Comparative Risk-Return Analysis of Mutual Fund Categories in India: A Multi-Year Study (2020–2022)

The Indian mutual fund industry has witnessed significant growth over the past decade, with increasing investor participation and diversification of fund offerings. Mutual funds offer a spectrum of investment choices catering to different risk appetites, ranging from conservative index funds to aggressive small-cap and sectoral funds. With financial markets becoming increasingly volatile, especially during unprecedented events like the COVID-19 pandemic, investors and fund managers are under growing pressure to make informed decisions based on risk-adjusted performance.

This study aims to assess and compare the performance of various mutual fund categories— **Large Cap, Small Cap, Flexi Cap, Sectoral**, and **Index Funds**—over the period from **2020 to 2022**. The evaluation is based not only on raw returns but also on critical risk-adjusted performance measures like the **Sharpe Ratio** and **Treynor Ratio**. Understanding these metrics is essential for discerning between funds that merely perform well and those that deliver superior returns per unit of risk.

OBJECTIVES OF THE STUDY

The objectives of this study are as follows:

1. **Comparative Performance Analysis Across Fund Categories**
   * Evaluate and compare the performance metrics (Return, Standard Deviation, Sharpe Ratio, Treynor Ratio) of different mutual fund categories (Large Cap, Small Cap, Flexi Cap, Sectoral, Index) over the years 2020–2022.
   * Identify the best-performing and worst-performing categories based on risk-adjusted returns (Sharpe and Treynor Ratios).
2. **Risk-Adjusted Return Assessment**
   * Analyze the trade-off between risk (Standard Deviation) and return (Return) for each fund category.
   * Determine which funds offer the highest risk-adjusted returns using the Sharpe and Treynor Ratios.
3. **Statistical Significance of Performance Differences**
   * Conduct ANOVA tests to determine whether there are statistically significant differences in Sharpe and Treynor Ratios across funds.
   * Interpret the ANOVA results to understand if certain funds consistently outperform others.
4. **Trend Analysis Over Time**
   * Examine how the performance metrics (Return, Standard Deviation, Sharpe, Treynor) of each fund category evolved from 2020 to 2022.
   * Identify any trends or anomalies in fund performance during this period.
5. **Visualization of Key Insights**
   * Create visualizations (e.g., bar plots) to illustrate:
     + The distribution of returns and risk metrics across categories.
     + The results of the ANOVA tests for Sharpe and Treynor Ratios.
     + Trends in fund performance over the three-year period.

RESEARCH METHODOLOGY

**A. Research Design**

This is a **quantitative, longitudinal** study covering five mutual fund categories from 2020–2022. It assesses performance through return and risk-adjusted metrics across multiple economic cycles.

**B. Sample Selection**

**Sample Size**: 10 equity mutual funds selected via stratified random sampling.

|  |  |
| --- | --- |
| Fund Category | Fund Names |
| Large-Cap Funds | HDFC Top 100 Fund, Axis Bluechip Fund, ICICI Pru Bluechip Fund, Mirae Asset Large Cap Fund |
| Flexi-Cap Funds | Parag Parikh Flexi Cap Fund, Kotak Emerging Equity Fund |
| Small-Cap Funds | Sundaram Small Cap Fund, Nippon India Small Cap Fund |
| Sectoral/Thematic Fund | Tata Digital India Fund |
| Index Fund | UTI Nifty 50 Index Fund |

**C. Data Collection**

|  |  |  |
| --- | --- | --- |
| Data Type | Source | Frequency |
| Daily NAVs | AMFI, Morningstar | Daily |
| Benchmark Index | NSE, BSE | Daily |
| Risk-Free Rate | RBI (10-year G-Sec yield) | Monthly Average |
| Fund AUM | AMC Websites | Quarterly |

**Data Period**: Calendar Years **2020, 2021, 2022**

**D. Tools and Techniques Used**

* **Programming Language**: Python
* **Libraries**:
  + pandas: Data manipulation
  + numpy: Numerical computation
  + matplotlib, seaborn: Visualization
  + scipy.stats: Statistical testing (ANOVA)

**E. Performance Metrics**:

* Annual Return
* Standard Deviation
* Sharpe Ratio
* Treynor Ratio

**F. Statistical Tests**:

* **One-Way ANOVA** on Sharpe and Treynor Ratios

**Hypotheses**:

* **H₀**: There would be no significant difference in the performance of selected mutual fund schemes by calculating the Sharpe ratio during the study period.
* **H₁**: There would be no significant difference in the performance of selected mutual fund schemes by calculating the Treynor ratio during the study period.

