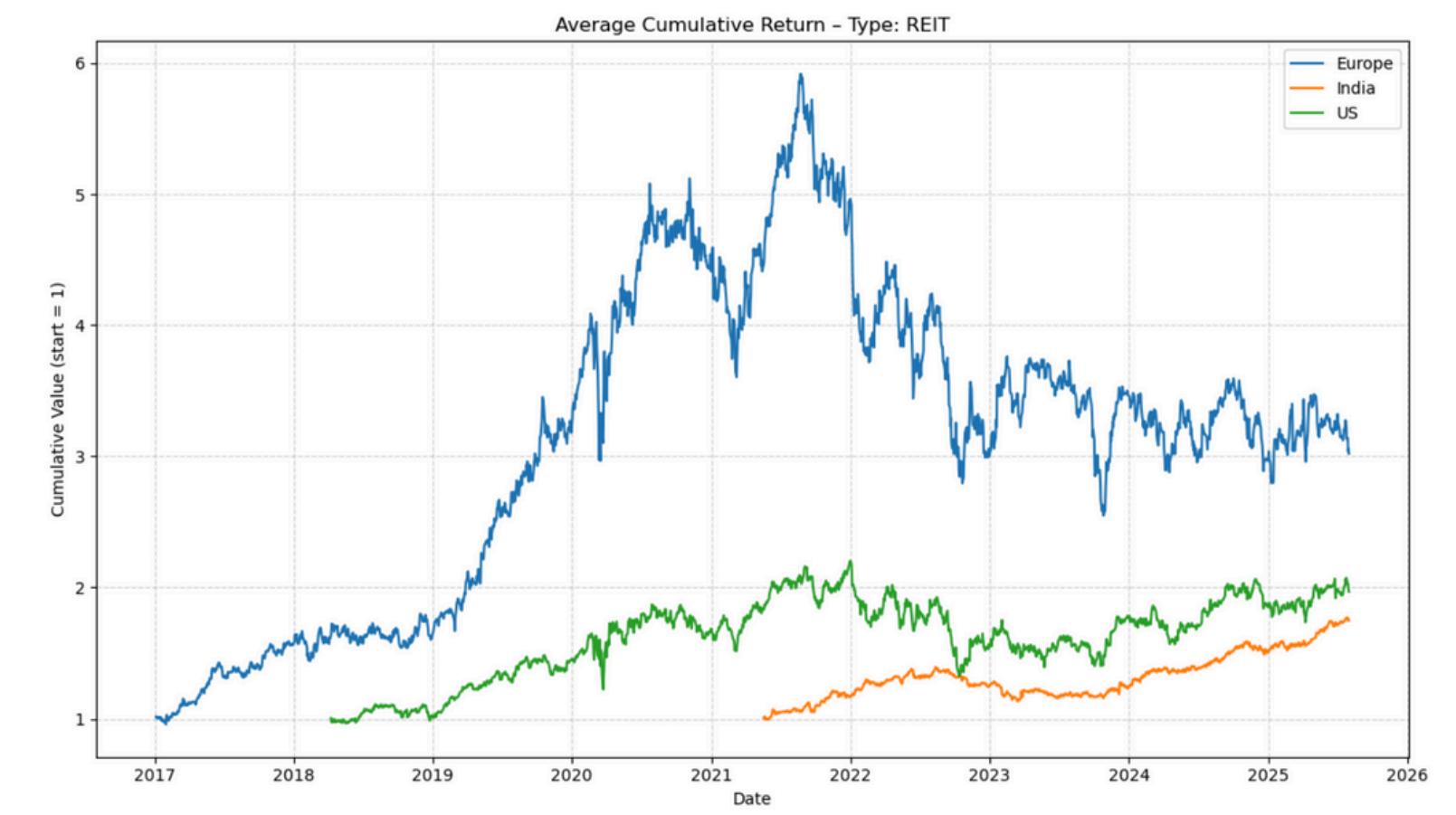


Fig.12

RESULTS AND DISCUSSION

Cross-Country Comparative Analysis

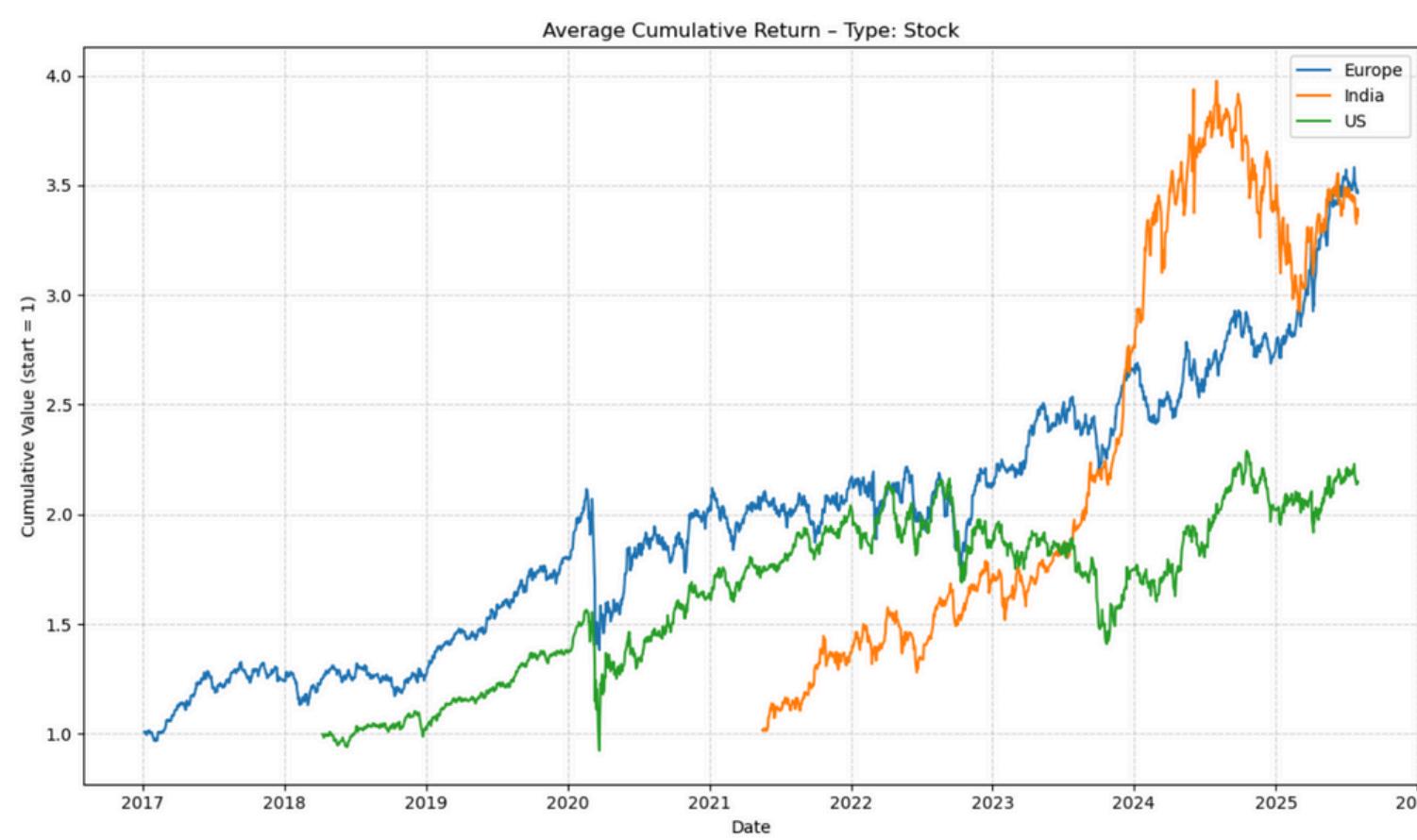


Fig.13

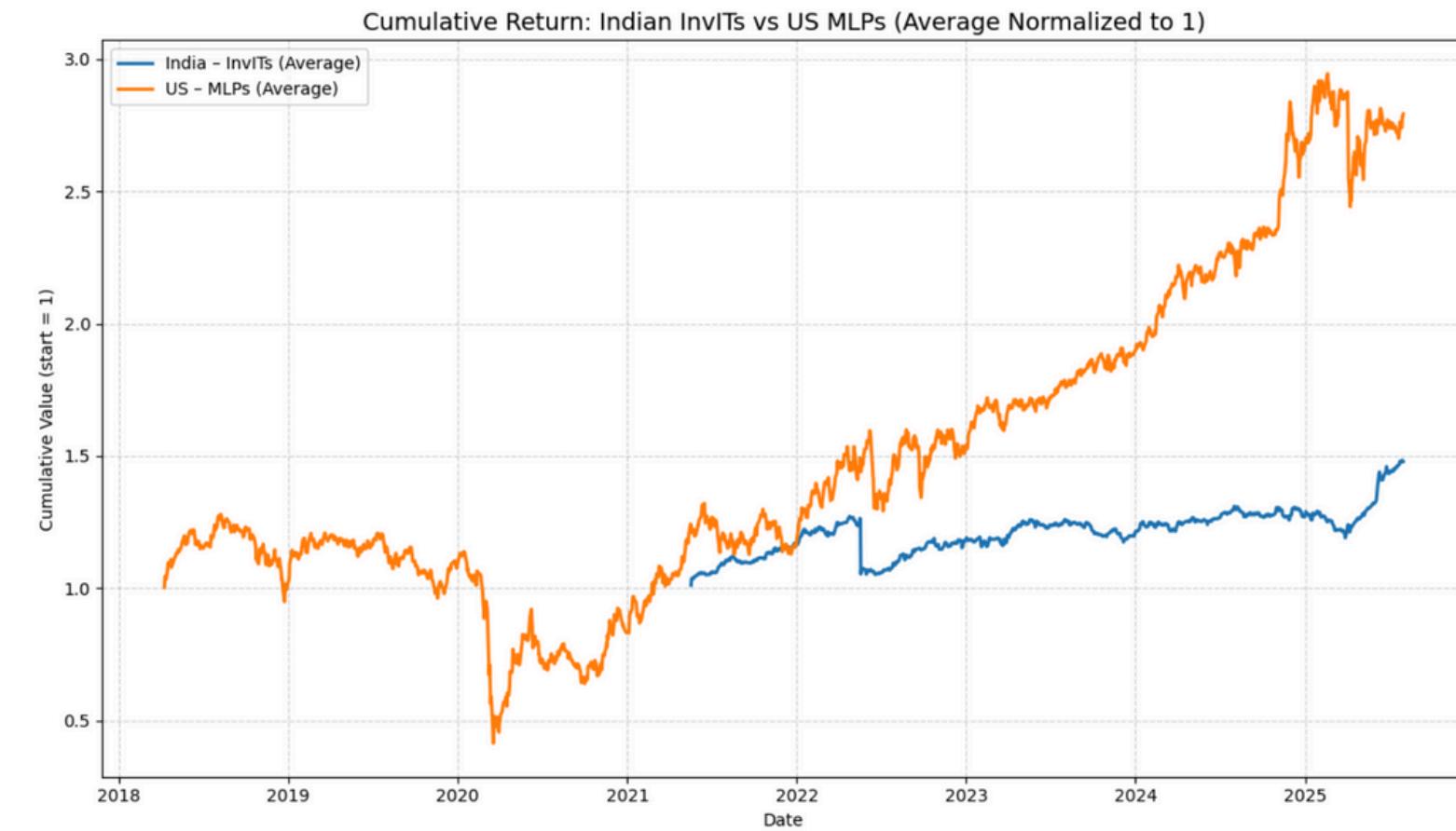


Fig.14

RESULTS AND DISCUSSION

Predictive Modelling of Indian Infrastructure Returns

- Granger causality tests show that US and European infra returns help predict Indian infra returns at short lags (p-values well below 0.01), so global indices are added as inputs in ARX, MLP and LSTM “global” models.

AR vs ARX (Daily Returns)

- **Models and linkages:** First estimated a simple AR(1) model on Indian infra returns, and then an ARX(1) model that also uses lagged US and European infra returns. Granger tests show strong and significant links from US/EU infra to India, so it is reasonable to try adding these global variables.
- **Effect of adding US & Europe:** The AR model reaches an RMSE of about 0.010 and a direction accuracy of ~53%. The ARX model with US and Europe keeps almost the same direction accuracy and a very similar RMSE. In other words, global returns do not dramatically change the forecast, but they also do not destabilise the model.
- **Takeaway:** For simple linear daily-return models, India's own past returns carry almost all the exploitable information, and adding US/EU mainly serves as a robustness check rather than a major performance boost.

