

Analyzing Currencies and Foreign Markets Indices on Indian It Stocks Using Ensemble MI: An Impact Perspective

¹David Annan, ²Rakesh Kumar Sharma

¹(PhD) SSBMGeneva, Switzerland

Email: david.annan@ssbm.ch

²(DBA) SSBMGeneva, Switzerland

Email: raskesh.sharma@arisglobal.com

Dr. David Annan (PhD) is a professor in the Swiss School of Business and Management (SSBM), Geneva, Switzerland. Before joining SSBM, he was a faculty member of Nazarbayev College, Kazakhstan and Regent Business College in South Africa as a supervisor, lecturer of Economics and Business Management. He is still a member of SSBM School of Management supervising and lecturing MBA and DBA doctorate students. His research work and interest lie in financial markets, Logistic Management, Knowledge Management, and Economic Development.

Dr. Rakesh Kumar Sharma (PhD) recently earned a doctorate degree from the Swiss School of Business and Management, Switzerland. He is currently employed in AI/ML Architect at Aris Global, a multinational Global artificial Intelligence organization conducting POCs. His research interest includes AI and financial markets analysis.

ABSTRACT

The stock market is vital to every nation's economy, and economies have become interlinked with globalization. Using the Granger causality technique, prior research has evaluated the impact of foreign stock exchanges, currency exchange rates, and economic publications on the Indian stock market. This study uses ensemble machine learning, deep learning, and statistical methods with a majority voting to provide more robust results. The study finds that foreign IT stock markets from France, the United States, Britain, and Germany impact positively and negatively to the Indian IT stock market. The study's findings could be valuable for financial markets to fill the gap in understanding strategies to increase IT stock indices and provide in-depth insights into developing different trajectories in the stock market. Portfolio managers and investment management organizations could also use the study to develop more profitable investment strategies.

Keywords:

Casual detection, Deep learning neural network, Stock price prediction, GrandalCasualty, Information Technology, Portfolio, Logarithms.

1. Introduction

Recent studies have assessed the effects of numerous variables on the Indian stock market, including overseas stock market performance, currency exchange rates, and news attitudes. The Granger causality test and the Johansen co-integration test were specifically used in works by authors including Kumar (2019), Kishor & Singh (2017), and Srivastava & Sharma (2016) in their studies to determine if one time series can forecast another, while the latter identifies long-run and short-run integration among variables. However, despite this topic's attention, research has yet to draw focus on a specific sector, such as information technology (IT). Furthermore, advances in causality detection using deep learning have yet to be fully incorporated into existing research. The impact of foreign stock market performance, currency exchange rates, and news sentiment on the Indian IT stock market has not yet been examined in any previous studies. Hence, this discourse perspective aims to fill this gap by analysing the impact of these factors on the Indian IT stock market using ensemble methods that combine statistical, machine learning, and deep-learning-based causality detection techniques. It is imperative to mention again that the discourse focuses on and narrows its scope to address the following research objectives:

To examine data for foreign IT indices and analyse their impact on Indian IT stocks using ensemble methods.

To Identify data for effective currency exchange rates and analyse its impact on Indian IT stocks using ensemble methods.

To analyse the impact of text features and sentiments of economic indices on Indian ITstocks using ensemble methods.

2. Theoretical constructs

Recently, several studies have been conducted to evaluate the impact of various factors, such as foreign stock market performance, currency exchange rates, and news sentiments, on the Indian stock market.

The co-integration between the Future Stock Market from advanced economies and the Nifty

(50) Future Index was studied by Kumar (2019). The list of these advanced economies is as follows: Nikkei 225 (Japan), NASDAQ 100 Futures (USA), Dow Jones 30 (USA), SSEC (China), Hang Seng Future (Hong Kong), and FTSE 100 (London). The study analysis was based on the monthly stock prices from April 2008 to March 2018. The interdependencies between the Indian and foreign stock markets were measured through the Granger causality test. The result of the study reveals that the Nifty 50 future can describe the future stock market of Nikkei (Japan), SSEC (China), and the Hang Seng future (Hong Kong) and Nifty50 futures can explain each other.

Furthermore, using the co-integration between the Nifty (50) Future Index and the Future Stock Market from advanced economies, Kumar (2019) analyzed the monthly stock prices from April 2008 to March 2018. He used the Granger causality test to measure the interdependencies between the Indian and foreign stock markets. The result from the study found that the Nifty 50 future can predict Nikkei (Japan) and SSEC (China) stock markets, and the Hang Seng Future (HSF) Hong Kong, and Nifty 50 futures can explain each other.

Similarly, Rao (2019) examined the stock market integration between China, Japan, India, the European Union (EU), the United Kingdom (UK), and the United States of America (USA). Rao's analysis was based on the stock price data from April 2013 to May 2018 and found through descriptive analysis that there is a long-run relationship among all six stock exchanges. However, the Granger causality test showed that the Indian stock market does not influence the foreign stock market and vice versa.

Another study by Gulzar et al. (2019) examined the global financial crisis's financial co- integration and spillover effect on emerging Asian financial markets, including India, China, Pakistan, Malaysia, Russia, and Korea. The study analyzed daily stock returns and divided them into three periods - pre-crisis, during the crisis, and post-crisis - from July 1, 2005, to June 30, 2015. The research used Johansen's co-integration test, vector error correction model (V.E.CM.), and GARCH to examine the integration between the global financial markets and emerging Asian markets. The study found a long-term co-integration between the US market and the emerging stock market, with the level of co-integration increasing post-crisis.

