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Exploring Corporate Recovery with Time Series Forecasting in the Indian Stock Market

Dr Divya Gautam[1*], Dr. Gaurav Paliwal[2]

[1*](Asst Prof. – School of Technology Management & Engineering, SVKM's Narsee Monjee Institute of Management Studies (NMIMS) Deemed-to-University, Indore, PIN 453112, India)
divyagautam06@gmail.com
[2](Asst Prof. – School of Technology Management & Engineering, SVKM's Narsee Monjee Institute of Management Studies (NMIMS) Deemed-to-University, Indore, PIN 453112, India)
gvpaliwal@gmail.com

Abstract - The paper analyzes post-COVID-19 performance of Adani Group shares by considering its three listed entities: Adani Green Energy, Adani Power, and Adani Ports & Special Economic Zone. Through utilizing time series analysis, in this instance the ARIMA model, and data manipulation via Python-based programs (Pandas, NumPy, and pmdarima) and Power BI for visualization, the study revisits past stock performance between 2019 and 2024 in efforts to find patterns, forecast trends, and investigate reaction by the market. The study reveals huge price and volume fluctuations in the shares of the companies, illustrating how the pandemic affected their financial trajectory. Not taking into consideration technical analysis, the study critically discusses the group's reaction strategies to market shocks like diversification, geographic diversification, and renewable power selection. The study also finds the socio-political and environmental implication within the group, giving a fair report of the performance of the group in the market and image among the public. The research presents executable recommendations on corporate resilience, investor sentiment, and market recovery tools and makes a contribution to the larger global financial resilience and economic nimbleness discourse in times of international crises.

Keywords - Post-COVID Economy; Financial Resilience; Investor Sentiment; Corporate Strategy; Renewable Energy Sector; Economic Impact

1. Introduction

The initial 2020 COVID-19 global pandemic created a record-shattering economic shock that ravaged the economies, companies, and industries of the entire world. In addition to its gargantuan health expense, the pandemic brought world supply chain disruption, changed consumption patterns, rearranged businesses, and triggered a chain of fiscal chaos in other parts of both developed and developing economies. India, a giant and dynamic economy in the world, was worst affected. The financial markets themselves were not affected, though they witnessed record price volatility because of risk aversion by investors, policy surprises, and disruption of cross-border and domestic trade supply chains [1]. Among Indian groups most hit by the crisis was the Adani Group, a group that diversified over spread-out activities in varied segments from energy, transportation, and logistics to infrastructure and farming.

Established by Gautam Adani in 1988, the group has grown by leaps and bounds and is today a force to be reckoned with on both the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE), becoming among India's top players in the economic saga. Its three business segments—Adani Green Energy Limited (AGEL), Adani Power Limited (APL), and Adani Ports and Special Economic Zone (APSEZ)—are excellent case studies to study corporate performance during a crisis.

Each of them is in their own domain, distinctive yet strategically significant: renewable energy, thermal power, and port logistics, respectively.

1.1. Background and Context

The COVID-19 pandemic placed system-level as well as sector-level stress on groups like Adani. National lockdown, restricted mobility of labor and goods, and volatility in the demand-supply trends impacted all the industries, be it energy or transport. Concurrently, world commodity prices like crude oil and coal—two most powerful pillars that drive the energy and logistics firms—experienced unprecedented volatility through these phases. Investor sentiment, galvanized by domestic woes and global uncertainty, created gargantuan share price volatility, which required advanced analytics models to predict and analyze. While economic blows struck a number of giant firms, the pandemic also acted as a driver of transformation. Those businesses that were able to transform at speed—through digitalization, product diversification, or greenfield innovation—were likeliest to recover. The Adani Group, which has been embroiled in controversy over green policy and disclosure of finance, exhibited strategic flexibility by ramping up investment in renewals and infrastructure [2], a reflection of Indian business resilience in the post-COVID era.

1.2. Research Motivation

Although there have been several macro-level post-COVID studies conducted in India, fewer data-driven firm-level analysis is conducted with state-of-the-art quantitative methods such as time series modelling to generate future performance predictions and unveil underlying trends.

In particular, the stock market performance of Adani's three flagship companies—AGEL, APL, and APSEZ—can reveal important insights into both investor expectations and the effectiveness of corporate strategy during crisis periods. Given their varied domains (renewable energy, thermal power, and port logistics), these entities serve as representative models of India's infrastructural and energy sectors, both of which are critical for economic recovery.

Other than that, increasing Adani Group dominance of foreign capital markets—with its higher market capitalization and rising foreign institutional investment—makes its share pattern post-pandemic a question of gigantic academic, regulatory, as well as investor interest [3].

1.3 Significance of Time Series Analysis

For greater clarity of the complex dynamics of action in the stock market here, the current research utilizes time series analysis as the primary methodological tool. Time series analysis is a statistical technique for modeling points that are built up sequentially over the course of time in order to identify trends, cycles, and seasonality. In finance markets, it is a handy technique to predict stock prices, analyze volatility, and analyze investor sentiment over time horizons [4].

The study most commonly employs the Autoregressive Integrated Moving Average (ARIMA) model, the most widely practiced method in forecasting non-stationary time series data. The ARIMA model incorporates three key elements—autoregression (AR), differencing (I), and moving average (MA)—to provide precise forecasts using previous trends [5]. Using computation software such as Python's Pandas, NumPy, and pmdarima libraries, the ARIMA model can be implemented effortlessly on large-scale and intricate data.

In addition, Microsoft Power BI is utilized to generate visualized results, interactive reports, and dashboards that help communicate quantitative results more easily. The union of statistical validity and visualization adds potency to the explanatory potential of the study and allows non-specialist stakeholders like policymakers and money men to enjoy it more.

1.4 Overview of the Adani Group Entities

The selection of Adani Green, Adani Power, and Adani Ports is deliberate and strategic. Each entity not only represents a key segment of the Indian economy but also offers contrasting risk profiles and growth trajectories in the aftermath of COVID-19. Adani Green Energy Limited (AGEL) focuses on utility-scale solar and wind energy generation. As of 2023, it owns India's largest renewable energy portfolio, with an operating capacity of over 8.4 GW and a target of 45 GW by 2030 [6]. AGEL's emphasis on decarbonization aligns with both national and global sustainability goals, making its stock performance particularly relevant in the context of green investment trends.

Adani Power Limited (APL) operates India's largest private sector thermal power generation capacity, with multiple plants across states such as Gujarat, Maharashtra, and Chhattisgarh. While thermal power has faced criticism over its environmental impact, APL continues to play a vital role in meeting India's base-load energy demand [7]. Adani Ports and Special Economic Zone Limited (APSEZ) is India's largest commercial port operator, handling nearly 25% of national cargo volumes. With 13 ports and integrated logistics parks, APSEZ forms the backbone of India's trade infrastructure and plays a critical role in supporting economic growth and supply chain efficiency [8]. Analysing these entities together provides a multidimensional view of how different sectors within the same corporate group respond to macroeconomic shocks and policy shifts.

1.5 Strategic Adaptations and Controversies

The Adani Group reported resplendent growth in the post-pandemic situation, growth is never unblemished. Its progress has been criticized on the grounds of environmental depreciation, aggressive acquisition practices, and areas of concern with regard to regulatory enforcement. Preferential treatment allegation and absence of accounting disclosure transparency have also attracted public and judicial scandal [9].

But diversification of the renewable power industry, strategic alliance, and business diversification have made the Group a revolutionary entity reshaping India's economic topography. Technical competence amidst and on-going controversy provide a challenging landscape to the inquiry of investor mood and market behavior, which are necessarily at the mercy of the mood of governance and sustainability.

