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# Data Visualization for Analyzing Macroeconomic Indicators

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**Abstract:** Data visualization is used for representing data in a visual format, such as charts, graphs, and maps. This helps in the interpretation of trends and patterns in the data and the identification of outliers. It also enables businesses to communicate complex data to non-technical individuals easily. Data visualization methods such as Box plots, Scatter plots, Bubble charts, Motion charts and Rain cloud charts can be used to represent different data types. Macroeconomic indicators are important measures of the overall health of the economy. The indicators, such as Gross Domestic Product (GDP), Inflation Rate and Stock market Indices can provide insights into the performance of the world economy. The analysis and interpretation of these indicators help the policy-makers/traders, make informed decisions on investments and other Strategic initiatives based on the current state of the economy. This research paper has discussed the use of data visualization techniques to analyse macroeconomic indicators, such as Gross Domestic Product (GDP), inflation rate, stock market indices (Nifty50) on the National Stock Exchange of India, DJI-Dow Jones Index on the United States Stock Exchange, DAX- Deutscher Aktien Index on the Frankfurt Stock Exchange), and precious metal rates (Gold and Silver). The data were collected for the above indicators for the past five years (2018-2022). It has also highlighted the importance of data Visualization in decision-making, problem-solving and investment strategies.

**Keywords:** Data Visualization, Scatter Plot, Bubble Chart, Motion Chart, Rain Cloud Chart, Macroeconomic Indicators.

## 1 Introduction

Macroeconomic indicators are numerical measurements that provide information about the economic conditions of a particular region, country, or sector. These indicators are utilized by analysts and governments to evaluate the present and future state of the economy and financial markets. They provide critical insights into the overall economic health of a region, and assist in making informed decisions related to policy-making, investments, and financial planning. Visualizing these indicators using Charts and graphs may provide a great insight to the investors/traders/policy makers.

The macroeconomic indicators used in this research paper are viz. Gross Domestic Product (GDP), Inflation Rate, Stock market indices (Nifty50 on The National Stock Exchange of India, DJI-Dow Jones Index on the United States Stock Exchange, DAX- Deutscher Aktien Index on the Frankfurt Stock Exchange), and precious metal rates (Gold and Silver).

The Gross Domestic Product (GDP) is the prime indicator of macroeconomic performance.

The GDP, as an absolute value, shows the overall size of an economy, while changes in the GDP, often measured as real growth in GDP, show the overall health of the economy. GDP is calculated as the sum of consumption expenditure, investment, the government expenditure, and net exports. Inflation is calculated by using Consumer Price Index. It uses the weighted average value of the price of goods and services to measure the change.

The NIFTY 50 is a popular stock market index in India, which represents the performance of 50 large-cap Indian companies across various sectors. The NIFTY 50 is widely used as a benchmark by investors and fund managers to track the overall performance of the Indian stock market.

The Dow Jones Industrial Average, also known as the Dow or DJIA, is a stock market index that consists of 30 large and well-known publicly traded companies in the United States. It has a long history and is widely used as a gauge of the overall health and performance of the U.S. stock market. In a recent study, the focus was on examining how macroeconomic factors affect the performance of the stock market, with the Dow Jones Industrial Average serving as the benchmark for measuring its performance.

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The DAX is a stock market index on the Frankfurt Stock Exchange. It consists of the 40 major German blue-chip companies. It is a total return index.

Gold and silver prices in both global and local markets are established through the interplay of various factors, including demand and supply dynamics, economic conditions, and prevailing interest rates. Any alterations in these elements have a direct or indirect impact on the valuation of gold. Gold is initially priced in US dollars. In India, most of the gold is imported to meet its requirements. Hence, the exchange rate and various duties further influence the gold price in India.

If the US dollar strengthens against the Indian rupee, gold prices in India go up and vice versa.

The price of silver in India is determined by international prices, which move in either direction. Other than that, it also depends on currency movement of the rupee against the dollar. Silver prices go up if the rupee falls against the dollar while international prices remain stable. The prices of commodities like gold and silver are subject to a multitude of influences, including supply and demand dynamics, geopolitical events, and economic conditions.

The analysis of macroeconomic indicators can be done effectively using interactive visualization methods.

The patterns and the relationships in the data can be quickly identified using visualization and different scenarios can be explored to gain a deeper understanding of the data.

Different Data visualization methods used for the analysis of the above Macroeconomic Indicators in this research work are as below.

