

**UNDERSTANDING THE CHANGING DISCOURSE OF FOREIGN EXCHANGE
MARKETS: INSIGHTS, CHALLENGES, AND OPPORTUNITIES**

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Abstract

One of the most important pillars of financial stability in the world is the foreign exchange (FX) markets, which drives international trade, international investment, monetary policy, and macroeconomic stability. As they are central to the world economy, scholars, practitioners and policymakers need to know how the FX research has developed over the years. The paper examines a full dataset of 2,994 examples of articles Scopus-indexed (over 100 years of study, 1919-2026) in order to identify overarching thematic trends and mental frameworks in FX research. Based on a sophisticated Natural Language Processing (NLP) tool, namely Latent Dirichlet Allocation (LDA) topic modeling, the paper analyses the abstract of these articles and discovers prevailing themes, paradigm changes, and future research topics. The review shows that there are ten large thematic groups, the derivatives pricing and market efficiency have become the most significant line of research, and the next ones are monetary policy, global economic linkages, forecasting models as well as corporate hedging strategies. Moreover, there is an increased level of research output after 2000, which can be explained by the development of digital technologies, globalization, and data-driven financial modeling. In general, the research offers a coherent and detailed mapping of the literature in FX, not only pointing out the already established areas and providing an in-depth understanding of a particular field but also presenting a set of excellent insights to inform further research in that fast-paced area.

Keywords: Foreign Exchange Markets, Natural Language Processing, Topic Modeling, Latent Dirichlet Allocation (LDA), Finance, Economic

1. Introduction

The foreign exchange (FX) markets have been an important core of the economic activity of the world and have affected the trade flows, patterns of investment and policy framework of various nations [1]. The field of foreign exchange has changed significantly over the last century, starting with initial theorization based on classical economics to present computational and algorithmic techniques used to study currency flows in high-frequency setting. This historical and conceptual path is manifested in the abstracts examined in the dataset, which indicates how FX studies have evolved over time, to more advanced analyses of market

stability and transmission of volatility, speculative behaviour, capital mobility and macro-financial interdependence. This development is connected with the growing sophistication of the international markets and the development of new problems demanding sophisticated analytical models [2]. The initial literature mainly focused on structural linkage between foreign exchange and international trade, rise of global finance capitalism and effects of monetary regimes on the value of currency. These works were the foundations of studying the effect of the macroeconomic fundamentals and institutions organization on the exchange rates [3]. As the world became globalized after the World War II and the liberalization of financial market began to take root in various regions of the world, the FX market became a dynamic and interconnected space, where the currency reacted quickly to the political events, economic releases, and change of speculative mood [4]. This transition can be found in many abstracts of the dataset, involving the discussion of how distortions in monopoly, policy changes, or shifts in trade formed influenced currency performance. With the development of global financial markets, scholars were more and more interested in understanding the contribution of pressures of speculation, the opportunities of arbitrage, and the formation of expectations to the exchange-rate outcomes [5]. Some of the studies mentioned in the dataset focus on how traders respond to market flaws, how they amass strategic information, or how they can take advantage of the difference between domestic and international interest rates. These lessons led to the creation of recent financial theories like deviations of uncovered interest parity; overshooting models and rational expectations models. The focus on the speculation and risk-taking behavior highlights how the FX markets had increasingly become susceptible to both the behavioural and market-microstructure factors, besides the economic fundamentals.