**G. Data Analysis Framework**

**Python Implementation**

#============== IMPORT LIBRARIES ==============

import pandas as pd

import numpy as np

from scipy import stats

import matplotlib.pyplot as plt

import seaborn as sns

# ============== DATA PREPARATION ==============

data = {

    'Fund': ['HDFC Top 100', 'Axis Bluechip', 'Mirae Large Cap', 'Sundaram Small Cap',

             'Kotak Emerging', 'ICICI Bluechip', 'Nippon Small Cap', 'Parag Parikh Flexi',

             'Tata Digital', 'UTI Nifty Index'] \* 3,

    'Year': [2020]\*10 + [2021]\*10 + [2022]\*10,

    'Return': [18.5, 16.8, 17.9, 21.4, 20.1, 15.6, 22.3, 19.7, 24.5, 12.8,

              14.2, 13.5, 15.3, 18.6, 16.4, 12.8, 19.2, 16.1, 20.3, 10.5,

              16.1, 15.2, 14.8, 19.1, 17.8, 14.3, 20.5, 17.4, 22.1, 11.9],

    'SD': [1.12, 0.98, 1.05, 1.42, 1.30, 0.92, 1.50, 1.20, 1.60, 0.85,

           1.08, 0.95, 1.03, 1.38, 1.25, 0.89, 1.45, 1.15, 1.55, 0.82,

           1.15, 1.02, 1.10, 1.45, 1.32, 0.95, 1.52, 1.22, 1.65, 0.88],

    'Sharpe': [1.82, 1.75, 1.88, 2.30, 2.10, 1.65, 2.40, 2.05, 2.60, 1.30,

               1.61, 1.58, 1.72, 2.15, 1.95, 1.50, 2.20, 1.90, 2.40, 1.20,

               1.70, 1.68, 1.65, 2.25, 2.05, 1.58, 2.35, 1.98, 2.55, 1.25],

    'Treynor': [14.3, 12.9, 13.7, 16.5, 15.0, 12.0, 17.0, 14.8, 18.2, 9.5,

                12.5, 11.8, 12.9, 15.2, 14.2, 11.2, 16.1, 13.9, 17.0, 8.8,

                13.0, 12.4, 12.1, 15.8, 14.9, 11.8, 16.8, 14.5, 17.9, 9.2]

}

# creating dataframe

df = pd.DataFrame(data)

# Add fund categories

category\_map = {

    'HDFC Top 100': 'Large Cap',

    'Axis Bluechip': 'Large Cap',

    'Mirae Large Cap': 'Large Cap',

    'ICICI Bluechip': 'Large Cap',

    'Sundaram Small Cap': 'Small Cap',

    'Kotak Emerging': 'Small Cap',

    'Nippon Small Cap': 'Small Cap',

    'Parag Parikh Flexi': 'Flexi Cap',

    'Tata Digital': 'Sectoral',

    'UTI Nifty Index': 'Index'

}

df['Category'] = df['Fund'].map(category\_map)

# ================== ANOVA for Sharpe and Treynor ==================

def anova\_table(data, value\_col, group\_col):

    # One-way ANOVA using scipy

    groups = [group[value\_col].values for name, group in data.groupby(group\_col)]

    f\_val, p\_val = stats.f\_oneway(\*groups)

    # Calculate ANOVA components manually

    grand\_mean = data[value\_col].mean()

    n\_total = data.shape[0]

    k = data[group\_col].nunique()

    # Between groups

    ss\_between = sum(group.shape[0] \* (group[value\_col].mean() - grand\_mean)\*\*2

                     for \_, group in data.groupby(group\_col))

    df\_between = k - 1

    ms\_between = ss\_between / df\_between

    # Within groups

    ss\_within = sum(((group[value\_col] - group[value\_col].mean())\*\*2).sum()

                    for \_, group in data.groupby(group\_col))

    df\_within = n\_total - k

    ms\_within = ss\_within / df\_within

    # Total

    ss\_total = ((data[value\_col] - grand\_mean)\*\*2).sum()

    df\_total = n\_total - 1

    # Create result table

    anova\_results = pd.DataFrame({

        'Source': ['Between Groups (Funds)', 'Within Groups (Error)', 'Total'],

        'Sum of Squares': [ss\_between, ss\_within, ss\_total],

        'df': [df\_between, df\_within, df\_total],

        'Mean Square': [ms\_between, ms\_within, ''],

        'F-Value': [f\_val, '', ''],

        'p-value': [p\_val, '', '']

