Risk, Return, and Market Integration:
An Empirical Analysis of Indian Green Equities

Soumya Pandey (U20230062)
Plaksha University

December 10, 2025

1 Project Overview

This repository contains code and analysis for studying the dynamics of an equal-weighted portfolio of Indian green stocks using daily data from 2020–2025. The project examines risk-return characteristics, market integration, and factor exposures of India's renewable energy equity sector through descriptive statistics and econometric analysis.

GitHub Repository: `https://github.com/soumyeet/finance`

1.1 Key Findings

- **Annualized Returns**: Approximately 12.4% mean log return with 27.8% volatility
- **Market Integration**: Statistically significant market beta of 0.83 relative to NIFTY 50 ($R^2 = 0.39$)
- **Currency Exposure**: Essentially zero explanatory power from CNY/USD exchange rate ($R^2 \approx 0.001$)
- **Tail Risk**: Negative skewness, excess kurtosis, and maximum drawdown of approximately 36%
- **Cumulative Performance**: Approximately 22.5% total return over 602 trading days

2 Repository Structure

```
Report.pdf                        # Complete research paper
data_extract.ipynb                # Data collection pipeline
analysis.ipynb                    # Econometric analysis
data/
   indian_green_stocks.csv      # Green stock daily prices
   control_variables_wide_format.csv  # Macro/financial controls
   ...                          # Additional data files
README.pdf                        # This document
```

3 Data Sources

3.1 Green Stock Universe

The portfolio includes **10 Indian NSE-listed green stocks**:

- Renewable power producers: Adani Green Energy, Tata Power, NTPC

- Solar manufacturers: Suzlon Energy, Jindal Saw
- Utilities: NHPC Limited, SJVN Limited, Power Grid Corporation

Data retrieved via Yahoo Finance API (`yfinance`) with coverage from 2020–2025 (1,470+ trading days per stock).

3.2 Control Variables

The analysis incorporates a comprehensive set of macro and financial controls:

- **Exchange Rates**: CNY/USD, EUR/USD, GBP/USD, INR/USD, JPY/USD
- **Market Indices**: S&P 500, NASDAQ, FTSE 100, NIKKEI 225, NIFTY 50
- **Commodities**: Brent crude, WTI, gold, silver, natural gas
- **Volatility**: VIX, VX EEM

3.3 FPI Flow Data

NSDL fortnightly sectoral FPI investment data (attempted collection; data quality issues encountered).

4 Methodology

4.1 Portfolio Construction

Equal-weighted daily log returns calculated as:

$$r_{G,t} = \frac{1}{N_t} \sum_{i=1}^{N_t} r_{i,t}$$

where N_t is the number of stocks with valid prices on day t, and $r_{i,t} = \ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right)$.

4.2 Regression Models

4.2.1 Global FX Exposure

$$r_{G,t} = \alpha_{\text{FX}} + \beta_{\text{FX}} \cdot \text{CNY/USD}_t + \varepsilon_t$$

4.2.2 CAPM with NIFTY 50

$$r_{G,t} = \alpha + \beta_{\text{Mkt}} \cdot r_{\text{Mkt},t} + \varepsilon_t$$

where $r_{\text{Mkt},t}$ is the NIFTY 50 daily log return. Both models estimated with HAC standard errors (5 lags).

4.3 Risk Metrics

$$\text{Annualized volatility:} \quad \sigma_{\text{annual}} = \sigma_{\text{daily}} \times \sqrt{252} \tag{1}$$

$$\text{Rolling volatility:} \quad \text{21-day window} \tag{2}$$

$$\text{Drawdown:} \quad DD_t = \frac{V_t}{\max_{i \le t} V_i} - 1 \tag{3}$$

5 Usage

5.1 Data Collection

Execute the data extraction notebook to download stock prices and control variables:

```
# Download green stock prices
# Run in Jupyter: data_extract.ipynb

# Key outputs:
# - indian_green_stocks.csv (10,290 rows)
# - control_variables_wide_format.csv (8,937 dates  103 variables)
# - green_stocks_summary_statistics.csv
```