RESULTS AND DISCUSSION

Predictive Modelling of Indian Infrastructure Returns

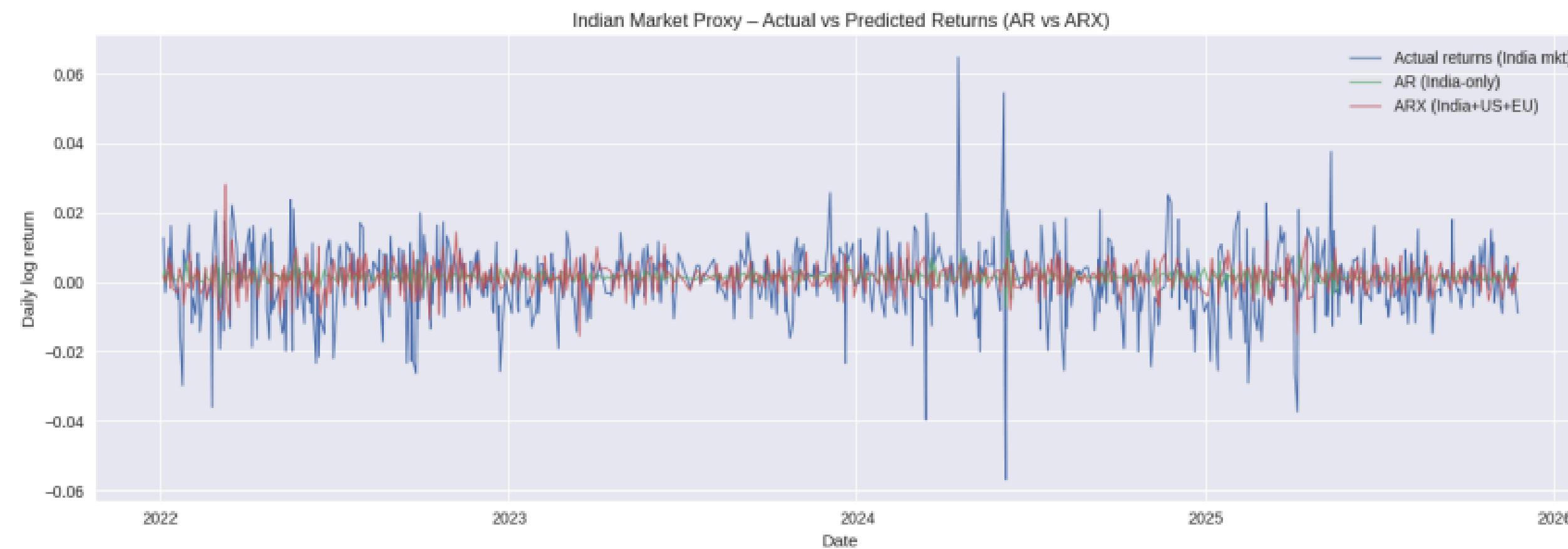


Fig.15

RESULTS AND DISCUSSION

Predictive Modelling of Indian Infrastructure Returns

LSTM Models (5-Day Regression & Classification)

- **Regression:** learning from sequences: The LSTM regression models (India-only vs Global) work on 5-day cumulative returns using full return sequences. The Global LSTM achieves a slightly lower RMSE and less negative R^2 than the India-only version, and both reach direction accuracy around 54%. This indicates that sequence information and global inputs can modestly improve how well the center of the distribution is captured.
- **Classification:** best result from India-only data: When the focus is only on the sign of the 5-day return, the India-only LSTM classifier reaches about 57% accuracy, clearly better than the 50% no-skill level. The global classifier underperforms here, suggesting that for this specific task, clean India-only signals work better than mixing in US/EU noise.
- **Takeaway:** Overall, the LSTM results highlight two points: (i) there is some exploitable directionality in Indian infra returns at the 5-day horizon, and (ii) global data can help modestly for regression-style forecasts, but the strongest single model in the study is the India-only LSTM classifier, which shows the most promising scope for practical timing strategies.