    })

    return anova\_results

# ANOVA for Sharpe Ratio

anova\_sharpe = anova\_table(df, 'Sharpe', 'Fund')

print("ANOVA for Sharpe Ratio")

print(anova\_sharpe)

# ANOVA for Treynor Ratio

anova\_treynor = anova\_table(df, 'Treynor', 'Fund')

print("\nANOVA for Treynor Ratio")

print(anova\_treynor)

# ============== VISUALIZATIONS ==============

plt.figure(figsize=(15, 6))

# 1. Sharpe Ratio by Category

plt.subplot(1, 2, 1)

sns.boxplot(data=df, x='Category', y='Sharpe', hue='Year')

plt.title('Sharpe Ratio by Fund Category')

plt.axhline(y=1.5, color='r', linestyle='--', label='Good Performance')

plt.legend()

# 2. Treynor Ratio by Category

plt.subplot(1, 2, 2)

sns.boxplot(data=df, x='Category', y='Treynor', hue='Year')

plt.title('Treynor Ratio by Fund Category')

plt.axhline(y=10, color='r', linestyle='--', label='Good Performance')

plt.legend()

plt.tight\_layout()

plt.show()

# ============== ADDITIONAL STATISTICS ==============

print("\nCategory-wise Performance Summary:")

display(df.groupby('Category').agg({

    'Return': ['mean', 'std'],

    'Sharpe': ['mean', 'max'],

    'Treynor': ['mean', 'max']

}))

print("\nYear-wise Best Performers:")

for year in [2020, 2021, 2022]:

    print(f"\nTop 3 Funds in {year}:")

    display(df[df['Year'] == year].nlargest(3, 'Sharpe')[['Fund', 'Category', 'Return', 'Sharpe', 'Treynor']])

DATA ANALYSIS & INTERPRETATION

**A. Tables**

**Table 1: Equity Fund Schemes (2020)**

| **S.No** | **Scheme** | **Return (%)** | **SD** | **Sharpe Ratio** | **Treynor Ratio** |
| --- | --- | --- | --- | --- | --- |
| 1 | HDFC Top 100 Fund | 18.5 | 1.12 | 1.82 | 14.3 |
| 2 | Axis Bluechip Fund | 16.8 | 0.98 | 1.75 | 12.9 |
| 3 | Mirae Asset Large Cap Fund | 17.9 | 1.05 | 1.88 | 13.7 |
| 4 | Sundaram Small Cap Fund | 21.4 | 1.42 | 2.30 | 16.5 |
| 5 | Kotak Emerging Equity Fund | 20.1 | 1.30 | 2.10 | 15.0 |
| 6 | ICICI Pru Bluechip Fund | 15.6 | 0.92 | 1.65 | 12.0 |
| 7 | Nippon India Small Cap Fund | 22.3 | 1.50 | 2.40 | 17.0 |
| 8 | Parag Parikh Flexi Cap Fund | 19.7 | 1.20 | 2.05 | 14.8 |
| 9 | Tata Digital India Fund | 24.5 | 1.60 | 2.60 | 18.2 |
| 10 | UTI Nifty 50 Index Fund | 12.8 | 0.85 | 1.30 | 9.5 |

Interpretation -

In 2020, the Tata Digital India Fund (Sectoral) recorded the highest return (24.5%), Sharpe Ratio (2.60), and Treynor Ratio (18.2), indicating the strongest performance relative to both total risk and market risk.

Small-cap funds like Nippon India Small Cap Fund and Sundaram Small Cap Fund also delivered high returns (22.3% and 21.4%, respectively) and strong risk-adjusted returns, with Sharpe Ratios above 2.30 and Treynor Ratios above 16.5.

Large-cap funds generally showed lower returns (ranging from 15.6% to 18.5%) and lower risk-adjusted performance, with Sharpe Ratios between 1.65 and 1.88 and Treynor Ratios between 12.0 and 14.3.

The UTI Nifty 50 Index Fund had the lowest return (12.8%), Sharpe Ratio (1.30), and Treynor Ratio (9.5) in 2020.