A stock market can have a long-term or short-term impact on another stock market. The relationship between foreign and Indian stock markets is no exception. Thus, Samadder&Bhunia (2018) analyzed the relationship between India and developed economies' stock markets, including Australia, Canada, France, Germany, the UK, and the USA. The study examined the short-run and long-run relationships, using Granger causality time-series data from 2001 to 2016. The test revealed that the Indian and USA stock markets have an association in the long run. In the short run, however, Germany and France are associatedwith the Indian stock market.

The Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE) are India's two major stock exchanges (NSE). As a result, most of the research used the BSE or NSE to represent the Indian stock market. Other authors such as Deo &Prakash (2017) and Singh (2015) also examined the impact of the foreign stock exchange on the NSE (the Indian stock exchange), and Manu & Menda (2017), Mohanty & Pathak (2017) also observed the foreign exchange on Bombay Stock market (BSE). These studies' specifics indicate that they represent the Indian stock market.

2.1 Economic article

Like the foreign stock market, economic articles can also significantly impact the movements of a national stock market. Therefore, our discussion analyzes the effect of news articles onthe Indian stock market. Hicham & Salah-Ddine (2012) conducted a study to predict stock movement based on financial news from various sources. The study utilized financial news from four Moroccan economic journals, covering September 2014 and February 2019. The methodologies employed in the study were a combination of support vector machines and artificial neural networks. The findings revealed that the merged learning approach yielded more accurate results than a simple news analysis based on a single source of information.

The impact of news articles on financial market volatility was analyzed by Paramanik & Signalhal (2020). The study

collected data from April 2007 to January 2020 and used the GARCH model to analyze the impact of sentiments on the stock market. The study found that negative views had a dominant effect on the stock market compared to positive opinions. Furthermore, Kumar et al. (2020) attempted to predict the Indian stock market using psycho-linguistic features extracted from financial news using LIWC and TAALES. The study found that GMDH and GRNN were the best statistical techniques for predicting stock prices using psycho-linguistic features of financial news.

The effect of news articles and Google web searches on the stock market downfall was examined by Nikkinen and Peltomäki (2020). The study used weekly newspaper articles and Google searches with the word "crash" for January 2016. The State-space model was used to analyze the dynamic interaction of GSVI and articles. The Distributed lag model was used to examine the effect of GSVI and news articles on the stock market. The study concluded that the impact of web searches is immediate on the stock market, while the effect of news articles can last up to 11 weeks.

Furthermore, Biswas et al. (2020) evaluated the impact of news article sentiments on the economic downfall of the primary international stock market. The study used the VADER tool for sentiment analysis and collected news articles and Dow Jones stock market reports from September 2001 to December 2001 and from January 2020 to May 2020 to evaluate the impact of previous events like terrorist attacks or epidemics. The study found that negative news was more prevalent during both events, resulting in a fall in the stock market.

Hwang and Kim (2019) further studied the inter-dependency between news sentiments and stock prices. Their study used news articles about North Korea and Tesla stock between April 2019 and July 2019. The study found that news content significantly influences stock prices. Machine learning models like GPs, LR, MLP, SVR, and RF were used to evaluate the relationship between news sentiments and stock prices.

The impact of news sentiment on pharmaceutical market sector stocks was studied by Shal et al. (2019) using a sentiment analysis dictionary created explicitly for the pharmaceutical domain. The study claimed to achieve 70.59% directional accuracy in predicting the trends in short-term stock price movements using news sentiment.

Again, Wong and Ko (2017) collected 24,763 articles on national business and politics in 2015. They proposed a model to predict the movements of stock market indices using public emotions extracted from news articles using DepecheMood. The study confirmed the significant correlation between public emotions and news articles.

Verma et al. (2017) presented methodologies for assessing the impact of news articles on the Indian stock indices using PESTEL events from 2013 to 2016. The study used the Granger causality test for impact analysis and LSTM for prediction. The result of the study confirmed that PESTEL events significantly impact the specific sector of the stock market. The LSTM model based on the PESTEL framework outperforms the previous state-of-the-art techniques due to its ability to learn long-term dependencies.

Additionally, Indian IT companies are heavily invested in Singapore, Mauritius, the Netherlands, and Germany (India Foreign Investment, updated). Thus, a study has also reviewed the impact of currency exchange rates on the Indian stock market. According to Bhattacharjee & Das's (2020) study, data from April 2005 to December 2019 were used to examine the link between the USD-INR exchange rate and the Indian stock market. The study employed the Dickey & Fuller (1979) test for non-stationarity, Johansen's co-integration, and the Granger causality tests to identify a long-run and bi-directional causal relationship between the USD-INR exchange rate and the Indian stock market.

2.2 Sectoral Indices: Impact of Currency Exchange

The currency exchange rates on selected sectoral indices during specific events were examined, such as Nifty Auto, Nifty Bank, Nifty Energy, Nifty Pharma, and Nifty FMCG, according to Mohith & Sangeetha (2019). The study revealed Uni-directional Granger causality between USD and Nifty Bank, USD and Nifty Energy, Nifty FMCG, and USD and Nifty Pharma during the 2008 financial crisis. However, the study revealed that a one-way impact was observed only between USD and Nifty Auto during demonetization. Moreover, for the 2018 crisis, only USD was considered, and Uni-directional causality was confirmed between USD and Nifty Auto.