The other theme of recurrence in the abstracts is the close correlation between the currency markets and the macroeconomic conditions [6]. Exchange rates are usually used as a measure of national economical well being, inflationary rates, vulnerability to the outside world as well as political stability. Numerous researches focus on the impact of crisis, whether international, regional, or national, on the exchange value as a major pressure [7]. Indicatively, the results regarding the fluctuation of commodity prices, the vulnerability of the emerging markets, and international shocks exhibit that the foreign exchange is not only a financial factor but a vital element of more significant economic resilience. The data set contains the studies that investigate the incidences of crisis, capital flight, and the intensification of shocks by currency depreciation, and the systemic significance of FX stability to both emerging and developed economies. FX research has also been transformed by technological change and financial innovation, which are also present in a number of abstracts [8]. Since the emergence of advanced trading platforms through the use of machine learning in predicting the market conditions in the finance sector, the tools used in the analysis of the currency markets have become more and more quantitative and data-based. This change has enabled researchers to explore high-frequency trading, dynamic volatility, and complicated causal relationships that were difficult to measure by traditional econometric models. Many of the abstracts indicate this trend towards empirical rigour, concentrating on modeling strategies, simulations, and using a statistical approach to determine the behaviour of FX. In addition, interactions between the

foreign exchange markets and regulatory or policy interventions are also pointed out in the abstracts. Central banks will often step in so that they can stabilize their currencies or deal with inflation or other macroeconomic goals. These interventions influence the market expectations and alter the exchange dynamics whether it is through direct purchase of currency, adjusting of interest rates or communication strategies. Some of the studies included in the dataset analyze the efficacy of such measures but they break down the flow of the policy change across financial markets and the effect it has on the liquidity, the price, and the risk perceptions.

It has also been a growing interconnectedness of world markets that, in turn, has attracted research focus to the area of spillover effects and cross market interconnections. The movements of currencies are becoming more linked to global value chain, capital mobility as well as international portfolio diversification [9]. Others focus on the importance of currency volatility in one area being transmitted to another because of the interconnectedness of the current financial ecosystems. It is important that such dynamics be known by investors, policy makers, multinational corporations, and scholars who need to predict risks and draw up sound strategies. The other theme that has arisen in the dataset is the socioeconomic aspects of the foreign exchange markets [10]. As the globalization process brings about greater integration of the various economies, there are effects of fluctuations in the currency not only to governments and institutions but also to individuals and businesses involved in cross-border transactions. A number of studies explain the impact of exchange-rate movements on education systems, labour relations, and trade competitiveness. This wider perspective proves that FX is not a strictly financial term but cuts across almost all levels of economic growth and social advancement. Although there has been extensive research on the determinants of exchange rates, its volatility, capital flows, and the effects of policies, the abstracts as a whole indicate that there is still a strong necessity to reexamine these issues with regard to the current global changes. Geopolitical strains, technological upheaval, pandemics, climate unpredictability, and digital money changes are redefining the behaviour of currencies and the market reaction to unpredictability. Conventional paradigms are frequently inadequate in their ability to offer such complicated interactions, requiring new approaches as well as interdisciplinary combinations. It is in this regard that natural language processing (NLP) has come out as an influential resource in deriving lessons out of considerable volumes of scholarly literature. NLP assists in determining the emerging research topics, conceptual groups, and knowledge gaps in the academic environment through systematic evaluation of textual information [11]. The abstracts in the dataset are rich and diverse, hence, an advanced computational approach would be most appropriate in the discovery of hidden patterns and guide future research directions. Thus, the paper will use the methods of natural language processing by applying the Latent Dirichlet Allocation (LDA) model to the abstracts to estimate emanating themes that can inform future researchers in the foreign exchange discipline [12].

1.1.Motivation

The rationale of the study is due to the growing complexity of foreign exchange markets that have become a multidimensional system during this time of global interdependence. Although decades of academic research have been done, the FX environment is changing as a result of

technological progress, financial integration, and the reoccurrence of global shocks, among others. Although traditional analysis schemes are typically enlightening, they frequently fail to reflect the new trends, interconnections between different disciplines, and nuanced conceptual transformations that can be traced throughout the expanding literature. A scientific and evidence-based knowledge of the research patterns is thus critical among researchers, policy makers and practitioners who want to manoeuvre modern realities like exchange-rate volatility, speculative actions and macroeconomic turmoil. Also, the sheer amount of scholarly literature generated throughout the years complicates the manual process of tracing the shifting themes or detecting the uncharted fields. Through the use of superior techniques of natural language processing, this paper hopes to fill this gap and offer an orderly mapping of the intellectual developments in the field of foreign exchange research. The information obtained during the analysis will be used to develop stronger theoretical models, new spheres of empirical research, and to make informed decisions in financial and policy processes.