1) **Box Plot:** A box plot, also known as a box-and-whisker plot, is a type of chart that displays the distribution of a dataset. It is a five-measure summary plot consisting of three quartiles, Maximum and minimum value of the variable. It is commonly used in statistical analysis to show the spread and symmetry in the data and to identify outliers. Box plots are useful for identifying patterns in data, such as the presence of outliers, skewness, and symmetry.
2) **Scatter Plot Matrix:** A scatter plot matrix, also known as a pair plot, is a type of visualization that displays multiple scatter plots arranged in a grid. It is commonly used in exploratory data analysis to identify patterns and relationships between variables in a dataset.
3) **Bubble Chart:** Three dimensions of data can be represented using a bubble chart. It is similar to a scatter plot, but it includes a third variable that is represented by the size of the "bubble" on the chart. The large size of the bubble indicates that the value of the third variable is high. the higher the value of the third variable. Bubble charts are often used to visualize data in which the size of the bubble represents a quantitative value.
4) **Scatter Plot with Line of regression:** A bivariate relationship can be studied using a scatter plot that simply plots the values of two variables. It is commonly used to visualize patterns in data and identify potential correlations between variables. A regression line is a line of best fit. The line of best fit can also be used for prediction. Outliers or unusual data points can also be identified using the line of best fit.
5) **Heat Map:** A heat map is a type of chart that displays data as a color-coded matrix. It is commonly used to visualize large datasets and to identify patterns and trends in the data. In a heat map, the data is displayed as a grid of coloured cells, with each cell representing a value in the dataset. The colours used to represent the values can range from cool colours (such as blue or green) to warm colours (such as red or orange), with the intensity of the colour indicating the magnitude of the value.
6) **Rain Cloud Plot:** A raincloud plot is a visualization that combines elements of a boxplot, violin plot, and a scatterplot to display the distribution of continuous data and compare distributions between groups. It was introduced by Allen et al. in 2018 as a modification to the traditional boxplot that provides more detailed information about the data and is easier to interpret. The “cloud” part of the plot is a combination of a violin plot and a scatterplot. The violin plot shows the kernel density estimation of the data, and the scatterplot shows the individual data points. The “rain” part of the plot is a box-and-whisker plot that shows the median, quartiles, and outliers of the data. The two parts are combined in a way that the cloud appears to rain onto the box-and-whisker plot. A raincloud plot can be used to a) compare the distribution of a continuous variable across different groups or categories b) visualize the spread, shape, and central tendency of the data. c) identify potential outliers in the data.
7) **Motion Chart:** A Motion Chart is a type of data visualization tool that displays changes in data over time using animated transitions. It allows users to view and interact with multidimensional data and analyse patterns and trends. Motion charts typically display data using bubble charts, where each bubble represents a data point and its size and colour represent different dimensions of the data.

## 2 Data Collection

The aim of this research paper is to elucidate several data visualization techniques and their practical application in analysing economic indicators using secondary data. The analysis utilizes quarterly macroeconomic indicators data from the past five years (2018-2022), obtained from publicly accessible sources. The data includes quarterly GDP figures, daily values for NIFTY50, DJI, DAX, Gold, and Silver, which are converted to quarterly data, as well as monthly inflation rate data, also converted to quarterly. Additionally, derived variables such as lagged GDP and lagged Inflation Rate are derived from the original GDP and inflation rate variables. The statistical software R is employed to visualize the aforementioned data using various techniques, including box plots, scatter plot matrices, bubble charts, scatter plots with regression lines, heat maps, rain cloud plots, and motion charts.

**Table 1:** Snapshot of Data used for Analysis

| Quarter | Year | GDP | Nifty_Qchange | DJI_Qchange | DAX_Qchange | Gold_Qchange | Inflation Rate | Silver_Qchange |
|---|---|---|---|---|---|---|---|---|
| Q1 | 2018 | 7.7 | -3.96 | -2.49 | -6.35 | 4.23 | 4.59 | -3.69 |
| Q2 | 2018 | 8.2 | 5.94 | 0.7 | 1.73 | -1.23 | 4.79 | 0.87 |
| Q3 | 2018 | 7.1 | 2.02 | 9.01 | -0.48 | -0.56 | 3.88 | -5.5 |
| Q4 | 2018 | 6.6 | -0.62 | -11.83 | -13.78 | 1.26 | 2.61 | -1.68 |
| Q1 | 2019 | 5.8 | 6.51 | 11.15 | 9.16 | 0.91 | 2.49 | -4.19 |
| Q2 | 2019 | 5 | 1.89 | 2.59 | 7.57 | 6.4 | 2.98 | -2.03 |
| Q3 | 2019 | 4.5 | -2.67 | 1.19 | 0.24 | 5.18 | 3.45 | 12.2 |

## 3 Visual representations of the Data and analysis

The following results are obtained for various Economic indicators.

1) Box Plot: Box Plots are obtained for quarterly changes in Nifty50, DAX and DJI resp.