1.6. Research Objectives

The purpose of ongoing research is to:

- Analyze AGEL, APL, and APSEZ's historical performance of shares over time using time series techniques.
- Post-COVID recovery, growth, and volatility trends 2019-2024: define and describe.
- Predict future stock price trends using ARIMA modeling.
- Define the interdependence of corporate strategy, market sentiment, and stock movement.
- Make recommendations to investors, analysts, and policymakers on market resilience and adjustment.

In arriving at these goals, the research achieves an even-handed realization of how Indian diversified business houses respond to world shocks.

1.7 Structure of the Paper

The rest of the paper follows this structure.
Section 2 presents methodology, i.e., step-by-step description of ARIMA modeling, Python implementation, and Power BI visualization. Section 3 presents corporate hierarchy overview of Adani Group, overview of financial performance, and industry overview. Section 4 presents data pre-processing and time series modeling, forecasting outcome presented in Section 5. Section 6 presents implication of findings, leading patterns and strategic implication emphasized. Last but not least, Section 7 concludes with summary findings and suggestions for future research

2. Literature Review

2.1 Financial Market Behaviour During Crises

Financial markets are inherently exposed to macroeconomic shocks, geopolitics, and disease pandemics. These were already observed in the 2008 financial crisis and 1997 Asian financial crisis in volatility and reversals' velocity in investor sentiment characteristic of such crises to be usually reflective of such crises. Investors during such crises are risk-averse, and this causes extensive sell-offs, liquidity appropriations, and sharp reversals in asset prices [10].

Neither was COVID-19 pandemic an exception. A health pandemic having grown into a global economic disruption, it ignited record-breaking drops in markets in early 2020 and subsequent months of reactionary growth with stimulus packages and monetary policy assistance from the government. Baker et al. [11] narrated that COVID-19 reached record-high levels of economic uncertainty, far larger than even the 2008 crisis itself in its very first impact on market volatility.

Other emerging economies such as India had huge capital flight, exchange rate weakening, and equity index loss in the early stages of the pandemic. India's stock market, as reflected by the Sensex and Nifty 50, had double-digit percentage drops in March 2020 before it went through a pattern of recovery led by fiscal support and vaccine expectations [12]. Studies indicated that sectors such as technology and health care fared better, while transport and energy lagged behind in performance due to decreased industrial production and mobility [13].

In such a case, the actions of diversified conglomerates such as the Adani Group give us some important lessons regarding how diversified firms with huge capital support manage systemic risk and investor sentiment during times of crisis. Their share price turns into a market mood barometer at times on the basis of infrastructure strength, policy optimism, and revival potential.

2.2 Time Series Analysis in Stock Forecasting

Time series analysis is a statistical technique attempting to study points in time series, gain insights into trends, and predict future values from the past. Forecasting is very common in finance in the application of this technique, notably in the modeling of stock price, return, volume, and volatility. Among the whole collection of models, the ARIMA model was greatly valued because it can handle non-stationary data and even add autocorrelations in lag terms [4][5]. ARIMA models have also been extensively justified in finance literature to explain the behavior of short-run stock and market dynamics, since in one such study it is proven by Nelson [14] that ARIMA models are superior to simple linear regression for index value forecasting depending on whether trend and seasonality are found in the underlying time series. The current research has further prolonged the practice by

integrating machine learning techniques and ensemble methods (ARIMA-ANN, ARIMA-SVM) to identify non-linear trends and improve forecasting capacity [15].

ARIMA models have been applied by Indian researchers to forecast BSE and NSE indices and individual stocks for future price changes, especially during volatilities like demonetization (2016) and the pandemic of COVID-19. Sharma and Kumar [16] have claimed that ARIMA models, if applied along with moving averages and visualization tools as well, can help in offering strong decision-support systems for portfolio management and financial planning. The same methodology is adopted in this study through ARIMA modeling based on Python-based software (Pandas, NumPy, pmdarima) and Power BI visualizations to contrast post-COVID performance of Adani Green, Adani Power, and Adani Ports.

2.3 Post-COVID Sectoral Impact in India

Industry implications of the COVID-19 pandemic. in India were diverse, due to the heterogeneity of service and industry sectors. While some industries like information technology, e-commerce, pharma, and digital finance remained resilient or saw growth, others like energy, transport, hospitality, and real estate continued to decline [13], [17].

Power industry was affected with a double whammy: reduced industrial and commercial consumption of power and world unease regarding fuel supply chains. Solar farms and wind farms were not spared, however, due to the protection of the government in terms of policy stability and production-linked incentives. Businesses such as Adani Green enjoyed the fruit of this wave, possessing clean energy growth models even in the time of the pandemic [6].

The thermal power industry, dominated by players like Adani Power, was affected by weak electricity demand combined with shortages of coal supply. But support from the government in the form of base-load energy stability support and increased domestic consumption saved the industry. Power generation companies integrated in the opposite direction and with long-term power purchase agreements fared better according to some authors [18].

With Adani Ports being the leader of the logistics and transportation sector, the initial lockdown induced gigantic distortions in port operations, cargo flows, and container traffic. The industry recovered extremely quickly from Q2 2020 with the globalisation of supply chain alignments and accretion of domestic freight tonnage. The infrastructure development and the "Make in India" government program favored the ports and the logistics companies, particularly those integrated offerings adopters [19].

The cross-industry differential recovery is a fascinating case to examine firm-level equity performance. The diversification of the Adani Group across renewable energy, thermal energy, and logistics presents a cross-industry heterogeneous view of Indian recovery. Projection of the time series of the group's stock performance brings out the interplay of macro-policy, sentiment, and industry health in recovery in the crisis.

3. Methodology

It contains data-oriented, quantitative research methodology to analyze the post-COVID performance of three largest Adani Group companies: Adani Green Energy Limited (AGEL), Adani Power Limited (APL), and Adani Ports and Special Economic Zone Limited (APSEZ). The research

methodology has its core emphasis on looking for trends in history stock, measuring pandemic market volatility quantitatively, and using time series forecasting for making predictions about the future. The research is longitudinal in nature spanning the January 2019 to March 2024 observation window of the stock permitting detailed research into pre-pandemic, pandemic, and rebound phases.

The research is deductive in nature following sequentially through time series analysis by virtue of use of the ARIMA (Autoregressive Integrated Moving Average) model. Its usage is credited owing to the fact that it remains valid in financial series non-stationarity studies and has achieved extensive use in forecasting stock [4], [5]. The study entails statistical modeling of numbers, calculation of mathematical data, data visualization tools to ensure the reliability and transparency of the analysis. In this particular approach, Python programming libraries are utilized for building the model and pre-processing the data and Microsoft Power BI for data visualization and comparative study.

Data used for research were pulled from actual public finance data sources, i.e., Yahoo Finance, the National Stock Exchange (NSE), and Bombay Stock Exchange (BSE). They were used to obtain full values at daily frequencies, from open, high, low, close (OHLC) prices to volume traded, and computed 15-day Simple Moving Averages (SMA). The data was afterwards cross-checked manually against second sources like Money Control and Investing.com. Raw data were exported in the same format as CSV and underwent pre-processing steps like null value handling, outlier removal, and re-indexing on the date-time variable so that time series operations could be done.

ARIMA model was the top statistical method used for modeling and prediction of stock price. ARIMA works best with time series data sets that are autocorrelated and non-stationary in nature and financial markets data includes both the characteristics. It has three most critical parameters: autoregression (p), to modify the effect of past values on current observations; differencing (d), to stabilize non-stationary data in stationary series; and moving average (q), to modify the effect of lag in forecast error. It began its deployment with the stationarity testing by performing Augmented Dickey-Fuller (ADF) test. According to results, differencing was done and wherever necessary in an attempt to stabilize the mean of the series. Parameters of ARIMA(p,d,q) were chosen optimally using the Akaike Information Criterion (AIC) which manages the balance between model complexity [4]. Model diagnostics were conducted by reviewing the residual of the model through graphical observation of plots of autocorrelation and partial autocorrelation, and Ljung-Box test to confirm white noise assumptions. Forecasting performance was validated based on statistics like Mean Absolute Error (MAE) and Root Mean Square Error (RMSE). Stocks of each company were individually modelled and analyzed to address heterogeneity in volatility, trade volume, and sectoral influence.