Hence, Bala & Hassan (2018) investigated the interaction between the exchange rate and the Nigerian stock market using annual data from 1985 to 2015. The study employed the autoregressive distributed lag (ARDL) model and Granger causality tests to examine the relationship between the exchange rate, economic growth, money supply, and the stock market. The study found that the exchange rate and economic expansion favorably and statistically significantly impact the Nigerian stock market. In contrast, the money supply has a detrimental and statistically significant impact on the Nigerian stock market.

Anuradha (2018) explored the dynamic linkage between the exchange rate and the Bombay stock exchange using data from 2010 to 2016. The study confirmed the effect of the currency exchange rate on the Bombay stock exchange using a regression algorithm, indicating that as the Rupee (Indian currency) depreciates against the US dollar, the stock price

increases and vice versa.

Manu and Bhaskar (2018) posit the effect of currency exchange rate volatility on the Indian stock market performance using four exchange rates (EURO/INR, USD/INR, GBP/INR, and YEN/INR) and three stock market indices (BSE SENSEX, BSE 500, and Nifty 50) from April 2000 to March 2016. The study employed the GARCH methodology and found that the previous day's currency exchange rate significantly impacts the current day's price of selected stock indices, indicating that currency exchange rate volatility significantly impacts the Indian stock indices.

All the studies above examined the impact of foreign stock markets, currency exchange, and economic articles on the Indian stock market. However, there is a lack of research on the combined impact of these variables, specifically on the Indian IT stock market, without using the ensemble analysis on the Indian stock market.

2.3 Ensemble Analysis to predict currency exchange rate.

Sharma (2020) used an ensemble of long-short term memory (LSTM) to predict Indian IT stock trends by incorporating global indices, currency exchange rates, historical stock prices, world news, and technical indicators. While this study achieved a 60% accuracy rate in predicting increasing and decreasing trends, it did not investigate the causal impact of these variables on the Indian IT stock market.

Therefore, this research discussion aims to determine the causal relationship between foreign stock markets, currency exchange, economic events, and the Indian IT stock market.

The studies mentioned above have shown that the Granger causality test has been widely used to detect causality between foreign stock markets and the Indian stock market. However, Granger causality has some limitations.

Firstly, it can only be applied to static data, and secondly, it needs help to detect causality in non-linear multivariate time series data. These limitations have motivated researchers to seek better alternatives to detect causality in non-linear data. Hence, Deep-learning networks are an alternative, as they can capture non-linearity in data.

In this regard, Rosol et al. (2022) recently introduced a Python package with a neural network-based causality analysis approach that supports Long Short-Term Memory (LSTM), Gated Recurrent Unit (GRU), and Multilayer Perceptron (MLP) for causality tests. This approach is more suitable for detecting patterns in non-linear settings, and experiments conducted by the authors have demonstrated that it is superior to the Granger causality method in detecting non-linear causal relationships. The readily available implementation and comprehensive support for deep learning-based methods make Rosol et al. (2020) a better alternative for causality tests on non-linear datasets.

Similarly, the TCDF framework proposed by Nauta et al. (2019) is a promising approach for discovering causal relationships in continuous time series data. TCDF combines an attention-based convolutional neural network with a causal validation step to construct a temporal causal graph that shows the relationships between time series and their corresponding time delays. This approach has shown state-of-the-art performance in discovering causal relationships in financial and neuroscientific benchmarks.

Therefore, this study considers the TCDF framework a potential approach to determine the causal relationship between the foreign stock market and Indian IT stocks. Using multiple causal inference techniques, including deep learning-based methods and statistical estimators, enhances the robustness and accuracy of the causal analysis.

In addition to the deep-learning methods, the "DoWhy" library, developed by Sharma & Kiciman (2020), is an open-source library that uses a causal graph framework to identify and test the causes of observed data. Unlike other causal inference libraries that mainly rely on statistical estimators, the "DoWhy" library emphasizes specifying assumptions about the underlying observed data and validating those assumptions with statistical estimators. The library provides an API with four common steps for causal analysis, including modeling data using a causal graph and structural assumptions, identifying desired causal effects using a graphical model, estimating the effect using statistical estimators, and refuting the obtained estimate using robustness checks and sensitivity analyses. By focusing on devising the correct causal model and testing its assumptions, the "DoWhy" library offers a more robust and accurate approach to causality detection.

Given its emphasis on specifying and testing assumptions, the "DoWhy" library may be a suitable candidate for determining the causal impact of the foreign stock market on Indian IT stock. The library's ability to handle non-linear data and its focus on causal modeling and testing may provide a more accurate and robust analysis of the relationship between the foreign stock market and Indian IT stock.

Previous studies have predominantly focused on analyzing the impact of foreign stock markets, currency exchange rates, and news articles on the Indian stock market. However, a gap exists in the literature regarding analyzing these variables in a specific sector of the Indian stock market, such as the information technology (IT) sector. Furthermore,

past research has relied mainly on Granger causality tests and Johansen co-integration tests to investigate the impact of international stock markets, currency exchange, and news items on the Indian stock market.

However, there is a need to consider ensemble models that incorporate statistical, machine learning, and deep-learning-based methods for analyzing the impact of these variables, which can provide a more robust and convincing analysis.

While some studies have explored the impact of news article sentiments on the Indian stock market, there is a lack of research that has expressed economic articles as named entity recognition (NER) and analyzed their impact on the Indian stock market, particularly in the context of the Indian IT stock market. Therefore, a substantial research gap exists in examining the impact of named entities from economic articles on the Indian IT stock market using deep-learning-based techniques.

Additionally, incorporating multiple causality detection techniques can enhance the credibility of the findings of this study (Kumar & Annan 2022). Thus, this study aims to analyze the impact of foreign IT stock markets, currency exchange rates, and economic articles (named entities and sentiments) on the Indian IT stock market using ensemble models that integrate statistical, machine learning, and deep-learning-based methods.