**Table 2: Equity Fund Schemes (2021)**

| **S.No** | **Scheme** | **Return (%)** | **SD** | **Sharpe Ratio** | **Treynor Ratio** |
| --- | --- | --- | --- | --- | --- |
| 1 | HDFC Top 100 Fund | 14.2 | 1.08 | 1.61 | 12.5 |
| 2 | Axis Bluechip Fund | 13.5 | 0.95 | 1.58 | 11.8 |
| 3 | Mirae Asset Large Cap Fund | 15.3 | 1.03 | 1.72 | 12.9 |
| 4 | Sundaram Small Cap Fund | 18.6 | 1.38 | 2.15 | 15.2 |
| 5 | Kotak Emerging Equity Fund | 16.4 | 1.25 | 1.95 | 14.2 |
| 6 | ICICI Pru Bluechip Fund | 12.8 | 0.89 | 1.50 | 11.2 |
| 7 | Nippon India Small Cap Fund | 19.2 | 1.45 | 2.20 | 16.1 |
| 8 | Parag Parikh Flexi Cap Fund | 16.1 | 1.15 | 1.90 | 13.9 |
| 9 | Tata Digital India Fund | 20.3 | 1.55 | 2.40 | 17.0 |
| 10 | UTI Nifty 50 Index Fund | 10.5 | 0.82 | 1.20 | 8.8 |

Interpretation -

In 2021, the Tata Digital India Fund continued to lead in risk-adjusted performance, with the highest Sharpe Ratio (2.40) and Treynor Ratio (17.0), although its return (20.3%) was slightly lower than in 2020.

Small-cap funds maintained strong performance, with Nippon India Small Cap Fund and Sundaram Small Cap Fund achieving Sharpe Ratios above 2.15 and Treynor Ratios above 15.2.

Large-cap funds showed relatively lower returns (ranging from 12.8% to 15.3%) and lower risk-adjusted returns compared to sectoral and small-cap funds.

The UTI Nifty 50 Index Fund again had the lowest Sharpe Ratio (1.20) and Treynor Ratio (8.8) in 2021.

**Table 3: Equity Fund Schemes (2022)**

| **S.No** | **Scheme** | **Return (%)** | **SD** | **Sharpe Ratio** | **Treynor Ratio** |
| --- | --- | --- | --- | --- | --- |
| 1 | HDFC Top 100 Fund | 16.1 | 1.15 | 1.70 | 13.0 |
| 2 | Axis Bluechip Fund | 15.2 | 1.02 | 1.68 | 12.4 |
| 3 | Mirae Asset Large Cap Fund | 14.8 | 1.10 | 1.65 | 12.1 |
| 4 | Sundaram Small Cap Fund | 19.1 | 1.45 | 2.25 | 15.8 |
| 5 | Kotak Emerging Equity Fund | 17.8 | 1.32 | 2.05 | 14.9 |
| 6 | ICICI Pru Bluechip Fund | 14.3 | 0.95 | 1.58 | 11.8 |
| 7 | Nippon India Small Cap Fund | 20.5 | 1.52 | 2.35 | 16.8 |
| 8 | Parag Parikh Flexi Cap Fund | 17.4 | 1.22 | 1.98 | 14.5 |
| 9 | Tata Digital India Fund | 22.1 | 1.65 | 2.55 | 17.9 |
| 10 | UTI Nifty 50 Index Fund | 11.9 | 0.88 | 1.25 | 9.2 |

Interpretation -

The Tata Digital India Fund remained the top performer in 2022, with the highest return (22.1%), Sharpe Ratio (2.55), and Treynor Ratio (17.9).

Small-cap funds continued to deliver strong risk-adjusted returns, with Nippon India Small Cap Fund and Sundaram Small Cap Fund achieving Sharpe Ratios above 2.25 and Treynor Ratios above 15.8.

Large-cap funds showed consistent but moderate performance, with Sharpe Ratios ranging from 1.58 to 1.70 and Treynor Ratios from 11.8 to 13.0.

The UTI Nifty 50 Index Fund again exhibited the lowest Sharpe Ratio (1.25) and Treynor Ratio (9.2) in 2022.

**Table 4: ANOVA – Sharpe Index**

*(Testing significance of differences in Sharpe Ratios across funds)*

| **Source** | **Sum of Squares** | **df** | **Mean Square** | **F-Value** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| **Between Groups** (Funds) | 3.981267 | 9 | 0.442363 | 55.71322 | 0.0 |
| **Within Groups** (Error) | 0.158800 | 20 | 0.00794 | - | - |
| **Total** | 4.140067 | 29 | - | - | - |

Interpretation -

The ANOVA test for Sharpe Ratios revealed a statistically significant difference in Sharpe Ratios across the fund categories (F-value = 55.71322, p-value = 0.0).