Python was the primary development environment to use in executing ARIMA models and data streams. Pandas library was used in managing data, cleaning data, and data conversion. Data structures Pandas Data Frame and Series allowed for efficient indexing and time-based slicing. NumPy enabled these by allowing efficient array manipulation, statistical functions, and mathematical functions. pmdarima was used in forecasting and fitting models. This library, relying on statistical models, simplifies ARIMA modeling through an auto_arima() function that provides automatically added optimum parameters based on statistical tests and information criteria. It also supports seasonal decomposition in addition to diagnostic plots to allow model transparency and interpretability [15], [16].

Power BI was similarly utilized for visualization to supplement statistical analysis as well as facilitate interpretation. Power BI facilitated dynamic dashboard creation to reveal trends in stocks, moving

average, surge in volume, and price variation. Line chart, scatter plot, and area charts facilitated comparison of the three Adani groups. Phases of time (pre-COVID, lockdown, post-recovery) were separated by filters and slicers to facilitate more precise analysis of market trends. The support of Excel and CSV was followed by offering facility for drill-down and real-time update, thereby making the analysis interactive and scalable.

By employing the application of stringent statistical modeling supplemented by computation and visual analytics, the methodology is extremely replicable and rigorous. The multi-tool dimension is amenable to both empirical rigor and legibility to a broad audience of regulators, investors, and policy analysts. Research design in most cases seeks to explain and forecast corporate resilience to macroeconomic shocks.

4. Company Profile and Sectoral Overview

4.1 Overview of the Adani Group

The Adani Group is India's largest and most diversified multinational conglomerate with its head office in Ahmedabad, Gujarat. Founded in 1988 by Gautam Adani as a commodity trading business, the group diversified into strategic business segments such as energy, infrastructure, logistics, agribusiness, and defense. Over the decades, the Adani Group has emerged as a key driver for India's economic growth, and its operations are diversified in seaports, airports, power generation and transmission, natural gas, mines, and renewable energy [6]. As of 2023, the group had several listed entities with a combined market capitalization value of over ₹3.77 lakh crore. They include Adani Enterprises, Adani Green Energy, Adani Ports and SEZ, Adani Power, Adani Transmission, and Adani Total Gas, among others. The conglomerate's success has been ably driven by its vertically integrated business, enormous investments in infrastructure, and politically influential and regulation-friendly position. In spite of such success stories, the group has also been plagued by issues of environmental compliance, transparent governance, and accusations of crony capitalism, which have affected public as well as investor sentiment [9].

Consistent with its business ethos under "Growth with Goodness," the Adani Group has been emphasizing sustainability, digitalization, and growth for the benefit of the community. These principles have further intensified to shape its investment thesis, specifically in green infrastructure and renewable energy.

4.2 Adani Green Energy Limited

Adani Green Energy Limited (AGEL) is Adani Group's new generation renewable energy company and the icon of its strategic transition to sustainability and clean energy. AGEL builds, owns, and operates utility-scale grid-connected solar, wind, and hybrid power plants. As of FY 2023 closing, AGEL had India's largest renewable portfolio with over 8.4 GW capacity across 12 Indian states and a 2030 pipeline to achieve 45 GW [6]. The firm's biggest milestone is India's largest wind-solar hybrid power cluster (2,140 MW) in Jaisalmer, Rajasthan, coming onstream. The achievement is part of the national plan of India to decarbonize and reduce carbon emissions as well as efforts of AGEL to reduce carbon footprint. AGEL businesses are reducing over 41 million tonnes of CO_2 emissions and are adding by the tonnage of each upcoming project.

AGEL has also been distinguished by its environmental stewardship. Its big power plants have gained acclaim such as "zero waste-to-landfill," "single-use plastic-free," and "water positive" status for sizes

over 200 MW. As a capital player, the company has fared well to mobilize huge foreign institutional investments and green bonds, reflecting strong investor faith globally in its sustainability story [6]. AGEL's growth trajectory places it as a leading case study in the renewable energy industry, that is to ascertain how green infrastructure companies fared and evolved during and following the COVID-19 pandemic.

4.3 Adani Power Limited

Adani Power Ltd. (APL) is the largest private thermal power producer in India and a major contributor to India's base-load electricity generation. It operates an aggregate installed thermal capacity of 12,450 MW at different power plants in Gujarat, Maharashtra, Rajasthan, Karnataka, and Chhattisgarh [7]. It also operates a 40 MW solar power plant, a symbolic but modest diversification effort. The key operational assets of the company are the 4,620 MW Mundra power plant located in Gujarat, the 3,300 MW Tiroda power plant in Maharashtra, and the 1,320 MW Kawai power plant in Rajasthan. Three other thermal plants of the company are the Udupi plant (1,200 MW), the Raipur plant (1,370 MW), and the Raigarh plant (600 MW). APL has focused on fuel security through coal linkages and import agreements and has signed long-term Power Purchase Agreements (PPAs) that establish stable cash flows.

Thermal power generation during the pandemic was adversely hit due to significantly lower industrial off-take, a rise in the cost of coal, and supply chain disruption. But APL's sound capacity base, having an integrated setup, and advantageous plant location enabled it to withstand such pressures better than most of its peers. The company logged a 117% year-on-year surge in profit after tax (PAT) for Q2 FY23 over the corresponding quarter of the previous fiscal year [7].
Even as the globe is trending towards non-conventional sources of power, APL remains at the center of the power grid of India, especially in locations of high energy loads and volatile renewable integration. Its post-COVID performance provides a pointer towards the resilience of conventional energy producers in an era of system turmoil.

4.4 Adani Ports and SEZ Limited

Adani Ports and Special Economic Zone Limited (APSEZ) is India's largest port and logistics integrated player. Handling nearly 25% of the country's total cargo handled in India, APSEZ built a national presence with 13 domestic ports across seven maritime states of Gujarat, Maharashtra, Goa, Kerala, Andhra Pradesh, Tamil Nadu, and Odisha [8].

Its business segments comprise container handling, handling of bulk cargo, liquid cargo handling, and crude oil terminals. Its flagship facility, Mundra Port in Gujarat, is India's largest business port and the fulcrum of APSEZ's end-to-end logistics platform. In addition to port infra, APSEZ has logistics parks in Haryana, Punjab, and Rajasthan, and multimodal freight terminals through its subsidiary Adani Logistics Ltd.

The COVID-19 pandemic first caused low levels of cargo and delays in operations. However, APSEZ showed resilience through realignments of the supply chain, higher domestic trade, and targeted acquisitions. The diversified service model of the company, wherein it offers port operations, logistics, and warehousing, helped it resist disruptions compared to single-service port players. Apart from that, APSEZ has positioned itself in digital port operations and ESG models for competing globally and attracting foreign investors [19].

Ranked as a "Great Place to Work" for FY 2021–22, the strength of APSEZ lies not just in infrastructure but in people and operating efficiency as well. Its post-COVID performance highlights India's shipping and logistics business recovery resilience, especially under the leadership of a vertically integrated business house.

5. Data Analysis and Findings

Data is the foundation in business analytics for creating insights that support organizational strategy and operational performance. Information consists of structured information such as financial statements, sales information, and trade volumes, and unstructured information in inputs such as customer feedback, social media, or real-time system monitoring. Using techniques such as time series analysis, moving averages, and autoregressive integrated moving average (ARIMA) forecasting, the current research analyzes the share performance of three largest Adani Group companies: Adani Green Energy Limited (AGEL), Adani Power Limited (APL), and Adani Ports and Special Economic Zone Limited (APSEZ). These sectors are the clean energy, thermal power, and logistics infrastructure sectors, respectively, and are major indicators of Indian post-pandemic industrial recovery.