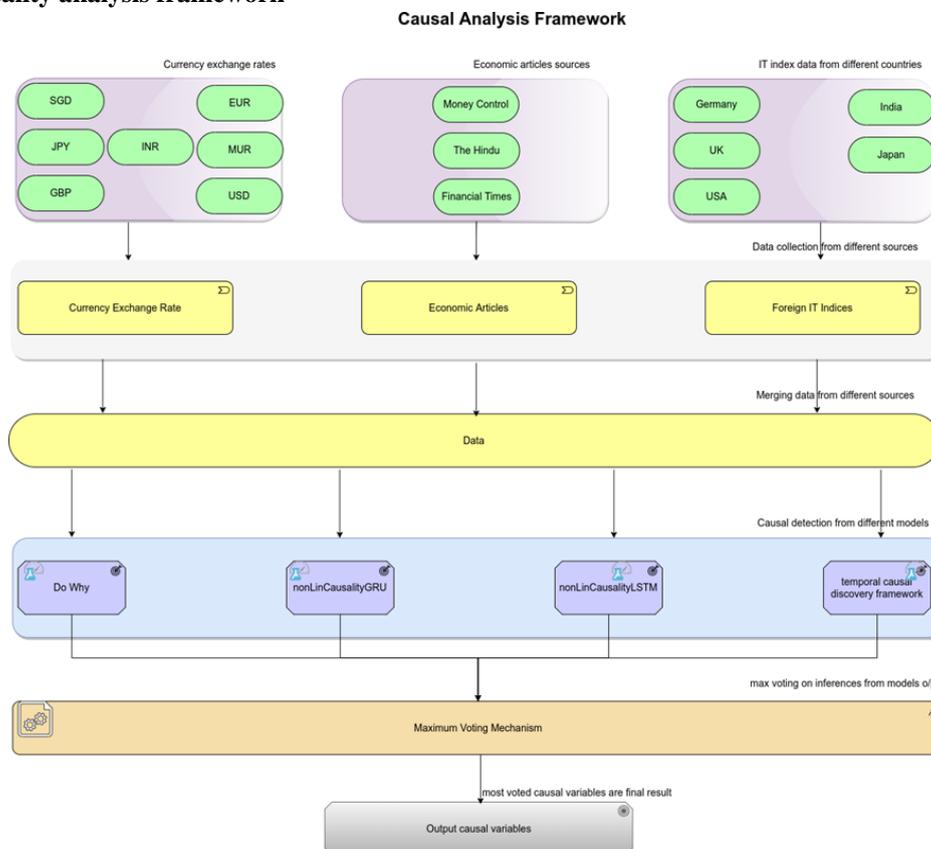
3. Methodology

This research employed an exploratory quantitative approach, utilizing secondary data sources to achieve the study's objectives. The data was retrieved from various sources, including www.investing.com, www.moneycontrol.com, www.ft.com, www.thehindu.com, and Google Finance Sheets.

The Granger causality test has been widely utilized in past research to detect causal relationships between variables. Nevertheless, this method has limitations when dealing with non-linear data. In contrast, deep learning techniques are proficient in identifying patterns in non-linear datasets. Thus, this study proposed an ensemble model that combines statistical, machine learning, and deep learning approaches to analyze the impact of foreign IT indices, economic article name entities and sentiment features, and currency exchange rates on Indian IT stocks.

To carry out the analysis, a causality analysis framework was developed. The framework outlines the proposed methodology, which aims to provide robust and credible results concerning the impact of the identified factors on Indian IT stocks.

Figure 1. Causality analysis framework



Singapore (SGD), Japan (JPY), the United Kingdom (GBP), Germany (EUR), Mauritius (MUR), and the United States (USD) are the six countries whose currency exchange rates are taken into account in the study. Additional sources for economic content include Money Control, The Hindu, and Financial Times. Additionally included are foreign IT indices from Germany, the UK, the US, France, and Japan.

The collected data undergoes a series of cleaning, pre-processing, and combining techniques. The resulting data is then utilized as input for four different causality detection algorithms, namely "DoWhy" (Sharma & Kiciman (2020), nonLinCausality GRU, nonLinCausality LSTM Rosol et al., (2022), and a temporal causal discovery framework Nauta et al., (2019).

The output of each deep-learning causality detection algorithm and the Granger causality algorithm is then passed to the top voting mechanism layer. This layer identifies the causal variables that appeared as output for most algorithms.

4. Findings

The research paper analyses and interprets the study's findings concerning its aims and research questions. Specifically, the section evaluates the effectiveness of ensemble methods, including Granger causality, machine learning, and deep learning-based causality detection methods, in achieving the research objective.

4.1 Impact of the foreign IT stock market using ensemble methods.

This research utilized various statistical, deep learning, and machine learning-based causality detection methods to analyze the influence of foreign IT stock markets on the Indian IT stock market. Each method provided unique insights into the impact of foreign IT stock markets on the Indian market.

According to the "DoWhy" library, a machine-learning-based method, the German, UK, and USA IT stock markets significantly impact the Indian IT stock market. In contrast, the nonLinCausality method, a deep-learning-based approach, revealed that the USA and France IT stock markets are the most influential foreign markets affecting the Indian IT stock market. Additionally, the Granger Causality method, a statistical-based approach, also identified France, Germany, the UK, the USA, and Japan's IT indices as having a causal impact on the Indian IT stock market.