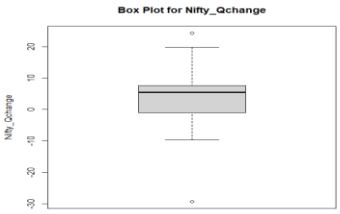


Fig. 1
(Box Plot- Nifty50_Qchange)

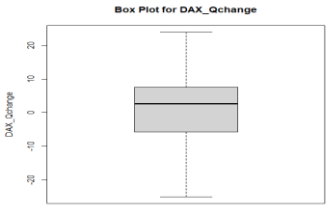


Fig. 2
(Box Plot-DAX_Qchange)

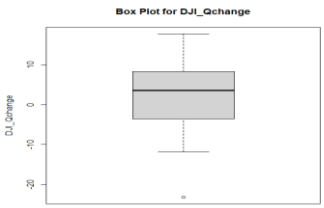


Fig.3
(Box Plot-DJI_Qchange)

All major Global Markets viz. Nifty50(Fig.1) , DAX (Fig.2) and DJI(Fig.3) show a lot of volatility in a period of last five years. An abnormal negative quarterly change is observed at the beginning of Covid-19 pandemic. Further it is also seen that Nifty50 has outperformed DAX and DJI. Median quarterly change is higher for Nifty50 as compared to DAX and DJI in the last five years.

2) Scatter Plot Matrix:

Pairwise Correlation between quarterly changes in Nifty50, DJI and DAX is explored using a Scatter plot Matrix and also between quarterly changes in Nifty50, Gold Rate and Silver Rate.

a) Fig. 4 indicates the Scatter Plot Matrix for three variables viz. Nifty_Qchange, DJI_Qchange and DAX_Qchange

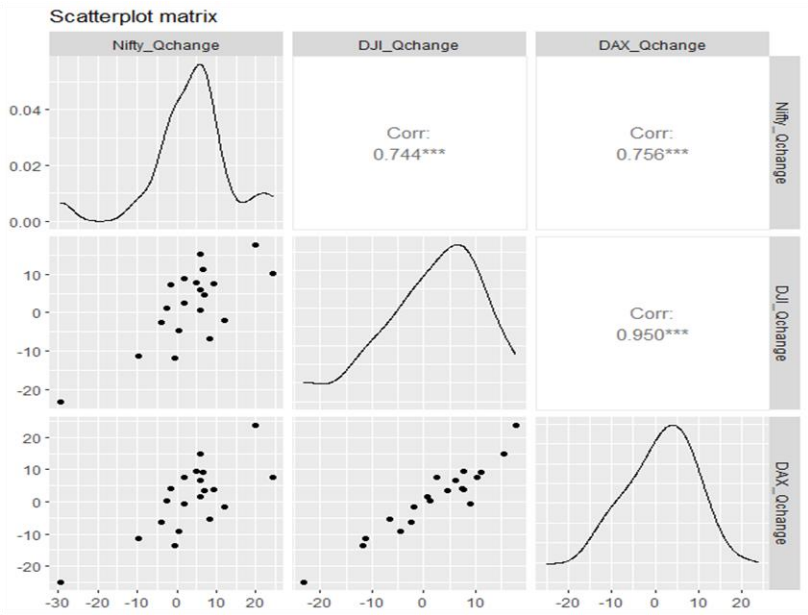


Fig. 4- Scatter Plot Matrix-Nifty 50m DJI and DAX Quarterly change

As seen in Fig. 4, all global markets are interrelated and the correlations between quarterly changes are statistically significant. The highest correlation is observed between DAX and DJI quarterly change (0.95).

b) Nifty_Qchange, Gold_Qchange, Silver_Qchange:

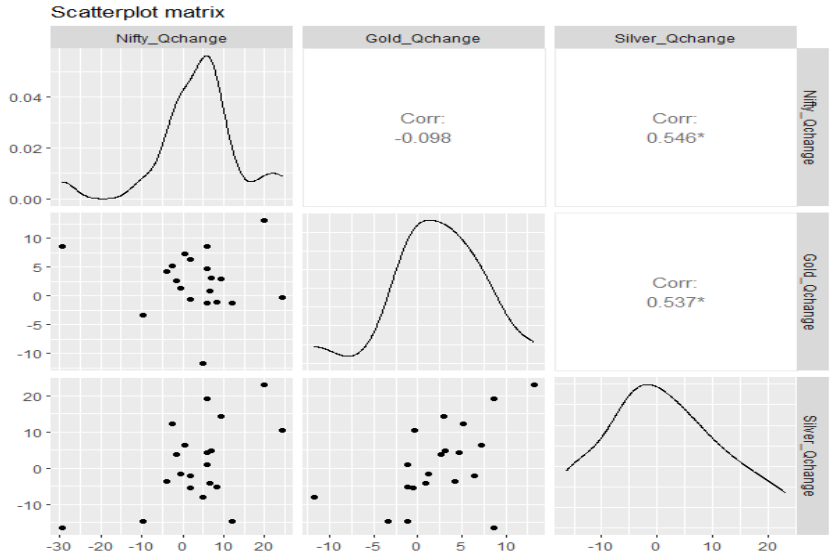


Fig. 5-Scatter Plot Matrix-Nifty50, Gold Rate and Silver Rate Quarterly Change

It is important to acknowledge that the relationship between the Nifty50 index, gold rates, and silver rates can be subject to change due to evolving market dynamics and fluctuations in investor sentiment. Therefore, a thorough analysis of the specific timeframe and relevant factors is necessary to comprehend the interplay between these variables accurately. The above Scatter Plot Matrix, shows statistically significant correlation between Nifty Quarterly Change and Silver Quarterly Change and also Gold Quarterly Change and Silver Quarterly Change whereas the Nifty Quarterly Change and Gold Quarterly Change are negatively correlated but this correlation is not statistically significant.