5.2 Analysis Pipeline

Execute the analysis notebook for econometric results:

```
# Run complete analysis
# Execute in Jupyter: analysis.ipynb

# Generates:
# - Descriptive statistics tables
# - CAPM regression results
# - Cumulative return plots
# - Volatility clustering analysis
# - Drawdown charts
```

5.3 Key Code Snippets

Equal-Weighted Portfolio Construction:

```
green_portfolio = (
    green
    .groupby('date', as_index=False)['logreturn']
    .mean()
    .rename(columns={'logreturn': 'green_eq_log_ret'})
)
```

CAPM Regression:

```
import statsmodels.api as sm

mask = panel['green_eq_log_ret'].notna() & panel['return_NSEI'].notna()
reg_capm = panel.loc[mask, ['green_eq_log_ret', 'return_NSEI']]

y = reg_capm['green_eq_log_ret'].astype(float)
X = sm.add_constant(reg_capm['return_NSEI'].astype(float))
capm = sm.OLS(y, X).fit(cov_type='HAC', cov_kwds={'maxlags': 5})
```

6 Results Summary

7 Data Quality Notes

7.1 Known Issues

1. **FPI Data**: NSDL website encountered connection resets during scraping; manual download recommended

Metric	Value
Daily Mean Return	0.0492%
Daily Std Dev	1.75%
Annualized Return	12.4%
Annualized Volatility	27.8%
Market Beta (vs NIFTY 50)	0.828***
CAPM Alpha	0.0006 (n.s.)
R^2 (CAPM)	0.392
Maximum Drawdown	–36%
Skewness	–0.566
Kurtosis	6.749

Table 1: Summary statistics and regression results. *** denotes $p < 0.001$.

2. **Missing Observations**: Some stocks have incomplete coverage (e.g., ADANIGREEN.NS, ORIENTGREEN.NS)
3. **Timezone Alignment**: All datetimes standardized to timezone-naive for merging

7.2 Data Cleaning Steps

- Converted all date columns to timezone-naive `datetime64[ns]`
- Resolved duplicate column names after multiple merges
- Dropped rows with missing green portfolio returns (final $N = 602$)

8 Interpretation & Policy Implications

8.1 Key Insights

1. **High Systematic Risk**: Green equities load significantly on domestic market factor ($\beta = 0.83$)
2. **No CAPM Alpha**: No evidence of abnormal daily returns after controlling for market risk
3. **Limited FX Sensitivity**: CNY/USD level explains less than 0.1% of variation
4. **Fat Tails**: Significant downside risk not captured by normal distribution

8.2 For Investors

- Green stocks behave as high-beta domestic equities, not a distinct asset class
- Require risk management for volatility clustering and large drawdowns
- Long-term horizon essential due to deep and persistent losses

8.3 For Policymakers

- Efficient capital flow more important than alpha generation
- Policy stability crucial given sector's sensitivity to regulatory changes
- Dedicated transition risk factors may improve pricing models

9 Literature & Context

This analysis contributes to:

- **Green finance in India**: Complements studies on green bonds (Chakraborty & Singh, 2021)
- **FPI flows**: Extends Dua & Sharma (2013) work on foreign investment determinants
- **Asset pricing**: Tests CAPM in renewable energy sector context

10 Limitations & Future Work

10.1 Current Limitations

- Single-factor CAPM model (omits sectoral/global clean energy factors)
- Daily frequency may miss longer-horizon dynamics
- Equal-weighting ignores market capitalization differences
- No explicit transition risk factors

10.2 Proposed Extensions

1. **Multi-Factor Models**: Add clean energy indices, carbon prices
2. **Event Studies**: Policy announcement impact analysis
3. **FPI Integration**: Complete sectoral flow data collection
4. **Firm-Level Analysis**: Individual stock characteristics

11 References

Key papers cited in analysis:

- Chakrabarti, R. (2001). "FII flows to India: Nature and causes." *Money & Finance*, 2(7), 61–81.
- Chakraborty, S., & Singh, P. (2021). "A comparative analysis of green bonds and conventional bonds in India." *Journal of Sustainable Finance & Investment*.
- Dua, P., & Sharma, E. (2013). "Foreign portfolio investment flows to India: Determinants and impact." Delhi School of Economics Working Paper.

12 Contact

Soumya Pandey
Plaksha University
Student ID: U20230062

Last Updated: December 10, 2025