In order to obtain a more accurate and comprehensive result, this study considered the findings of all three approaches. The consolidated result of all the causality detection methods used in this research is presented in the following table.

Independent Variable	Impact on the Indian IT Stocks		
	Statistical based. (Granger Test)	Machine-learning-based. (DoWhy)	Deep-learning-based. (nonLinCausality)
FRANCE_Index_Price	Yes	No	Yes
GERMAN_Index_Price	Yes	Yes	No
UK_Index_Price	Yes	Yes	No
USA_Index Price	Yes	Yes	Yes
JAPAN_Index_Price	Yes	No	No

Table 1. Most impacted foreign IT variables using ensemble methods (GRU)

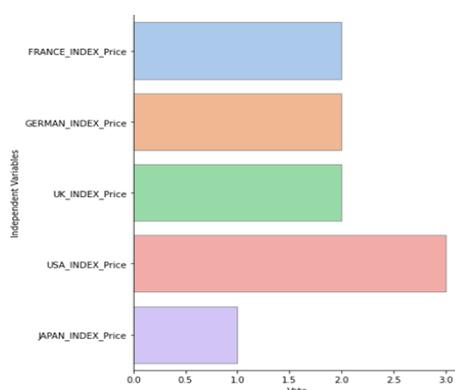


Figure 2. Most impacted foreign IT variables Vs. Vote count for ensemble methods

Table 1 demonstrates that the statistical-based, machine-learning-based, and deep-learning-based methods employed in this research consistently point towards France, USA, UK, and Germany IT stock markets having a causal impact on the Indian IT stock market.

Moreover, we have also visually analyzed the correlation and found a direct correlation between the France, USA, UK, and Germany IT stock markets and the Indian IT stock market. Essentially, when the closing prices of these foreign markets rise, it is likely that the Indian IT stock market will also experience a corresponding increase.

4.2 Ensemble methods Impact of currency exchange rate on the Indian IT stock market

This research used a range of statistical, deep learning, and machine learning-based causality detection methods to analyze the impact of currency exchange rates on the Indian IT stock market. These methods offered valuable insights into which currency exchange rates have a discernible effect on the Indian IT stock market.

According to the "DoWhy" library, a machine-learning-based approach, the GBP_INR, MUR_INR, USD_INR, EUR_INR, JPY_INR, and SGD_INR currency exchange rates have impacted the Indian IT stock market. In contrast, the nonLinCausality method, a deep-learning-based approach, determined that only the MUR_INR currency exchange rate has impacted the Indian IT stock market. Furthermore, the Granger Causality Test, a statistical-based approach, identified that the JPY_INR, SGD_INR, and USD_INR currency exchange rates have a causal impact on the Indian IT stock market.

This study incorporated the findings of all three approaches to obtain a more precise and comprehensive result. The following table presents a consolidated outcome of all the causality detection methods used in this research.

Independent Variable	Impact on the Indian IT Stocks		
	Statistical based (Granger Test)	Machine-learning-based. (DoWhy)	Deep-learning-based. (nonLinCausality)
GBP_INR_Price	No	Yes	No
MUR_INR_Price	No	Yes	Yes
USD_INR_Price	Yes	Yes	No
EUR_INR_Price	No	Yes	No
JPY_INR_Price	Yes	Yes	No
SGD_INR_Price	Yes	Yes	No

Table 2. Most impacted currency exchange variables using ensemble methods.

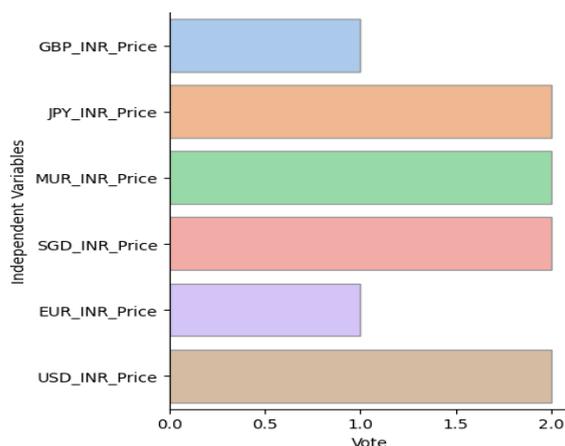


Figure 3. Most impacted currency exchange variables vs. Vote count for ensemble methods.

The study employed statistical, machine learning, and deep-learning methods to investigate the causal impact of currency exchange rates on the Indian IT stock market. Table 2 presents the results of these methods, indicating that the MUR_INR, USD_INR, JPY_INR, and SGD_INR currency exchange rates have a discernible causal impact on the Indian IT stock market.

The study visualizes the relationship between the Indian IT stock market and the currency exchange rates of USD_INR, JPY_INR, SGD_INR, and MUR-INR. The results indicate a positive correlation between the Indian IT stock market and the currency exchange rates of USD_INR, JPY_INR, and SGD_INR.

However, the MUR-INR currency exchange rate is inverse to the Indian IT stock market. Specifically, when the currency exchange rates of USD_INR, JPY_INR, and SGD_INR increase, it is likely that the Indian IT stock market will also experience a corresponding increase. Conversely, when the MUR-INR currency exchange rate decreases, the Indian IT stock market increases and vice versa.