3) Bubble Chart: Nifty_Qchange, Lag GDP, Lag Inflation Rate.

In a bubble chart (Fig. 6) for the lag of GDP and Nifty quarterly change, each bubble represents a distinct observation or data point, typically associated with a specific quarter. The bubble's size is indicative of the magnitude of the Lag of Inflation rate. Outliers are those individual bubbles that deviate significantly from the general pattern. These outliers could indicate exceptional quarters with unique factors influencing the relationship between GDP lag and Nifty changes.

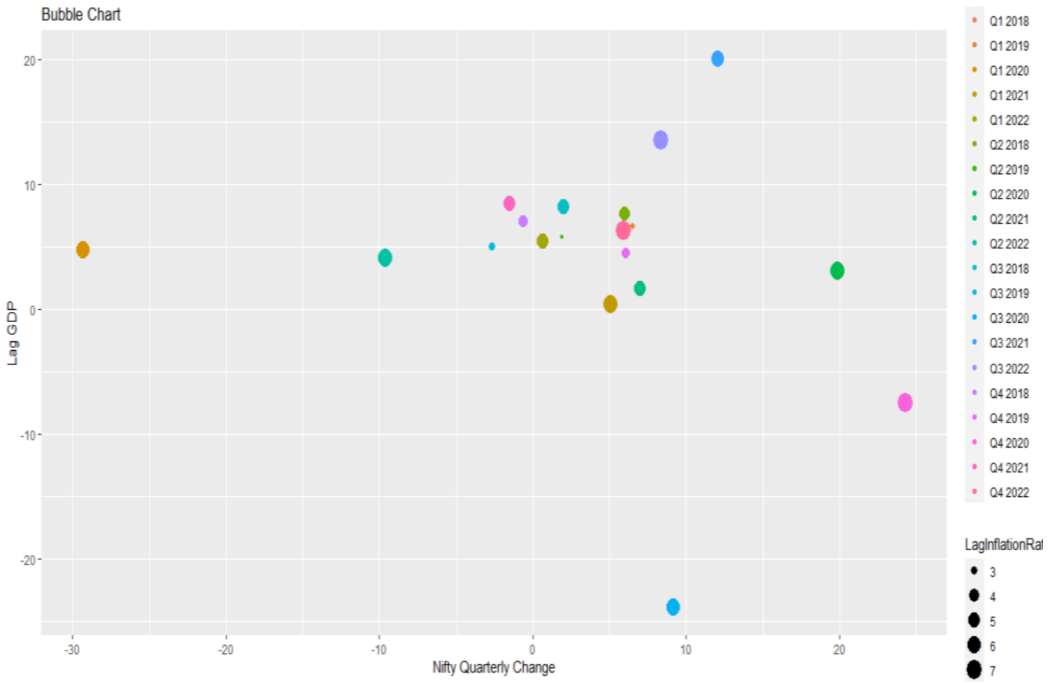


Fig. 6-Bubble Chart-Quarterly Change in Nifty 50, Lag of GDp and Lag of Inflation Rate

4) Scatter Plot with Regression Line:

a) Nifty_Qchange(Y) and GDP(X)

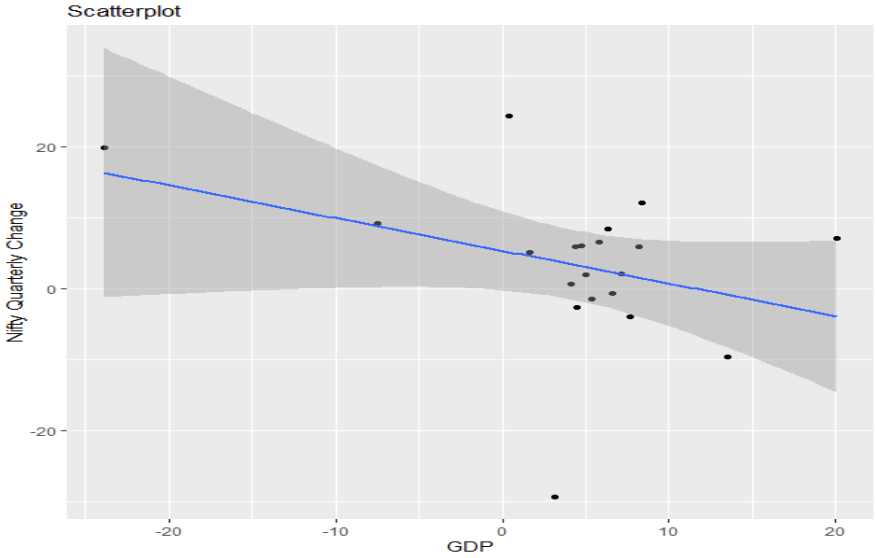


Fig. 7-Scatter Plot with Line of Regression-Nifty 50 Quarterly change and GDP

b) Nifty_Qchange(Y) and Lag GDP(X)