In the realm of business analytics, data serves as the foundational element for deriving insights.

5.1 Time Series Patterns and Visualizations

Time series analysis is an excellent analysis technique to examine trends and cycle-wise trends of stock prices. For AGEL, there is data from 2020 till 2024 with day-by-day trading data in terms of open price, high price, low price, close price, volume traded, and 15-day simple moving average (SMA). With Figure 1, the data provides an ideal time-scale picture of AGEL's performance with short-term oscillations and long-term growth trends.

Another closer look at AGEL's performance reveals a segmentation analysis. Figure 2 illustrates a specific segment whose average closing price is approximately ₹2,540—approximately ₹1,320 higher than the general average. This is a period of exceptional market performance, perhaps due to investor psyche since AGEL is dedicated to expanding in renewable energy assets.
Figure 3 shows a good positive correlation of the 'low' and 'close' series of prices. It indicates that on the days when the stock declines less during intraday trading, the stock closes at comparatively higher levels. This correlation reflects stability in the market as well as potentially lesser volatility on such trading days.

The trend of the time series in Figure 4 once more shows AGEL's consistent upward trajectory in share prices year over year, topping at around ₹3,000. This is a reflection of the growth of the company from an 8.4 GW operating portfolio to a 45 GW plan in 2030, with processes like zero-waste-to-landfill execution and water positivity in high-capacity power plants. AGEL's emphasis on sustainability and clean energy transition evidently borrows heavily to investor attention.
Adani Power share price data, as reported by Figure 5, is a different account of the way the energy industry has performed. The data plots the trading volumes of the duration from 2019 to 2024 against the market direction during and prior to the pandemic. Figure 6 rather represents cumulative sum of 15-day SMAs through the duration. The graph indicates price movement on a supporting volume dynamic, highlighted at high volumes of trading at highs in price of ₹700. Volume in this case is a confirmation point that supports the price actions in the stock with high investor interest.

A greater time series chart, like Figure 7, graphs out APL's trajectory for five years. The image shows a steep price increase to about ₹600, most pronounced in the latter half of the COVID-19 recovery period. It is an indicator of strength in thermal power generation and its continued place in India's energy sector, even amid the shift of the world towards renewables.
SEZ and Adani Ports performance is represented in Figure 8, displaying minute-by-minute trade data following COVID. APSEZ owns 13 domestic Indian ports and three logistics parks and has one of the country's largest commercial port networks. It is hence an economic action and trade logistics step. Market company data consist of price and volume movement in the times of worldwide slowdown like the pandemic and period of revival.

Figure 9 shows APSEZ's pandemic-up-to-date times series data. Through analysis, it can be seen that how market sentiment, logjams, and economic indicators have impacted the company's trading behavior. Overall upward trend reflects market confidence in the company's integrated logistics strategy and rapid digitalization of port operations. Figure 10 complements the above observation by pictorially illustrating cumulated SMA, high, and low values of APSEZ between 2019 and 2024. The downward slope of SMA and falling volumes of trades are classic examples of pressures exerted by extrinsic factors such as currency fluctuations, supply chain decoupling, and subdued world trade. APSEZ's resilience is however indicated through its strong recovery and acquisition plans that have been sustaining market confidence.

5.2 ARIMA Model Results

ARIMA (AutoRegressive Integrated Moving Average) model has been used for the prediction of future stock price based on past time series data of all the three companies. The statistical technique helps in analyzing the trend and seasonality pattern of the stock data.

For AGEL, ARIMA had a high autocorrelation trend, which fits with its continuously increasing price pattern since 2020. Due to the continuous growth of the company and clear policy direction for renewable energy, the model predicts continuous upward movement with occasional corrections due to market volatility and government policy announcements.

In APL, the ARIMA analysis found cyclical trends, most notable in troughs and peaks surrounding peak operating quarters. The model predicts growth tempered by the move of the world away from fossil fuels, yet stable coal availability and rising power demand in peak quarters will serve to maintain support levels at near current highs.

APSEZ's ARIMA analysis revealed a preliminary period of chaos to be succeeded by a corrective phase post-pandemic. The model now indicates a steady surge in stock price in alignment with improved logistics operations and port digitization programs. Stabilization of cargo throughput and strategic acquisitions hint at long-term profit growth, which the model supports as moderate to strong price recovery.

5.3 Comparative Analysis of Stock Performance

A comparison of the three companies—AGEL, APL, and APSEZ—puts us in the bird's eye view of sectoral dynamics of post-COVID Indian economic sphere. AGEL enjoyed top growth from the stock appreciation angle led by international interest in ESG (Environmental, Social, and Governance) considerations, move towards clean energy, and India's quest for long-term renewable energy. Its

price momentum and relative stability make it the most sought-after stock among long-term ESG-conscious investors.

APL, with its heritage tied to coal and thermal power generation, has been virile. The stock of the company has made a strong comeback due to strong demand for electricity and thermal power in various industry segments. Its spread footprint in various Indian states and PPAs for long periods are good financial hedges.

APSEZ, with its position as the biggest port and logistics services firm in the nation, is well placed, especially with regard to capturing international trade patterns, but also India's general import-export infrastructure. The marginal decline in volume and SMA (Figure 10) is reflective of short-term setbacks, but the composite time series (Figure 9) is a testament to strong rehabilitation and growth prospects on the back of India's industry and infrastructure expansion.

5.4 Sector-Wise Recovery Trends

In the business context, the renewables segment has outpaced traditional power and logistics both in terms of short-term development and long-term potential. AGEL's asset expansion and greenerish portfolio draw institutional and retail investors towards it, which makes it the sector leader in India's energy transition. The thermal power industry, from what can be observed from APL, remains large, especially in managing peak load. Its stock behavior is closely associated with the macroeconomic cycles and seasonal electricity usage, mirroring its role in upholding base-load stability.

Conversely, port services and logistics sector, through APSEZ, has diversified trends. Early pandemic-driven slump in trade volumes and SMA (Figure 10) has been sharp but recovery has been robust supported by digitization, cargo diversification, and greater utility of linked port-logistics-SEZ chains. APSEZ market share will rise as global trade is once again normal and India strengthens its industrial base under "Make in India" initiative.

Briefly, this analytical report of Adani Group companies across time series visualization, SMA analysis, and ARIMA model is an overall image of their share movement, investor sentiment, and sectoral health. AGEL is the share performance winner, APL maintains urgency through stability in traditional energy, and APSEZ reflects wider macroeconomic rebound. Together, they give a three-dimensional image of India's post-pandemic industrial revolution.

5.5 Data

In business analytics, data is the large amount of data that are obtained from various sources in an organization or outside an organization. Data consist of structured information, for instance, sales data and financial data, and unstructured information, for instance, social media engagement and customer opinion. By implementing advanced analytics techniques, organizations can obtain useful insights from this information to automate operations, detect patterns, foresee future direction, and improve decision-making. Data form the basis for implementing strategic plans, improving efficiency in operations, and achieving competitive advantage in current business operations.