RESULTS AND DISCUSSION

Predictive Modelling of Indian Infrastructure Returns

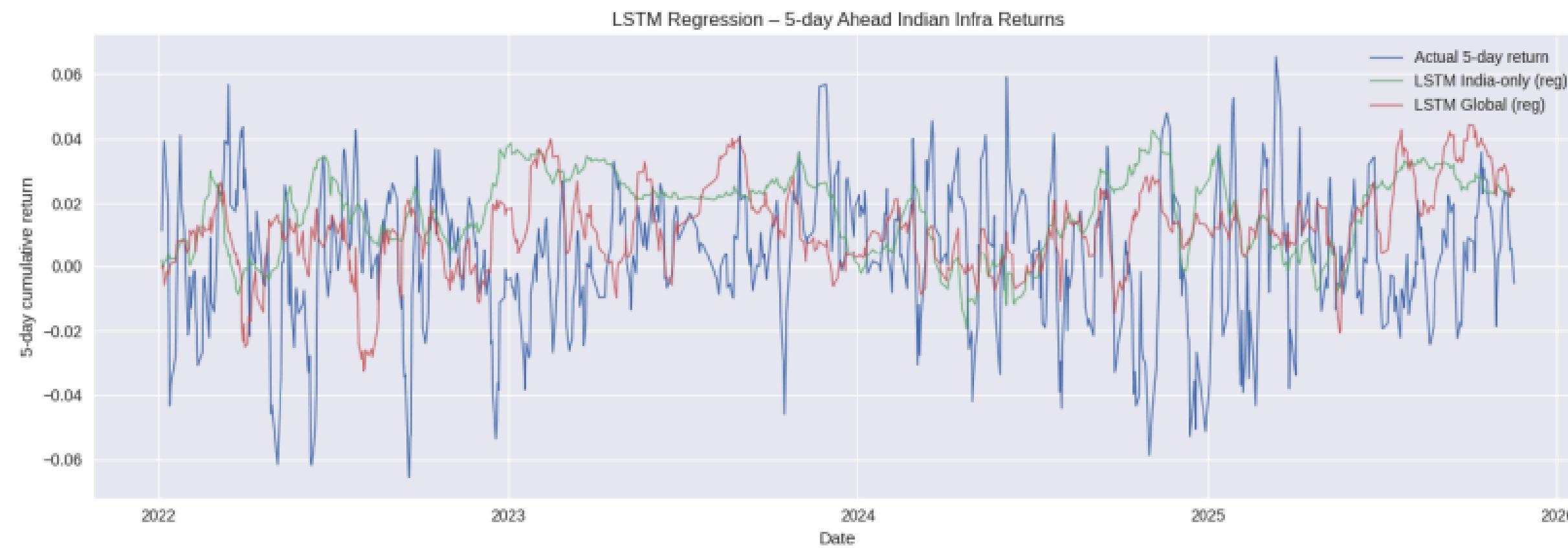


Fig.16

RESULTS AND DISCUSSION

Predictive Modelling of Indian Infrastructure Returns

MLP Models (Daily and 5-Day Horizon)

- **Daily horizon – matching the linear benchmark:** At the daily level, both the India-only MLP and the Global MLP (with US/EU inputs) deliver accuracy around 50% and fit similar to the AR benchmark. This confirms that daily infra returns are very noisy, and even flexible non-linear models cannot easily extract extra signal.
- **5-day horizon – where global data helps:** When I move to 5-day cumulative returns, both MLP models do slightly better in terms of direction, around 55% correct. Adding US and Europe gives a small improvement in RMSE and R^2 , suggesting that global infra indices contain some useful medium-horizon information, even if the effect is modest.
- **Takeaway:** The MLP results show that (i) short-term infra returns are hard to predict, but (ii) once we look at 5-day windows, there is a weak but visible predictive structure, and global data gives a gentle push in the right direction.