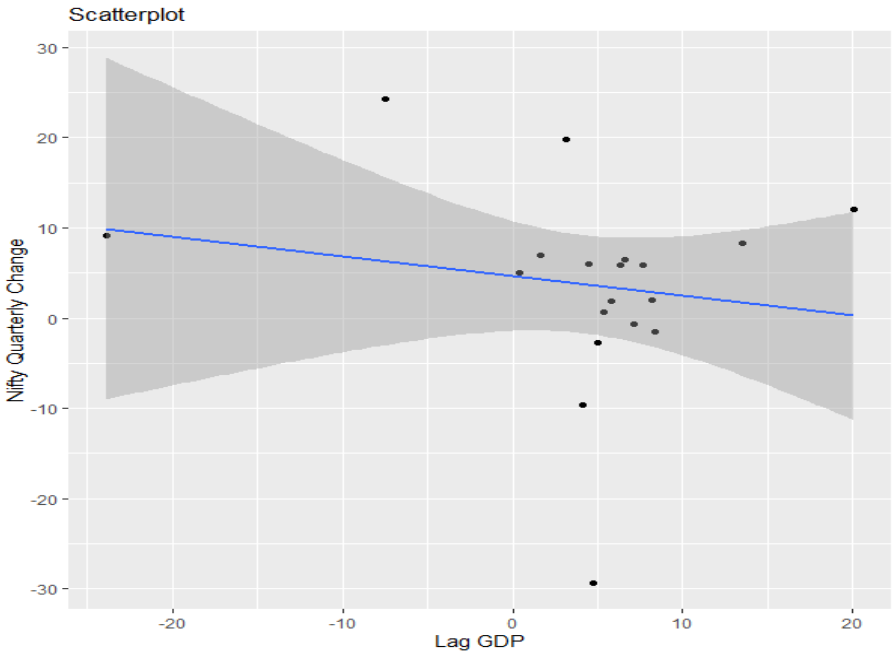


Fig.8-Scatter lot with Line of Regression-
Nifty 50 Quarterly change and Lag GDP

c) Nifty_Qchange(Y) and Inflation Rate (X)

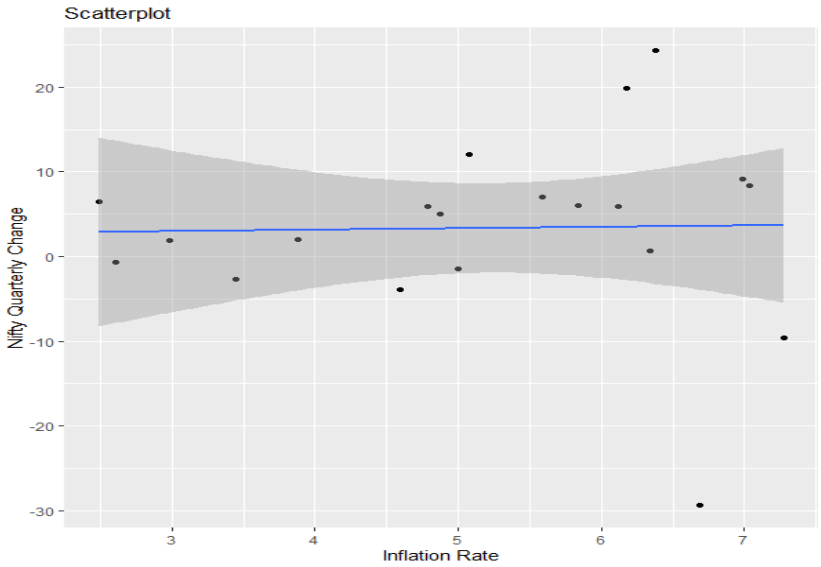


Fig. 9-Scatter Plot with Line of Regression-
Nifty 50 Quarterly change and Inflation Rate

d) Nifty_Qchange(Y) and Lag Inflation Rate (X)