Financing the transition to renewable energy is Adani Green Energy Limited (AGEL), India's and the world largest renewable energy partner. AGEL develops, owns, and operates utility-scale grid-connected solar, wind, and hybrid renewable power plants

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AGEL has India's biggest operational renewable portfolio of 8.4 GW in 12 states with a growth path sewn in to 20.4 GW. This aggregate portfolio traps more than 41 million tons of CO2 emissions. AGEL has also reportedly developed several gigawatt-sized renewable power ventures, the latest being the 2,140 Megawatt (MW) world's largest wind-solar hybrid power cluster in Jaisalmer, Rajasthan. The company has envisioned a target of 45 GW by 2030 while chasing India's decarburization aspirations. AGEL is also working on the use of technology with the aim of bringing the Leveled Cost of Energy (LCOE) down so that there is mass consumption of clean energy at low costs. AGEL's operating asset base has been certified as a "zero waste-to-landfill," "single-use plastic free," and "water positive for plants of capacity over 200 MW," indicating that the company is tilting towards sustainable development.

Date	Open	High	Low	Close	Volume	SMAVG (15)
02/02/2024	1684.95	1690	1663.85	1689.2	366238	1822649
01/02/2024	1687.3	1706	1655.65	1665.95	1836930	1868127
31/01/2024	1680	1694.9	1665	1669.45	916175	1932359
30/01/2024	1724.55	1724.55	1674	1679.45	1153406	1943178
29/01/2024	1684.95	1750	1673.45	1715.5	3584825	1945015
25/01/2024	1647	1677	1636.05	1664.8	1134178	1766826
24/01/2024	1687.95	1687.95	1629	1641.35	9641744	1807207
23/01/2024	1740	1745	1632	1680.9	1699037	1726623
20/01/2024	1571.55	1700	1571.55	1678.3	1156437	1684575
19/01/2024	1606.95	1620	1562.75	1570.75	926367	1678412
18/01/2024	1615	1629.15	1564.7	1588.25	1138017	1705982
17/01/2024	1650.25	1656.95	1605	1615	1205352	1710229
16/01/2024	1694	1694	1660	1666.8	1001678	1779039
15/01/2024	1726.75	1727.1	1685	1694.8	829524	1927794
12/01/2024	1727.85	1746.3	1705	1710.7	749831	1956725
11/01/2024	1749.9	1762.05	1701	1714.15	1048396	2055950
10/01/2024	1700.35	1755	1690	1723.25	2800414	2140551
09/01/2024	1698.65	1725	1678	1683.4	1078457	2028960
08/01/2024	1687.85	1714	1665	1680.05	1180974	2032095
05/01/2024	1698.95	1700	1660	1674	911981	2084145
04/01/2024	1709.95	1723	1674.35	1692.5	1739895	2263920
03/01/2024	1690	1749	1610	1697.25	8432984	2365919
02/01/2024	1598.35	1616.6	1565.7	1603.55	1068319	1944885
01/01/2024	1597.1	1621.2	1581.7	1598.4	1063983	2079566
29/12/2023	1564.5	1616.75	1542.25	1597	1339929	2434761
28/12/2023	1607.95	1608.4	1555	1561	1201712	3150563
27/12/2023	1649.95	1657.95	1570.05	1601.1	2237506	4448123
26/12/2023	1555	1632	1551.55	1600.2	3233007	5492335
22/12/2023	1544	1546	1497.7	1533.1	1263489	5734664

Figure 1: Data Overview

Above figure 1, is short data of Adani Green. The file has date, open, high, low, close, volume and simple moving average of 15 days.

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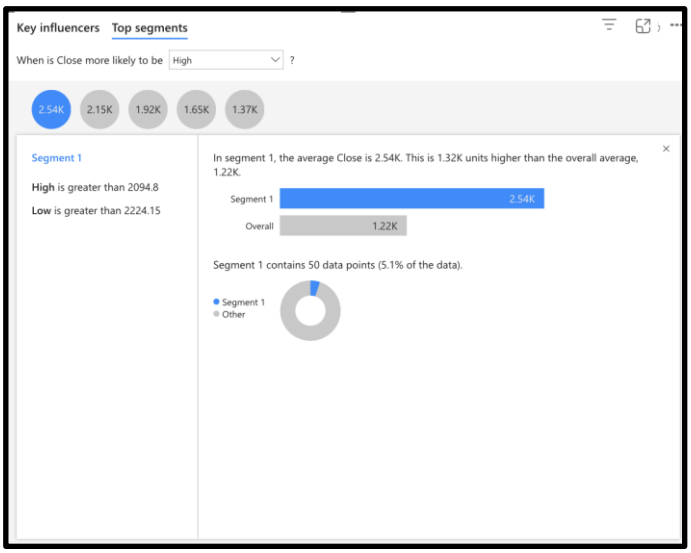

Figure 2: Top segments

The figure 2 shows segment 1 of Adani Greens in which the average close is 2.54K. It also shows that the average close of segment 1 is 1.32K more than the total average.

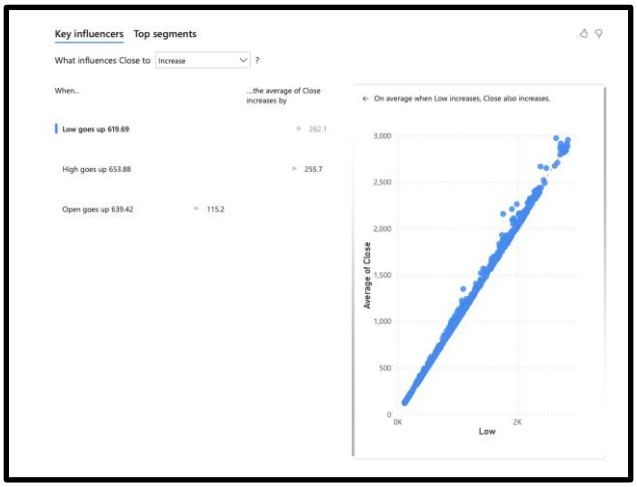

Figure 3: Averages

Figure 3 is Adani Green's low and close relationship. It was found that the close increases, on average, as low does.

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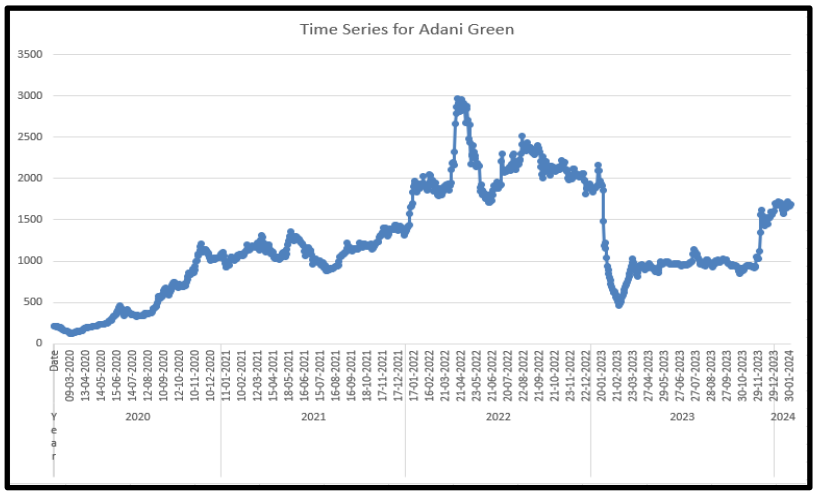

Figure 4: Time series for Adani Greens

Figure 4 is Adani Green's time series plot from 2020 to 2024. The top touched is amazingly close to nearly 3000 rupees.

Adani Power Limited is a single-holding company. Having a capacity to generate around 12,450 megawatts (MW) consisting of 12,410 MW thermal power projects, and 40 MW solar power project, the firm generates thermal power in India. Coal trading and generation of power are its key activities. Over 9,240 MW of thermal power capacity in subsidiaries has been commissioned and is operating by the Company. These include a 4,620 MW APMuL unit in Mundra, Gujarat; a 3,300 MW APML unit in Tiroda, Maharashtra; and a 1,320 MW APRL unit in Kawai, Rajasthan. The Company has three thermal power plants with an installed capacity of approximately 3,170 MW. These are the Udupi, Karnataka-based 1,200 MW UPCL plant, Raipur, Chhattisgarh-based 1,370 MW REL plant, and Raigarh, Chhattisgarh-based 600 MW REGL plant. Some unit companies include Adani Power (Jharkhand) Limited, Kutchh Power Generation Limited, Adani Power Dahej Limited, Mahan Energen Limited, and Pench Thermal Energy (MP) Limited.