4.3 Text features and sentiments of economic articles impact on the Indian IT stock market using ensemble methods.

The research employed various causality detection methods, including machine-learning, deep-learning, and statistical-based techniques, to investigate the impact of economic articles from Money Control, The Hindu, and the Financial Times on the Indian IT stock market. These methods provided insights into which named entities and sentiments of economic articles impact the Indian IT stock market. The “DoWhy” library (a machine-learning-based method) revealed that named entities from MoneyControl, The Hindu, and The Financial Times impacts the Indian IT stock market. In contrast, the nonLinCausality methods (a deep-learning-based method) determined that certain named entities from these sources have a causal impact on the Indian IT stock market. Additionally, the statistical based (Granger Test) method revealed certain named entities have a causal impact on the Indian IT stock market.

According to the “DoWhy” library, named entities such as Date, Event, Gpe, Language, Law, Loc, Norp, Percent, Person, Product, Quantity, Time, Cardinal, Fac, Ordinal, Money, Org, Positive, Negative, and Work_Of_Art from MoneyControl, The Hindu, and The Financial Times have an impact on the Indian IT stock market. The nonLinCausality methods identified specific named entities from these sources that impact the Indian IT stock market, including Language, Person, Time, Loc, Event, Product, Money, Norp, Law, Fac, Percent, Ordinal, Cardinal, and Org. Additionally, the statistical-based method (Granger Test) revealed that named entities such as Fac, Gpe, Product, Work_Of_Art, Language, Quantity, Cardinal, Law, and Norp have a causal impact on the Indian IT stock market.

This study considered the findings of all three approaches to obtain a more accurate result. The consolidated result of all the causality detection methods used in this research is presented in the following table.

Table 3. Most impacted economic article variables using ensemble methods.

Independent Variables	Impact on the Indian IT Stocks		
	Statistical based (Granger Test)	Machine-learning-based. (DoWhy)	Deep-learning-based (nonLinCausality)
FAC_MoneyControl	Yes	Yes	Yes
GPE_MoneyControl	Yes	Yes	Yes
PRODUCT_MoneyControl	Yes	Yes	Yes
WORK_OF_ART_MoneyControl	Yes	Yes	No
CARDINAL_TheHindu	Yes	Yes	Yes
LANGUAGE_TheHindu	Yes	Yes	Yes
LOC_TheHindu	Yes	Yes	Yes
LANGUAGE	Yes	Yes	Yes
NORP	Yes	Yes	Yes
PERCENT	Yes	Yes	Yes
PRODUCT	Yes	Yes	Yes
POSITIVE	Yes	Yes	No
LANGUAGE_MoneyControl	Yes	Yes	Yes
QUANTITY_MoneyControl	Yes	Yes	Yes
GPE_TheHindu	Yes	Yes	No

LAW_TheHindu	Yes	Yes	Yes
EVENT_TheHindu	Yes	Yes	Yes
DATE_MoneyControl	No	Yes	Yes
EVENT_MoneyControl	No	Yes	Yes
LAW_MoneyControl	No	Yes	Yes
ORG_MoneyControl	No	Yes	Yes
PERSON_MoneyControl	No	Yes	Yes
TIME_MoneyControl	No	Yes	Yes
FAC_TheHindu	No	Yes	Yes
NORP_TheHindu	No	Yes	Yes
PRODUCT_TheHindu	No	Yes	Yes
WORK_OF_ART_TheHindu	No	Yes	Yes
FAC	No	Yes	Yes
LAW	No	Yes	Yes
LOC	No	Yes	Yes
MONEY	No	Yes	Yes
ORDINAL	No	Yes	Yes
ORG	No	Yes	Yes
QUANTITY	No	Yes	Yes
POSITIVE_MoneyControl	No	Yes	Yes
NEGATIVE_MoneyControl	No	Yes	Yes
ORDINAL_TheHindu	No	Yes	Yes
CARDINAL	No	Yes	Yes
EVENT	No	Yes	Yes
PERSON	No	Yes	Yes
MONEY_MoneyControl	No	Yes	Yes
DATE	No	Yes	Yes
GPE	No	Yes	Yes
LOC_MoneyControl	No	Yes	Yes
WORK_OF_ART	No	Yes	Yes
NORP_MoneyControl	No	Yes	No
PERCENT_MoneyControl	No	Yes	No
DATE_TheHindu	No	Yes	No
ORG_TheHindu	No	Yes	No
PERCENT_TheHindu	No	Yes	No
PERSON_TheHindu	No	Yes	No
QUANTITY_TheHindu	No	Yes	No
TIME_TheHindu	No	Yes	No
TIME	No	Yes	No
POSITIVE_TheHindu	No	Yes	No
NEGATIVE_TheHindu	No	Yes	No
NEGATIVE	No	Yes	No
CARDINAL_MoneyControl	No	Yes	No
ORDINAL_MoneyControl	No	Yes	No
MONEY_TheHindu	No	Yes	No