RESULTS AND DISCUSSION

Predictive Modelling of Indian Infrastructure Returns

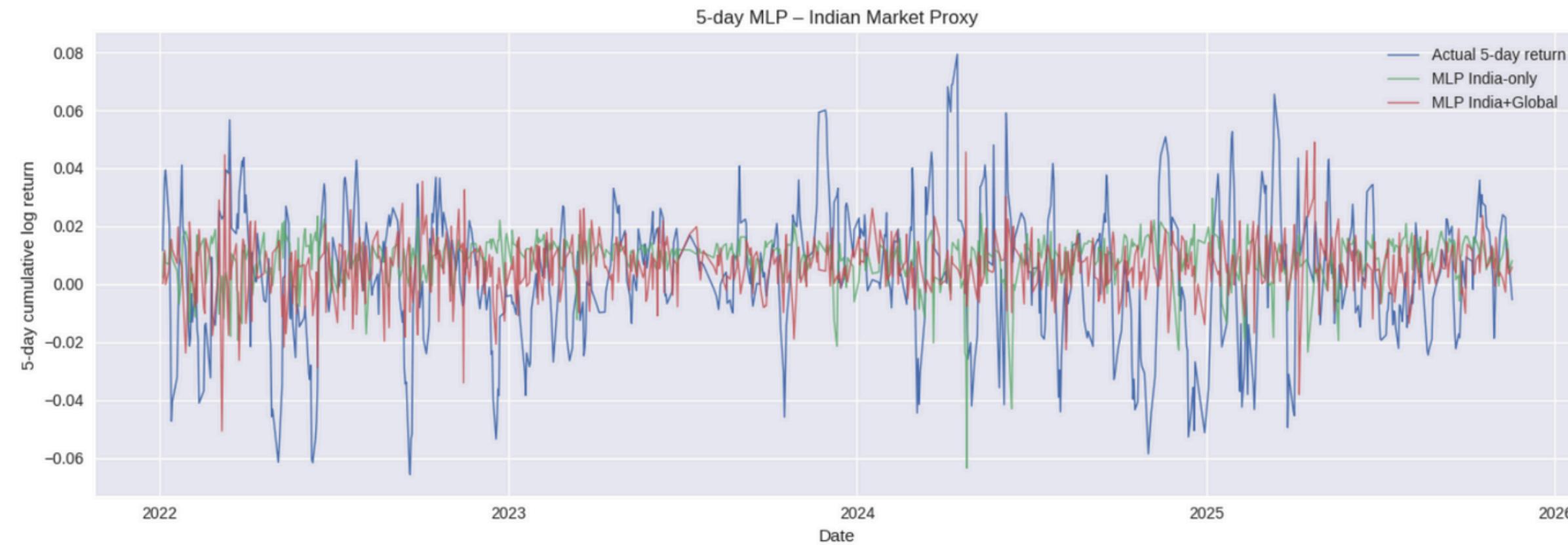


Fig.17

CONCLUSION

- Across India, the US and Europe, InvITs/REITs and infra/utility stocks sit at different points on the risk-return spectrum. Stocks behave like high-beta growth equity; InvITs/REITs give moderate returns with lower volatility and beta.
- In India, InvITs and REITs act as a lower-risk equity sleeve – they reduce portfolio volatility while still keeping exposure to infrastructure cash flows.
- Cross-country results show that trust/REIT-type vehicles are generally lower-beta with smaller drawdowns than infra stocks, and can be used as a separate building block in infra portfolios.
- Short-horizon prediction of Indian infra returns is hard. AR, MLP and LSTM models find only weak signals; some 5-day models reach mid-50% direction accuracy, but gains over simple benchmarks are small.

Future Scope

- Build a richer dataset and deeper risk models, and use longer histories and multi-factor frameworks to understand why infra assets differ across regions.
- Explore smarter prediction frameworks, and bring in broader information sources such as fundamentals and news.

SELECTIVE REFERENCES

1. A. Lazcano, M. A. Jaramillo-Morán, and J. E. Sandubete, "Back to Basics: The Power of the Multilayer Perceptron in Financial Time Series Forecasting," *Mathematics*, vol. 12, no. 12, p. 1920, 2024, doi: [10.3390/math12121920](https://doi.org/10.3390/math12121920)
2. W. Zhang, B. Li, A. W.-C. Liew, E. Roca, and T. Singh, "Predicting the returns of the US real estate investment trust market: evidence from the group method of data handling neural network," *Financial Innovation*, 2023, doi: [10.1186/s40854-023-00486-2](https://doi.org/10.1186/s40854-023-00486-2)
3. A. Habbab, N. Boussaada, A. Ghernoul, F. Guenab, and A. Azizi, "Improving Real Estate Investment Trusts (REITs) time-series prediction accuracy using machine learning and technical analysis indicators," *Artificial Intelligence Review*, 2025, doi: [10.1007/s10462-025-10864-2](https://doi.org/10.1007/s10462-025-10864-2)
4. M. Shah and K. Bhagwat, "Critical Assessment of Infrastructure Investment Trusts (InvITs) in India and Suggesting measures to increase their Efficiency in comparison with International Instruments," *Australasian Accounting, Business and Finance Journal*, vol. 16, no. 5, pp. 106–129, 2022, doi: [10.14453/aabfj.v16i5.08](https://doi.org/10.14453/aabfj.v16i5.08)
5. PwC India, India's New Real Estate and Infrastructure Trusts: The Way Forward. PwC India and Asia Pacific Real Estate Association, industry report, 2018



THANK YOU