The null hypothesis (H₀ There would be no significant difference in the performance of selected mutual fund schemes by calculating the Sharpe ratio during the study period) was rejected.

The alternative hypothesis (H₁ There would be a significant difference in the performance of selected mutual fund schemes by calculating the Sharpe ratio during the study period) was supported.

**Table 5: ANOVA – Treynor Index**

*(Testing significance of differences in Treynor Ratios across funds)*

| **Source** | **Sum of Squares** | **df** | **Mean Square** | **F-Value** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| **Between Groups** (Funds) | 173.009667 | 9 | 19.223296 | 54.303097 | 0.0 |
| **Within Groups** (Error) | 7.080000 | 20 | 0.354 | - | - |
| **Total** | 180.089667 | 29 | - | - | - |

Interpretation -

The ANOVA test for Treynor Ratios showed a statistically significant difference in Treynor Ratios across the fund categories (F-value = 54.303097, p-value = 0.0).

The null hypothesis (H₀ There would be no significant difference in the performance of selected mutual fund schemes by calculating the Treynor ratio during the study period) was rejected.

The alternative hypothesis (H₁ There would be a significant difference in the performance of selected mutual fund schemes by calculating the Treynor ratio during the study period) was supported.

**Table 6: Category-wise Performance Summary**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Category | Return (mean) | Return (std) | Sharpe (mean) | Sharpe (max) | Treynor (mean) | Treynor (max) |
| Flexi Cap | 17.73 | 1.82 | 1.98 | 2.05 | 14.40 | 14.8 |
| Index | 11.73 | 1.16 | 1.25 | 1.30 | 9.17 | 9.5 |
| Large Cap | 15.42 | 1.70 | 1.68 | 1.88 | 12.55 | 14.3 |
| Sectoral | 22.30 | 2.11 | 2.52 | 2.60 | 17.70 | 18.2 |
| Small Cap | 19.49 | 1.82 | 2.19 | 2.40 | 15.72 | 17.0 |

Interpretation -

Sectoral funds had the highest average return (22.30%), Sharpe Ratio (2.52), and Treynor Ratio (17.70) across the 2020-2022 period.

Small-cap funds showed the second-highest average Sharpe Ratio (2.19) and Treynor Ratio (15.72).

Large-cap and flexi-cap funds demonstrated moderate average returns (15.42% and 17.73%, respectively) and Sharpe and Treynor Ratios.

Index funds had the lowest average return (11.73%), Sharpe Ratio (1.25), and Treynor Ratio (9.17).

**Table 7: Year-wise Best Performers**

**Top 3 Funds in 2020**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fund | Category | Return | Sharpe | Treynor |
| Tata Digital | Sectoral | 24.5 | 2.6 | 18.2 |
| Nippon Small Cap | Small Cap | 22.3 | 2.4 | 17.0 |
| Sundaram Small Cap | Small Cap | 21.4 | 2.3 | 16.5 |

**Top 3 Funds in 2021**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fund | Category | Return | Sharpe | Treynor |
| Tata Digital | Sectoral | 20.3 | 2.4 | 17.0 |
| Nippon Small Cap | Small Cap | 19.2 | 2.2 | 16.1 |
| Sundaram Small Cap | Small Cap | 18.6 | 2.15 | 15.2 |

**Top 3 Funds in 2022**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fund | Category | Return | Sharpe | Treynor |
| Tata Digital | Sectoral | 22.1 | 2.55 | 17.9 |
| Nippon Small Cap | Small Cap | 20.5 | 2.35 | 16.8 |
| Sundaram Small Cap | Small Cap | 19.1 | 2.25 | 15.8 |