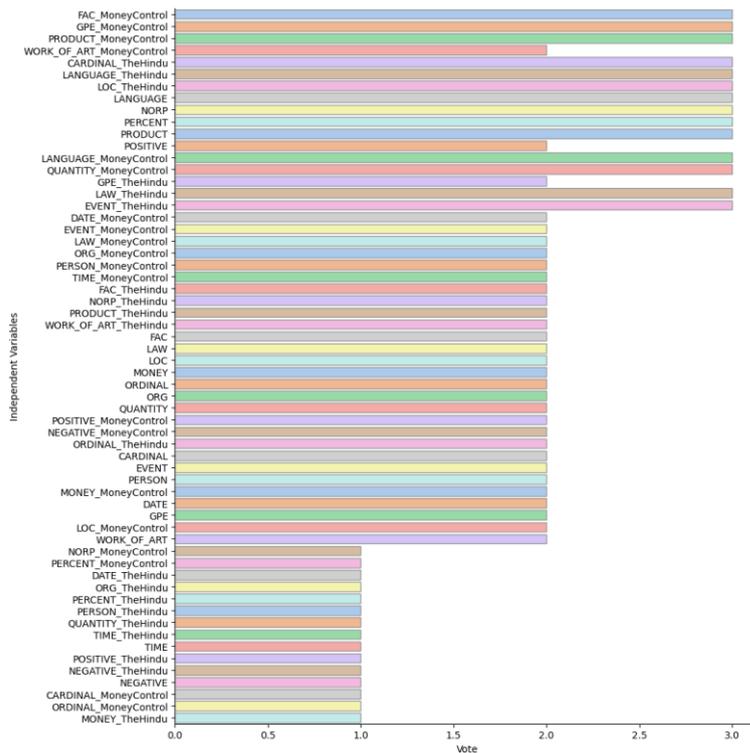


Figure 4. Most impacted economic articles variables vs. Vote count for ensemble methods.

We employed machine-learning, deep-learning, and statistical-based causality detection methods to investigate the impact of economic articles from MoneyControl, The Hindu, and The Financial Times on the Indian IT stock market. The results from these methods suggest that the named entities and sentiments of economic articles significantly affect the Indian IT stock market. Specifically, MoneyControl's entities (e.g., Fac, Gpe, Product, Work_Of_Art, Language, Quantity, Date, Event, Law, Org, Person, Time, Positive, Negative, Money, and Loc), The Hindu's entities (e.g., Cardinal, Language, Loc, Gpe, Law, Event, Fac, Norp, Product, Work_Of_Art, and Ordinal), and The Financial Time's entities (e.g., Language, Norp, Percent, Product, Positive, Fac, Law, Loc, Money, Ordinal, Org, Quantity, Cardinal, Event, Person, Date, Gpe, and Work_Of_Art) have a substantial impact on the Indian IT stock market. The visual analysis of correlation depicted an inverse relationship between the Indian IT stock market and the named entities and sentiments identified by machine-learning, deep-learning, and statistical methods, except for positive sentiment in articles from The Hindu and The Financial Times. Thus, an increase in positive sentiments in economic articles from The Hindu and The Financial Times will likely increase the Nifty IT price. In contrast, an increase in other entities from The Hindu and The Financial Times leads to a decrease in the Indian IT stock market.

Based on the study's findings, it can be concluded that foreign IT stock markets, currency exchange rates, and economic articles from various sources impact the Indian IT stock market. Specifically, an increase in the selected foreign IT stock markets corresponds to an increase in the Indian IT stock market.

Moreover, an increase in currency exchange rates such as USD_INR, JPY_INR, and SGD_INR also leads to an increase in the Indian IT stock market. However, an increase in the MUR_INR currency exchange rate leads to a decrease in the Indian IT stock market. Additionally, an increase in positive sentiments reflected in articles from The Hindu and The Financial Times corresponds to an increase in the Indian IT stock market. Conversely, an increase in other representations of economic articles apart from positive sentiments in The Hindu and The Financial Times corresponds to a decrease in the Indian IT stock market.

Despite the study's robust findings, certain limitations must be acknowledged. These limitations are discussed in the following section of this research.

6. Conclusion

The research paper explores the impact of foreign IT stock markets, currency exchange rates, and economic articles on the Indian IT stock market, using advanced techniques such as deep-learning-based, machine-learning-based, and statistical-based methods.

The results indicate that foreign IT stock markets from France, America, Britain, and Germany positively impact the Indian IT stock market. At the same time, an increase in the MUR-INR currency exchange rate corresponds with a decrease in the Indian IT stock market. Positive economic sentiments reflected in articles from *The Hindu* and *The Financial Times* correspond with an increase in the Indian IT stock market. In contrast, other representations of economic articles lead to a decrease. The study's implications can provide valuable insights for portfolio managers to devise profitable portfolios and assist investors in making intelligent investment decisions in the Indian IT stock market. The research study also contributes to the existing literature by providing a more robust and confident analysis of the impact of foreign and domestic factors on the Indian IT stock market. Finally, the study serves as a synoptic analysis for business performance and indicates that comparative analysis in the global indices can improve the international financial stock market.