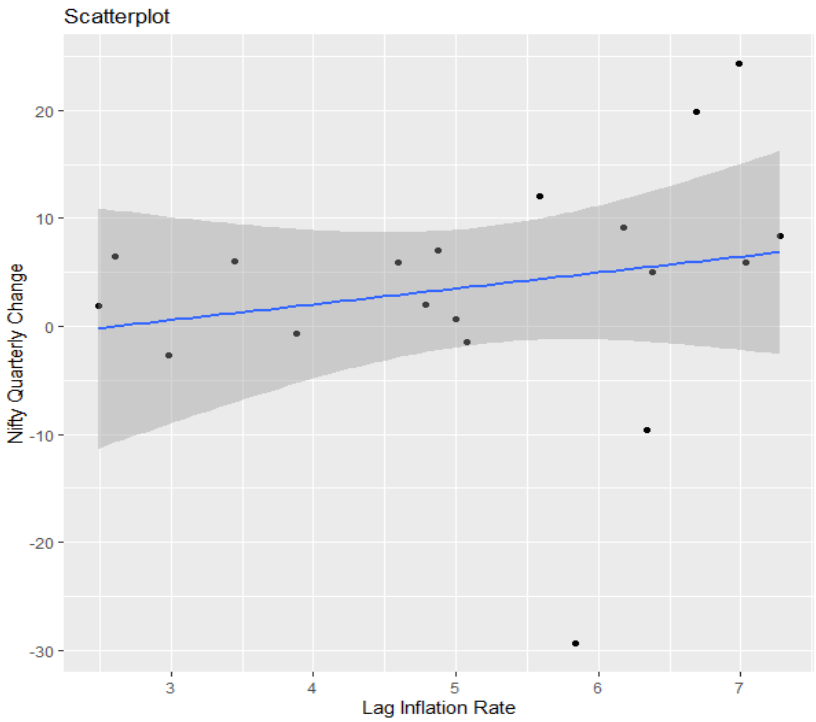


Fig. 10-Scatter Plot with Line of Regression
Nifty 50 Quarterly change and Lag of Inflation Rate

In all the above cases (Fig. 7, Fig. 8, Fig. 9 and Fig. 10) the regression line doesn't seem to be a good fit.

5) Further, Nifty50 is inspected by Quarter and Year using a Heat Map.

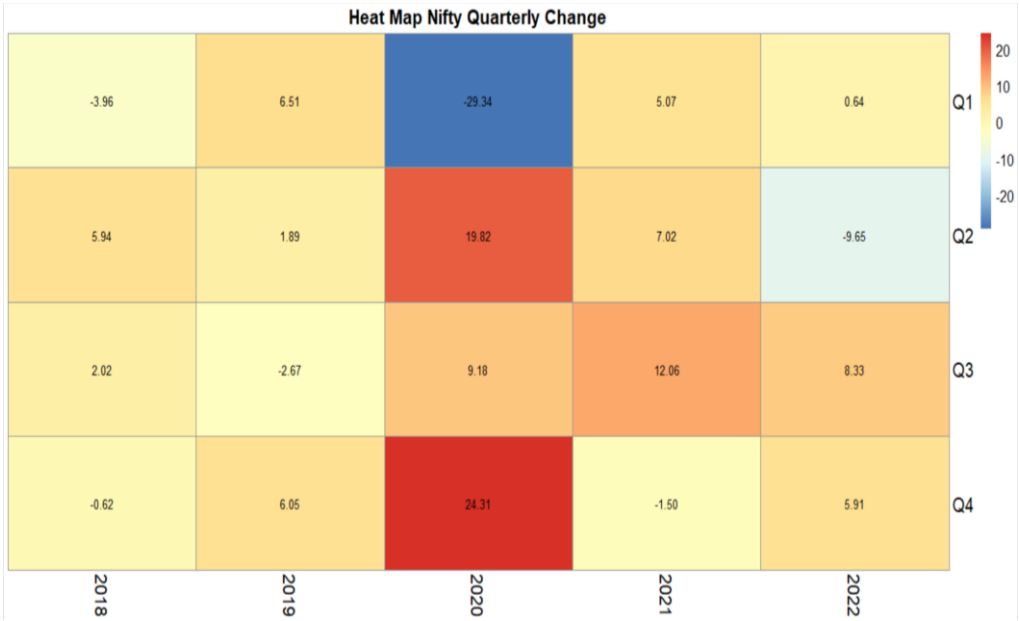


Fig. 11-Heat Map

As seen in Fig. 11, the most negative return is highlighted in **blue colour** (-29.34%) and it is observed for Quarter 1 of 2020, this phenomenon can be related to onset of Covid-19 pandemic.

6) Rain Cloud Plot: Rain Cloud Plot is an enhancement over Box Plot and is more informative. Interpreting a rain cloud plot for economic indicators necessitates a comprehensive understanding of statistical concepts, domain expertise, critical thinking skills, and contextual familiarity with the specific data being analysed.

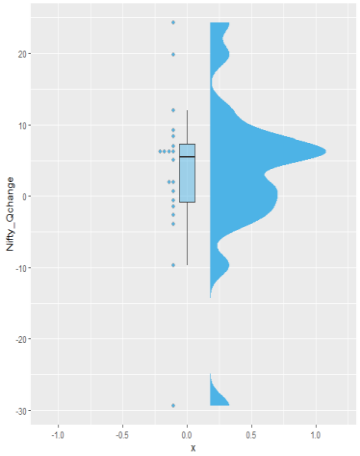


Fig. 12
(Rain Cloud Plot-
Nifty_QChamnge)