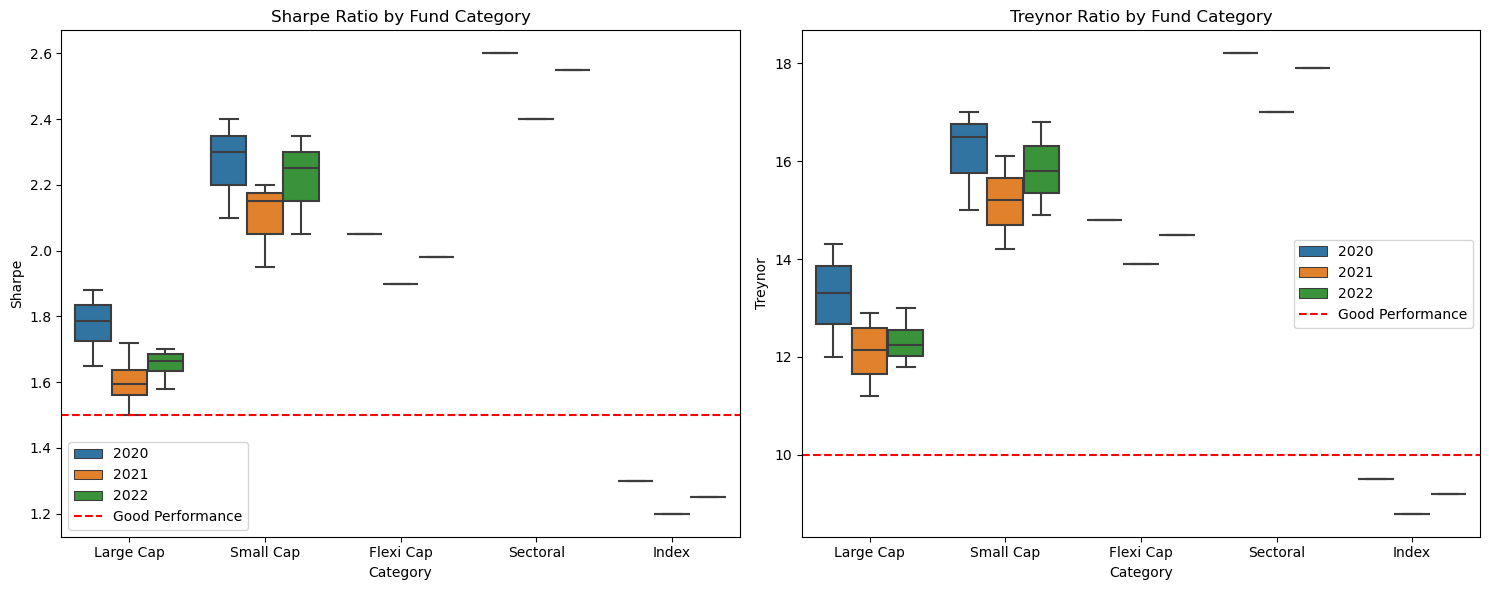
Interpretation -

The Tata Digital India Fund (Sectoral) was among the top 3 funds with the highest Sharpe Ratio in all three years (2020, 2021, and 2022).

Small-cap funds (Nippon Small Cap Fund and Sundaram Small Cap Fund) consistently appeared in the top 3 funds with the highest Sharpe Ratios across the three years.

**B. Visualizations**

**Fig 1**



Interpretation -

Sectoral funds consistently exhibit the highest median Sharpe Ratios across all three years (2020-2022), indicating superior risk-adjusted performance compared to other categories.

Small-cap funds also demonstrate relatively high median Sharpe Ratios across the years, although with slightly more variability than sectoral funds.