References

- [1] AbdulRahman Bala, S., & Hassan, A. (2018). *Arabian Journal of Business and Management Review*. *Arabian Journal of Business and Ar A Management Review*. <https://www.researchgate.net/publication/363121226>
- [2] Anuradha, A. (2018). Impact of Exchange Rate Fluctuation on Stock Market Volatility - a Study to Predict the Economic Scenario in India. *International Journal of Pure and Applied Mathematics*, 118(July), 4309–4316.
- [3] Bhattacharjee, A., & Das, J. (2020). The Relationship between USD-INR Exchange Rate and Indian Stock Market. *An International Peer Reviewed Research Journal*, 8(January 2021), 1–6.
- [4] Biswas, S., Ghosh, A., Chakraborty, S., Roy, S., & Bose, R. (2020). Scope of sentiment analysis on news articles regarding stock market and GDP in struggling economic condition. *International Journal of Emerging Trends in Engineering Research*, 8(7), 3594–3609. <https://doi.org/10.30534/ijeter/2020/117872020>
- [5] Deo, M., & Arun Prakash, P. (2017). A Study on Integration of Stock Markets: Empirical Evidence from National Stock Exchange and Major Global Stock Markets. *ICTACT Journal on Management Studies*, 03(02), 479–485. <https://doi.org/10.21917/ijms.2017.0065>
- [6] Dickey, D. A., & Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, 74(366), 427. <https://doi.org/10.2307/2286348>
- [7] Gulzar, S., Mujtaba Kayani, G., Xiaofeng, H., Ayub, U., & Rafique, A. (2019). Financial co-integration and spillover effect of global financial crisis: a study of emerging Asian financial markets. *Economic Research-Ekonomska Istrazivanja*, 32(1), 187–218. <https://doi.org/10.1080/1331677X.2018.1550001>
- [8] Hicham, E. B., & Salah-Ddine, K. (2021). Stock market forecasting model from multi news data source using a two-level learning algorithm. *Turkish Journal of Computer and Mathematics Education*, 12(5), 1022–1030. <https://doi.org/10.17762/turcomat.v12i5.1746>
- [9] Hwang, E., & Kim, Y. H. (2019). Interdependency between the Stock Market and Financial News. *Proceedings - 2019 IEEE International Conference on Big Data, Big Data 2019*, 6074–6076. <https://doi.org/10.1109/BigData47090.2019.9006533>
- [10] INDIA: FOREIGN INVESTMENT. (n.d.). <https://santandertrade.com/en/portal/establish-overseas/india/foreign-investment>
- [11] Kishor, N., & Singh, R. P. (2017). Contagion Effect among the BRICS Stock Market Indices. *Journal of Poverty, Investment and Development*, 31(ISSN 2422-846X), 32–46. https://www.researchgate.net/publication/317209759_Contagion_Effect_among_the_BRI_CS_Stock_Market_Indices
- [12] Kumar, A. (2019). Understanding the Interdependency between the Nifty 50 Future Index and the Advanced Future Stock Market through Econometrics. *International Journal of Recent Technology and Engineering*, 8(4), 3660–3664. <https://doi.org/10.35940/ijrte.d7880.118419>
- [13] Kumar, B. S., Ravi, V., & Miglani, R. (2020). Predicting Indian Stock Market Using the Psycho-Linguistic Features of Financial News. *Annals of Data Science*, 1–45. <https://doi.org/10.1007/s40745-020-00272-2>
- [14] Kumar Sharma, R., Geneva, S., & Annan, D. (2022). “IMPACT OF FOREIGN MARKET AND CURRENCY EXCHANGE RATE ON INDIAN IT STOCKS.” *Global Journal of Business and Integral Security*.

- [15] Manu, K. S., & Bhaskar, P. (2018). Effect of Exchange Rates Volatility on Stock Market Performance. *Asian Journal of Management*, 9(4), 1337. <https://doi.org/10.5958/2321-5763.2018.00212.3>
- [16] Manu, K. S., & Menda, V. L. (2017). Dynamics of Indian stock market integration with global stock markets. *Asian Journal of Management*, 8(3), 559. <https://doi.org/10.5958/2321-5763.2017.00090.7>
- [17] Mohanty, S., & Pathak, P. (2017). Interlinkages of Asian and US Stock Market: A Study of selected Indices. *Asian Journal of Research in Banking and Finance*, 7(10), 1. <https://doi.org/10.5958/2249-7323.2017.00114.6>
- [18] Mohith, M., & Sangeetha, R. (2019). Impact of Foreign Exchange Rates on the Sectoral Indices of the Nse-. *International Journal of Research and Analytical Reviews*, 6(July), 1199–1208.
- [19] Nauta, M., Bucur, D., & Seifert, C. (2019). Causal Discovery with Attention-Based Convolutional Neural Networks. *Machine Learning and Knowledge Extraction*, 1(1), 312–340. <https://doi.org/10.3390/make1010019>
- [20] Nikkinen, J., & Peltomäki, J. (2020). Crash Fears and Stock Market Effects: Evidence from Web Searches and Printed News Articles. *Journal of Behavioral Finance*, 21(2), 117–127. <https://doi.org/10.1080/15427560.2019.1630125>
- [21] Paramanik, R. N., & Singhal, V. (2020). Sentiment analysis of Indian stock market volatility. *Procedia Computer Science*, 176, 330–338. <https://doi.org/10.1016/j.procs.2020.08.035>
- [22] Patel, D., & Patel, R. (2012). the Study on Co-Movement & Interdependency of Indian Stock Market With Selected Foreign Stock. *Researchers World: Journal of Arts, Science & ...*, 3(2(3)), 9–13.
- [23] Rao, G. V. K. (2019). AN EMPIRICAL INVESTIGATION OF CO-INTEGRATION BETWEEN SENSEX AND THE SELECTED WORLD STOCK MARKETS. *International Journal of Advance and Innovative Research*, 6(1), 24–32.
- [24] Rosoł, M., Młyńczak, M., & Cybulski, G. (2022). Granger causality test with non- linear neural-network-based methods: Python package and simulation study. *Computer Methods and Programs in Biomedicine*, 216, 106669. <https://doi.org/10.1016/J.CMPB.2022.106669>
- [25] Samadder, S., & Bhunia, A. (2018). Integration Between Indian Stock Market and Developed Stock Markets. *Journal of Commerce & Accounting Research*, 7(1), 13–23. https://www.researchgate.net/publication/323918127_INTEGRATION_BETWEEN_INDIAN_STOCK_MARKET_AND_DEVELOPED_STOCK_MARKETS
- [26] Shah, D., Isah, H., & Zulkernine, F. (2019). Predicting the Effects of News Sentiments on the Stock Market. *Proceedings - 2018 IEEE International Conference on Big Data, Big Data 2018*, 4705–4708. <https://doi.org/10.1109/BigData.2018.8621884>