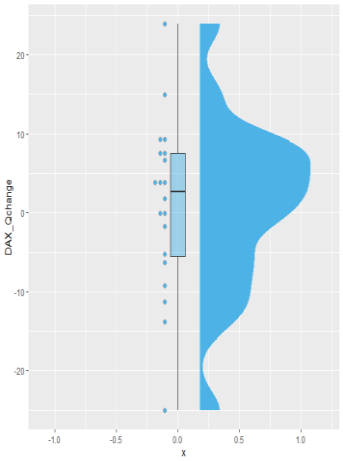


Fig. 13
(Rain Cloud Plot-
DAX_Qchange)

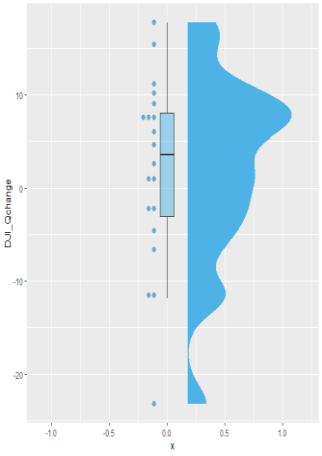


Fig. 14
(Rain Cloud Plot-
DJI_Qchange)

Fig. 12, Fig. 13 and Fig. 14 are the rain cloud plots for Nifty50 Quarterly change, DAX Quarterly change and DJI Quarterly change respectively. The statistical distribution of quarterly returns is not similar for NIFTY50, DAX and DJI however more variation is observed in case of quarterly change for DAX and DJI.

7) Motion Chart:
Motion charts are particularly effective in illustrating trends and patterns that unfold over time.
When examining a motion chart, carefully observe how the data points move across the chart, whether they ascend or descend, shift left or right, or cluster in specific regions. One needs to take note of any general trends, such as consistent upward or downward trajectories, recurring cycles, or oscillations.
For a comprehensive interpretation of a motion chart, it is crucial to examine the economic indicators within a broader context. Take into account external factors that could have impacted the observed trends, including shifts in government policies, global events, technological advancements, or economic cycles. Considering these contextual elements will provide a more nuanced understanding of the patterns and movements depicted in the motion chart. Motion Chart allowed to inspect the trend as it moves from Q1 2018 to Q4 2018. The insights gained through the Motion Chart can help the analyst to make predictions.

a) Motion Chart for quarterly change in Nifty50(Nifty_Qchange):

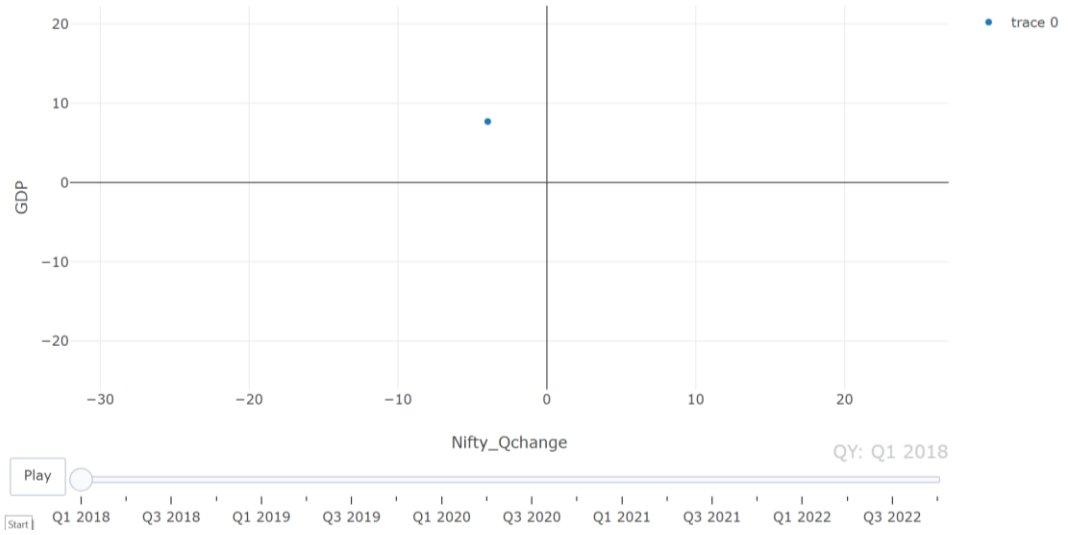


Fig. 15-Motion Chart-Nifty50_Qchange

b) Motion Chart for quarterly change in DAX(DAX_Qchange):