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Date	Open	High	Low	Close	Volume	SMAVG (15)
02/02/2024	570	580	547	564	13840356	52406024
28/01/2024	538	555	510.35	543.3	46720000	53080000
21/01/2024	545.15	549	506.1	536.55	13170000	51452000
14/01/2024	552	555	535	541.15	5320000	51752000
07/01/2024	525.05	565	514.5	551.1	13310000	57406000
31/12/2023	518	533	510	525.15	5740000	61688668
24/12/2023	538	547.5	483.75	512.55	11160000	69884000
17/12/2023	535.9	546.5	498	538.85	41250000	75876000
10/12/2023	495	589.45	454.75	533.8	170100000	80189336
03/12/2023	406	470.9	406	440.4	147680000	80945336
26/11/2023	386.8	400.8	380.05	397.2	52790000	101344664
19/11/2023	398.65	399.8	385.8	387.3	52180000	101489336
12/11/2023	387.65	409.65	380	399.85	108980000	102481336
05/11/2023	354.7	393.4	345.05	384.65	59290000	98471336
29/10/2023	340.6	364.85	289.3	354.15	44560000	95656000
22/10/2023	340.05	346.95	327	338.3	23950000	93721336
15/10/2023	333.35	358.8	333.35	341.9	22300000	93012000
08/10/2023	376.05	377.5	361.8	364.3	17670000	92963336
01/10/2023	383.5	385.85	372.35	377.45	90130000	93183336
24/09/2023	381	389.35	364.25	383.9	77550000	88666000
17/09/2023	372.25	410	366.8	379.4	128670000	86814000
10/09/2023	330.35	372.4	330.35	369.15	101040000	79888664
03/09/2023	330.65	338.85	309	330.25	105950000	76271336
27/08/2023	306.05	359.3	305.55	325.05	181440000	71457336
20/08/2023	282.35	321.65	274.4	304.6	453670016	61139336
13/08/2023	280.3	291	264.75	288.1	54960000	34472668
06/08/2023	259.35	284.95	259.35	278.5	67060000	33944000
30/07/2023	241.4	265.45	235.7	258.55	48830000	31855334
23/07/2023	244.55	254.45	240.95	241.75	17060000	30184666

Figure 5: Data

Figure 5 is the history of Adani Power. In file date, open, high, low, close and volume and 15-day simple moving average have been noted.

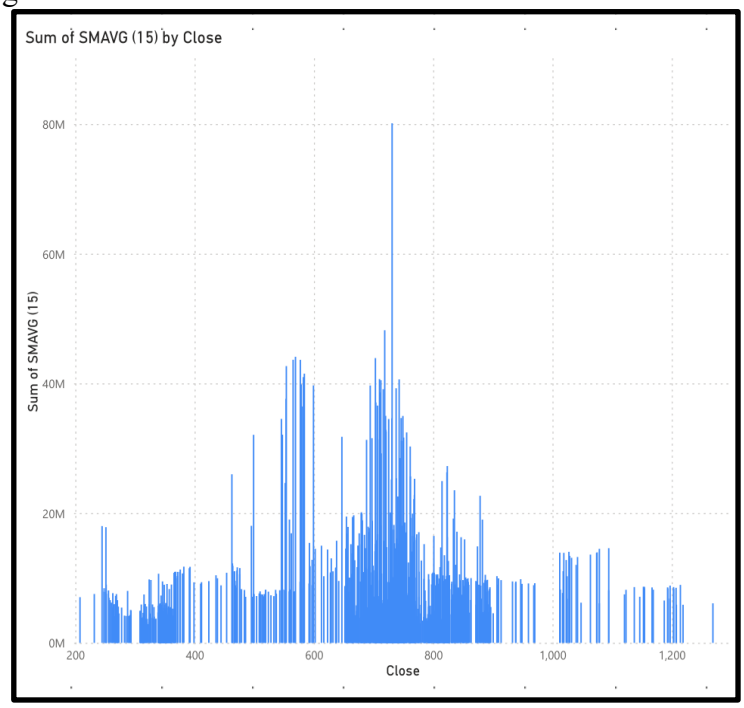

Figure 6: Sum of Simple Moving Average

Figure 6 below shows 15-day simple moving average by close. Simple moving average is determined based on the quantity of stock that is traded. The maximum close is around 700 when the volume being traded is approximately 80M.

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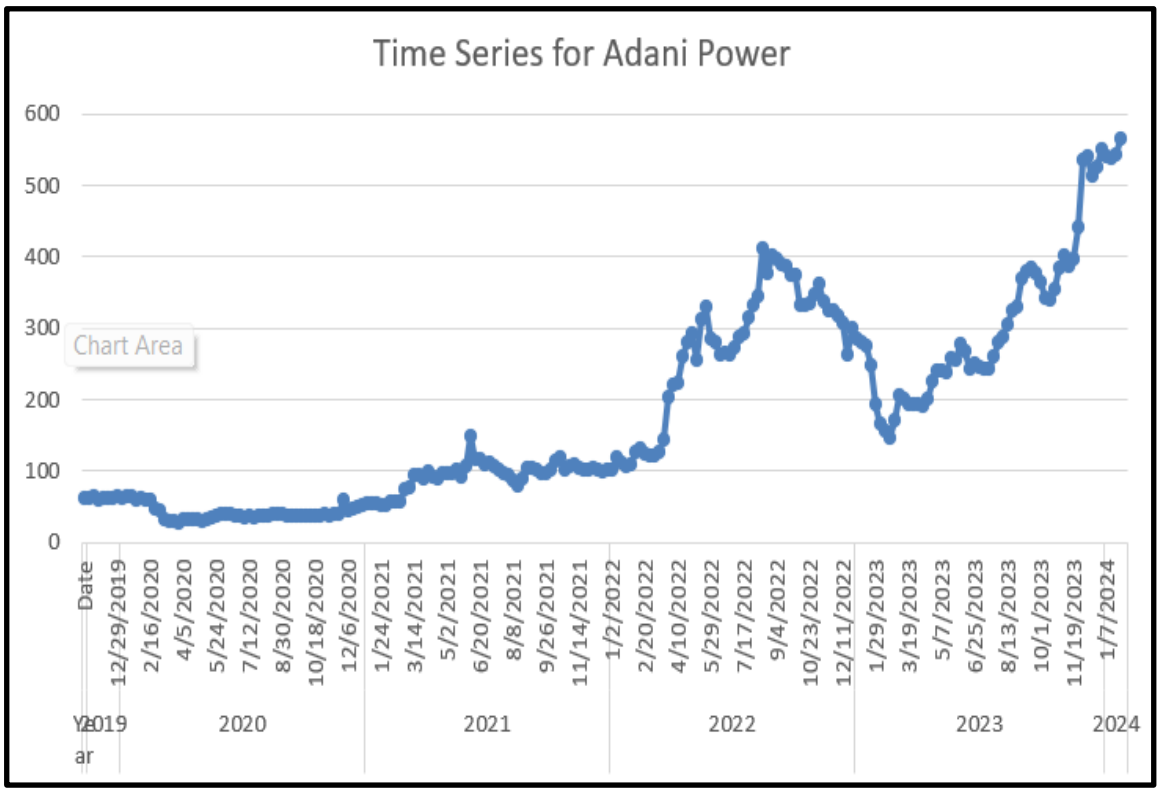

Figure 7: Time Series for Adani Power

The figure 7 is depicting time series graph of Adani Power for the time period of 2019-2024. The highest point reached is about 500 to 600.