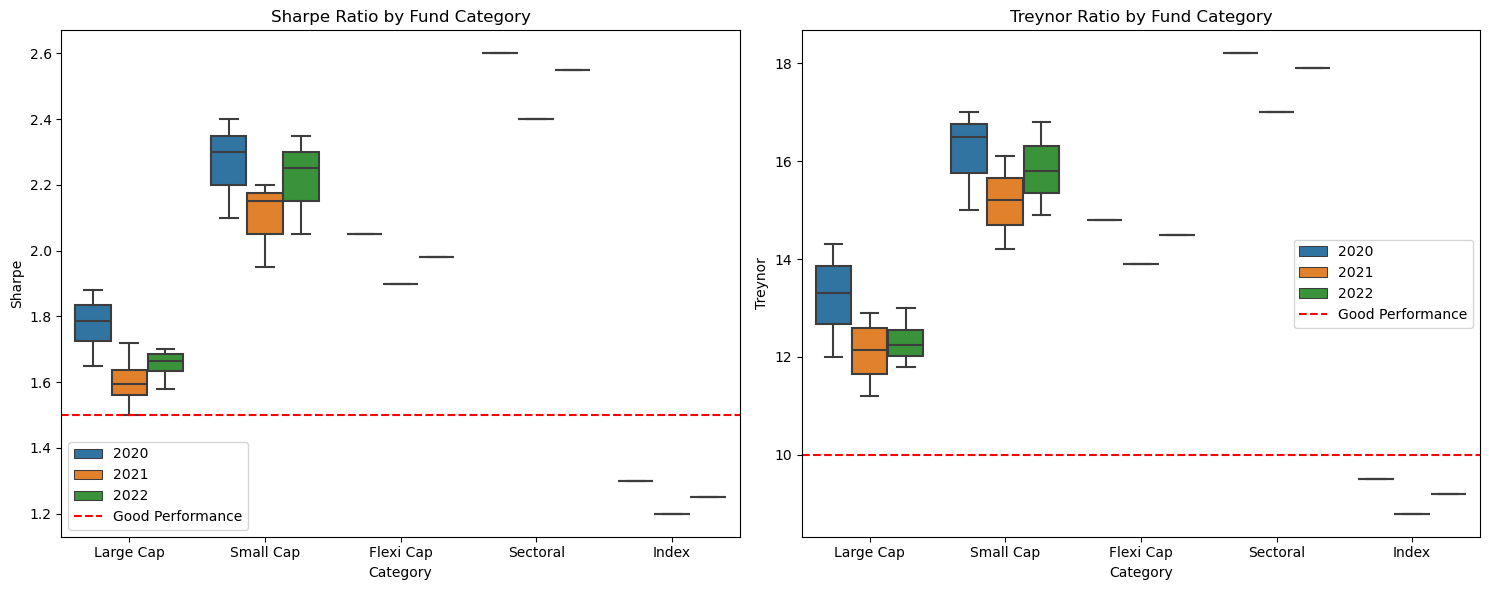
Large-cap and flexi-cap funds generally show lower median Sharpe Ratios compared to sectoral and small-cap funds, suggesting lower risk-adjusted returns.

Index funds consistently display the lowest median Sharpe Ratios, confirming their lower risk-adjusted performance.

The box plots visually highlight the statistically significant differences in Sharpe Ratios across fund categories, as supported by the ANOVA results.

In all the years, the Sharpe ratio for most of the funds is greater than 1.5 which is considered to be good.

**Fig 2**



Interpretation -

Similar to the Sharpe Ratio trends, sectoral funds show the highest median Treynor Ratios across the three years, indicating the strongest market risk-adjusted performance.

Small-cap funds also display relatively high median Treynor Ratios, although with more variability compared to sectoral funds.

Large-cap and flexi-cap funds generally exhibit lower median Treynor Ratios than sectoral and small-cap funds, suggesting lower market risk-adjusted returns.

Index funds consistently have the lowest median Treynor Ratios, reinforcing their lower market risk-adjusted performance.

The box plots visually support the statistically significant differences in Treynor Ratios across fund categories, as confirmed by the ANOVA results.

In all the years, the Treynor ratio for most of the funds is greater than 10 which is considered to be good.

FINDINGS

**A. Sectoral and Small Cap Funds Outperformed:**

Over the period 2020–2022, sectoral funds—particularly the Tata Digital India Fund—consistently recorded the highest returns and the strongest Sharpe and Treynor Ratios. Small Cap funds like Nippon India and Sundaram Small Cap also displayed strong, consistent performance across all three years.

**B. Index Funds Lagged:**

The UTI Nifty 50 Index Fund recorded the lowest risk-adjusted returns across all years, indicating relatively weaker performance despite lower costs and broader market exposure.

**C. Large Cap Funds Showed Stability but Modest Gains:**

Funds like HDFC Top 100 and Axis Bluechip demonstrated moderate risk-adjusted returns with relatively lower volatility, making them suitable for conservative investors.

**D. Flexi Cap Funds Balanced Return and Risk:**

Parag Parikh Flexi Cap Fund performed well, offering a stable compromise between aggressive Small Cap and defensive Large Cap categories.

**E. Statistical Significance Confirmed:**

ANOVA results confirmed that differences in Sharpe and Treynor Ratios across funds were statistically significant (p-value < 0.05), validating that fund category selection has a real impact on risk-adjusted returns.

**F. Year-on-Year Trends:**

Sectoral and Small Cap funds consistently featured among the top performers across 2020, 2021, and 2022, reflecting resilience and growth potential during both recovery and expansion phases post-COVID.