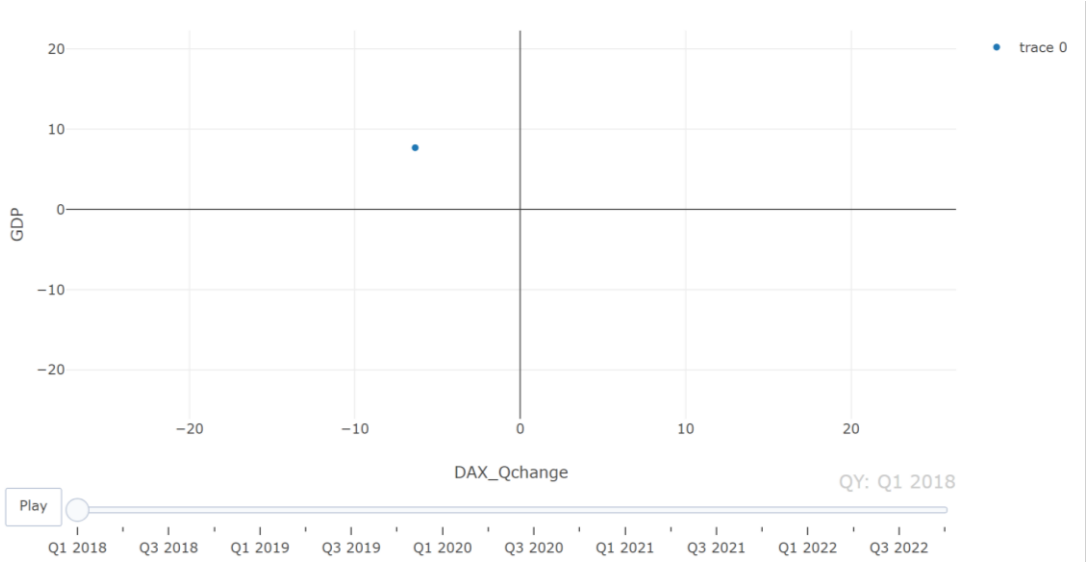


Fig. 16-Motion Chart-DAX_Qchange

c) Motion Chart for quarterly change in DJI(DJI_Qchange):

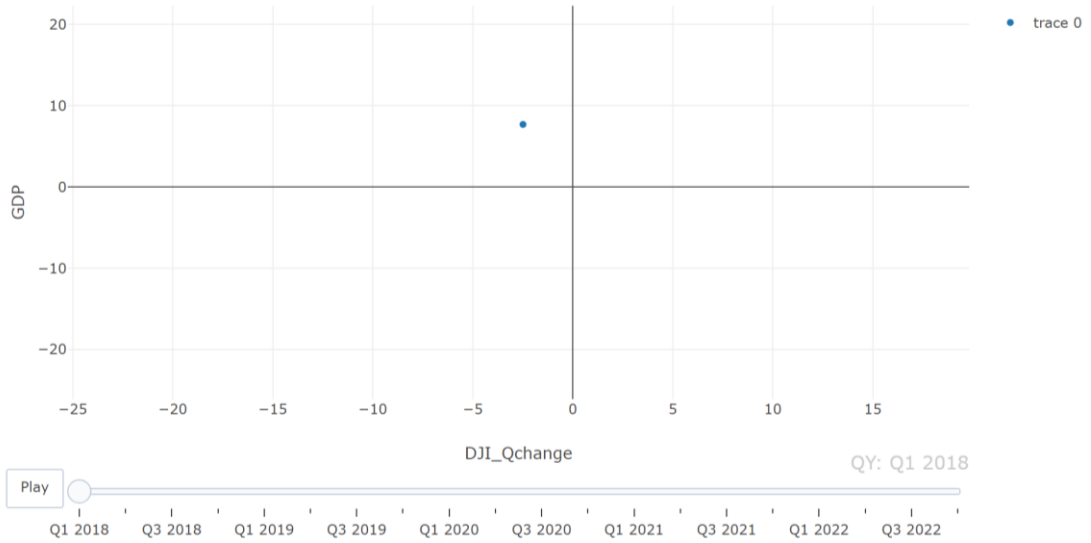


Fig. 17-Motion Chart-DJI_Qchange

## 4 Conclusions

Data visualization plays a vital role in comprehending and analysing economic indicators such as GDP, inflation, stock market indices (such as DAX, DJI, Nifty50), and metal commodity prices (such as gold and silver rates).

Data visualization is crucial for understanding intricate economic trends and patterns. By creating visually engaging and intuitive representations, data visualization aids users in grasping complex economic information more effectively.

It is important to choose the appropriate visual format for accurately conveying the intended message in data visualization. Different charts/plots such as Box Plots, Scatter plots, Bubble Charts, Motion Chart, Rain Cloud Plot and more, have distinct advantages in representing specific types of economic data. By selecting the most suitable format, clarity is achieved, interpretation is enhanced and that would minimize the risk of miscommunication. R programming can be efficiently used for Data visualization of the Global Macroeconomic indicators.

The researchers/traders/investors can effectively utilize data visualization to analyse global economic indicators and present their findings in a visually compelling and informative manner.

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**Conflicts of Interest Statement**

The authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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## Data source:

1. DJI, DAX, Nifty50 :R package quantmod- Data fetched from yahoofinance
2. Inflation Rate: https://dbie.rbi.org.in/DBIE/dbie.rbi?site=home
3. GDP: https://in.investing.com/economic-calendar/indian-gdp-quarterly-434
4. Gold Rate and Silver Rate: https://www.mcxindia.com/market-data/mcx-icomdex-indices