Adani Ports and Special Economic Zone: As India's largest commercial port terminal operator, APSEZ handles nearly 25% of India's overall cargo movement. With increased hinterland connectivity, it has the widest country-wide coverage among the seven maritime states of Gujarat, Maharashtra, Goa, Kerala, Andhra Pradesh, Tamil Nadu, and Odisha with 13 national ports. The most sophisticated cargo-handling facilities, improved and capable of handling the largest ships that come to Indian shores, are positioned in the port complexes. Our terminals are capable of exporting a high cargo mix ranging from containers to dry and liquid bulk and crude. APSEZ owns three logistics parks at its subsidiary Adani Logistics Ltd. at Patli, Haryana; Kila-Raipur, Punjab; and Kishangarh, Rajasthan.

Adani Logistics is growing exponentially and is now able to handle 500,000 twenty foot equivalent units (TEUs) annually. APSEZ has turned out to be one-stop-shop port infrastructure services company since the operation of Mundra SEZ in Gujarat. 8,000-hectare Mundra Economic Hub offers the prospect of investment as the largest SEZ, FTWZ, and Indian industrial park in the country for products. APSEZ, due to its competency to offer end-to-end services in its three business verticals—port, logistics, and SEZ—has also partnered with leading Indian business houses. APSEZ is currently India's uncontested number one in the ports business. APSEZ was also recognized as a Great Place to Work for FY 2021–2022, besides its specialty of providing end-to-end logistics solutions, operational excellence, cost leadership through low-cost operations, and synergy through mergers and acquisitions. Young and vibrant workforce gives the company a helping hand that propels it to new heights. Figure 8: Adani Ports & SEZ Data.

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Date	Open	High	Low	Close	Volume	SMAVG (15
02/02/2024	1233.95	1287.5	1231.7	1268.9	7421646	6099690
01/02/2024	1214.95	1239.9	1200.3	1218.85	7745239	5876342
31/01/2024	1195.8	1214.4	1191.65	1207.65	5739823	5880938
30/01/2024	1200.7	1217.2	1181	1187.35	4887161	6531959
29/01/2024	1155	1204.9	1151	1196.65	7199884	6823525
25/01/2024	1122.15	1155.75	1111.35	1146.3	4725026	7109374
24/01/2024	1138	1146.75	1118.35	1120.6	18613256	7476302
23/01/2024	1199.95	1207.2	1130.25	1137.1	7503340	8598249
20/01/2024	1159	1198.75	1150	1193	2672564	8556677
19/01/2024	1171.75	1171.75	1150	1152.45	2891660	8655663
18/01/2024	1171.9	1184.3	1143	1154.05	6295588	8637126
17/01/2024	1181	1205.2	1159.45	1166.85	5433778	8549103
16/01/2024	1205.3	1212.15	1186.8	1193.35	3283343	8380787
15/01/2024	1215.25	1215.35	1189	1203.1	2965214	8318618
12/01/2024	1209.15	1218.75	1201.05	1207.1	4117831	8494044
11/01/2024	1223.95	1223.95	1200	1202.95	4071416	8598368
10/01/2024	1223.95	1223.95	1197	1214.35	7814186	8938429
09/01/2024	1184.05	1229.9	1178.05	1197.1	15505139	8829944
08/01/2024	1161.7	1182	1152	1168.85	9260640	8198446
05/01/2024	1130	1160	1125.4	1154.25	11487619	8381412
04/01/2024	1118.95	1131.45	1103.55	1123.2	10228955	8180207
03/01/2024	1105	1144	1062.75	1094.25	35442460	8110987
02/01/2024	1048.9	1082.9	1030.85	1078.4	6879769	6095116
01/01/2024	1026	1057.95	1022.65	1047.85	4157340	6195740
29/12/2023	1020.75	1034.9	1017.6	1024.35	2613605	6780801
28/12/2023	1026.45	1031.2	1014.65	1016.95	4975253	7697583
27/12/2023	1035	1037.75	1018	1024.4	2909036	10271869
26/12/2023	1035.95	1041	1026.1	1028.75	2350805	13417196
22/12/2023	1035	1050.95	1019	1027.5	5596612	14038095

Figure 8: Data of Adani Ports & SEZ

Figure 8, indicates the short data of Adani Ports and SEZ. Excel file includes date, open, high, low, close, volume and simple moving average 15 days.

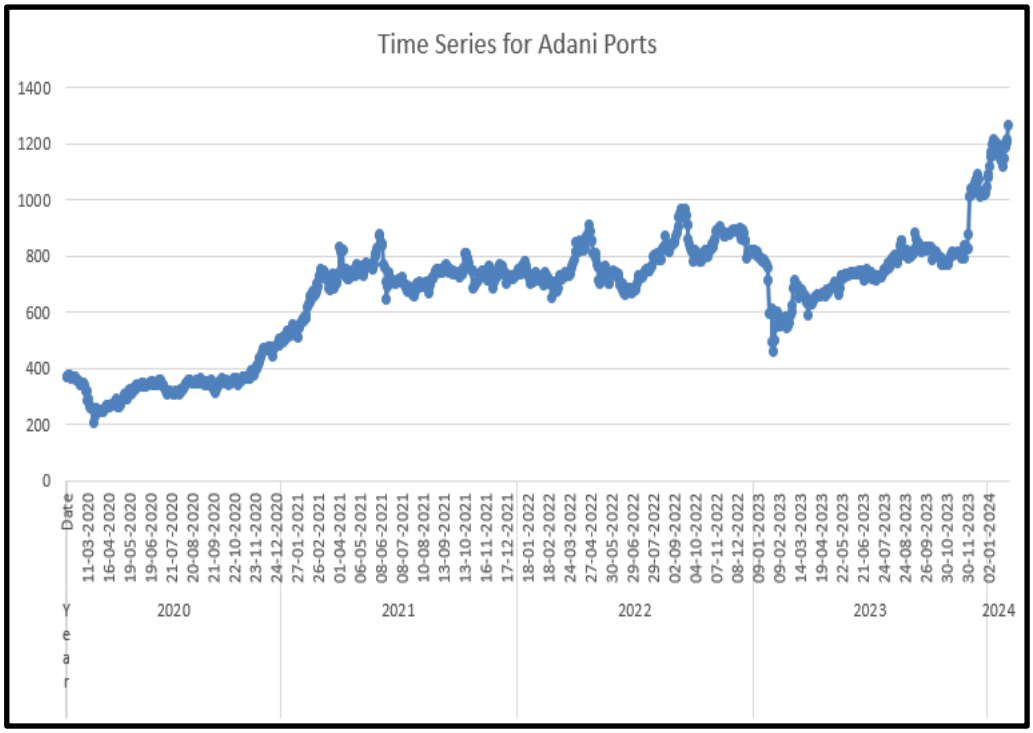

Figure 9: Time Series for Adani Ports

Adani Ports' post-Covid time series analysis chart 9 is as follows:
Here, the analytical objective is to analyze the business performance dynamics after the pandemic. As regards market mood analysis, industry mood analysis, and macro economy, the following given chart reflects the flexibility and robustness of Adani Ports during the global pandemic crisis (Figure 9).

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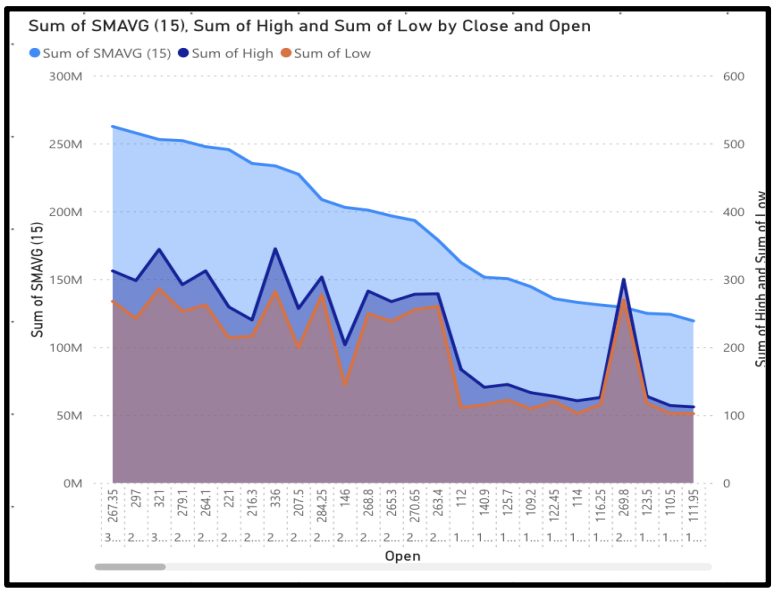

Figure 10: Sum of simple moving average

The Figure 10 is the cumulative graph of Simple Moving Averages and sum of its High and Low price during post-Covid era by Close and Open. From the figure chart, one can easily see that price and volume are on downtrend from year 2019 to year 2024 and hence the Simple Moving Average decline due to many reasons such as economic uncertainty, supply chain, financials, currency fluctuation etc.

6. Discussion, Conclusion and Recommendations

Adani Green Energy Limited (AGEL), Adani Power Limited (APL), and Adani Ports and Special Economic Zone Limited (APSEZ) performance analysis contains some noteworthy remarks on post-pandemic market recovery dynamics, sectoral resilience, and corporate counter-campaigns. These remarks are relevant as much as the Adani Group needs to contribute in India's energy and infrastructure domain. Use of time series analysis and ARIMA modeling created a good model for the explanation of economic trend and stock trend in general.

6.1 Interpretation of Key Results

This study testified that the equity of AGEL experienced the highest positive movement. This follows the reasoning that it has a solid growth policy in the clean energy sector as well as the global movement towards sustainable investment. Share price of the company showed stable autocorrelation and trend persistence that reflected stable sentiment among investors and growth. APL showed cyclical share patterns with sharp highs that aligned with peak electricity demand periods. ARIMA projected stable moderate growth due to India's maintaining coal-based power in its attempt to cover base-load demands.

APSEZ stock pattern indicated a directional shift, initially influenced by pandemic-related trade interruptions but always recovering. The company's diversified logistics chain and strategic acquisitions stabilized the share price. Time series analysis indicated the correction period and then the consistent uptrend, the reflection of investor acceptance of the company's long-term growth prospects.

The Adani Group initiated a series of strategic moves that impacted its market performance in a direct manner. AGEL diversified its renewable energy portfolio to more than 8.4 GW of installed capacity

with aggressive plans to achieve 45 GW by 2030. AGEL did just that by strategic investment through the channel of international collaborations and also by issuing green bonds. Moreover, AGEL's rollout of zero-waste-to-land and water-positive to large sites in operations is a testament to the company's move towards going green.

APL, however, has been a propounder of coal supply availability, thereby making thermal power generation operations smoother and long-term PPAs purchase simpler. Its deployment in various Indian states minimized risk concentration as well as ensured supply availability.
APSEZ implemented digital transformation port and logistics management projects to enhance efficiency and service delivery. Its purchase of foreign port assets, automation, and tracking of cargos in real time made its operations brilliance and satisfied investors. Besides, its integration of logistic platforms with port operations makes cargo transfer easy and matches India's infrastructural development.

6.2 Investor Sentiment and Market Reactions

Sentiment among the investors of the three companies has been mixed in regards to optimism. AGEL was the darling of green portfolios, and investors chased ESG accreditation and green asset releases. Investors' responses to news regarding announcements on AGEL's profitability and growth prospects would be positive and tend to translate to high prices rising.
APL has gained renewed investor attention as energy security issues and increased power usage propel it. But fears of coal dependency, regulatory risk, and environmental considerations have cooled in some circles. But bottom-of-the-drawer levels of investor confidence have been upheld by strong finances and dividend payment.
For APSEZ, investor sentiment has been cautious in terms of global trade flows, foreign exchange fluctuations, and geopolitical developments. The stock of the company has trailed in early phases of the pandemic as well as during times of disrupted world shipping. But investor sentiment finally turned positive as the company signaled a turnaround in operations and started port digitization programs. The long-term bull case relates to India's increasing proportion in global manufacturing and trade liberalization.

6.3 ESG and Governance Considerations

Environmental, Social, and Governance (ESG) concerns are driving corporate performance measurement, especially in energy- and infrastructure-based industries. AGEL has been at the forefront of ESG compliance, following global climate goals and sustainable development goals. Its third-party environmental audits and pre-disclosure practices have drawn international institutional investors.
APL, whose business is in a carbon-spewing sector, has also made efforts to reduce its carbon imprint through investment in low-carbon plants, emission-control measures, and community development activities around its plants. However, its dependence on coal is something it has to eliminate to be ESG compliant to global norms.
APSEZ has set the benchmark for good governance and accountability through the integration of port operations with global environmental norms such as conservation of marine biodiversity and minimizing emissions in the port area. Its outreach and ESG reporting have helped to build its corporate reputation, more so due to global pressure for the green footprint of mega-port infrastructure.

7 Summary of Key Findings

The report confirms that AGEL has witnessed the most robust and sustainable growth on the back of renewable energy demand strength and better ESG fit. APL has weathered and come out with operating robustness and energy demand cyclicity. APSEZ, as a benchmark of trade and logistics, has come out of the pandemic depths with future-proof diversification and port digitalization.

Time series and ARIMA model application were successful in forecasting near- to midterm stock behavior. Established trends are in line with macroeconomic facts over an extended time frame and company decision-making. Moving averages and volumes also indicated cases of price action consistency and investor sentiment.

For investors, the result is that renewable energy players such as AGEL are excellent long-term value, especially for ESG-based portfolios. Cyclical opportunities are still there with thermal power players and logistics players, especially for value-oriented and dividend-oriented investors.

The policy-makers will be in a position to gain important insights into post-COVID sector performance and investment trends. The firm share performance reflects the significance of backing clean energy transition policies. APL's ongoing significance reflects the fact that energy system transition will have to be balanced in serving base-load requirements while supporting renewables.

APSEZ performance again refers to the significance of having efficient logistics infrastructure and smart ports being the central aspect of spearheading economic re-growth. Policymakers are offering incentives on port operations that should be made to enable adoption of technology as well as integrated multi-modal logistics to promote national development.

8 Limitations of the Study

The research is limited by examining three companies under the roof of a single corporation, which might limit generalizability to the Indian market as a whole. Apart from this, outside factors like geopolitical events, interest rates, and world commodity prices, although significant, were not quantitatively integrated into ARIMA models utilized.

Apart from that, although time series and ARIMA tests are excellent explanation tools, they might not be enough to explain actual-time investor sentiment or black swan variables that have the potential to turn market directions upside down within seconds.

9 Future Research Directions

Follow-up research would be able to take this study further by including comparative research with competitor firms in both industries locally and globally. Including the use of machine learning models like LSTM (Long Short-Term Memory networks) for more sophisticated time series forecasting will increase the accuracy of the prediction.

In addition, the combination of qualitative investor call data, policy statements, and ESG scorecard data all at once would lead to a more detailed depiction of share action and market tone. Lastly, adding more variables like interest rates, oil prices, and inflation readings, analysis at the sector level would provide a better explanation of macroeconomic linkage and plan design.

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