2. Literature Review

The foreign exchange (FX) markets analysis field has changed considerably during the last century as it no longer focuses on the classical approaches to the currency valuation, but on the multifaceted, data-driven models that take into consideration the interactions between the global economies, speculative activity, and market microstructure [13]. The early literature mostly focused on the monetary relationships in terms of structure, where trade balances, gold standards and fundamentals of the economy conditioned the exchange rates [14]. These initial publications led to a setting of the pretext that the FX movements were mainly due to macroeconomic fundamentals like inflation, interest rates and the level of national income. With the opening up of global economies and the integration of financial markets, academic interest changed to the behavior of FX markets in the floating exchange-rate regimes [15]. Studies were broadened to the contribution of expectations, speculative pressures and arbitrage opportunities. Researchers emphasized how the failure to satisfy parity based conditions like purchasing power parity or interest rate parity tended to be brought about by short term speculative process, capital mobility or market frictions. It is also during this time that models of overshooting and volatility clustering were developed as well as the effects of an informational asymmetry on currency pricing [16]. The emergence of globalization made researchers focus more on the interrelated character of FX markets and their vulnerability to shocks on the international level. Literature has investigated the effect of global crises, commodity variation, political instability, and cross-country trade correlations on the dynamics of exchange rate [1]. Emerging markets were getting much attention especially in the aspect of currency crisis, capital flight and the susceptibility of the domestic currency to global shocks. A number of studies proved that exchange-rate volatility might increase the macroeconomic instability, trade competitiveness, or financial vulnerability [1]. The other body of literature concerned the role of institutional responses and policy interventions. Interventions by the central banks, be it in altering the interest rates, direct FX interventions, or communications, were revealed to affect market expectations and alter the exchange outcomes. There was also research done on regulation structures and the degree to which the policy actions would be able

to absorb volatility or keep the currency markets stable in turbulent times. Technological progress in recent decades has presented new dimensions of analysis of FX research. The spread of electronic trading, high-frequency data, and the development of computing technologies allowed scholars to simulate complicated trends and identify unprofitable market dynamics [17]. This trend facilitated the use of machine learning methods, improved econometric models, and simulations to understand volatility transmission, the spillover effects, and predictability of the market. In more recent studies, researchers have found it necessary to examine large literature in order to gain a deeper insight into how themes in FX research have changed over time. The increasing interdisciplinary literature, such as the connection of foreign exchange and education, development, global value chains, labor markets and emerging technologies, requires the use of systematic textual analysis techniques [18]. The problem of uncovering latent themes, identifying research gaps, and informing future scholarly inquiry have all become the subject of increased use of natural language processing (NLP) tools, including topic modeling [19]. The techniques permit objective and scalable mapping of the long-term knowledge development of the foreign exchange literature. The thematic diversity reflected in the global FX research is employed in the abstracts of the current dataset. They mirror historical views of finance capitalism, studies of the speculative behavior, studies of the effects of the crisis, debates of the policy intervention, and studies of the macro-financial nexus. Other studies reach out in related areas of international business, global development and socio-economic outcomes. Such richness makes the dataset a perfect corpus to use NLP-based topic modeling in order to detect dominant and emerging research themes [20].

3. Research Methodology

The current paper uses a quantitative text-mining methodology based on Natural Language Processing (NLP) to understand thematic characteristics of foreign exchange research field. NLP offers computational methods to comprehend, interpret and model human language and as such, it allows researchers to derive valuable patterns to large textual corporate masses [21]. The authors within this broad umbrella utilized the Latent Dirichlet Allocation (LDA) model, which is a procedure of probabilistic topic-modeling generally used to identify latent themes in unstructured textual information [22]. This study data was obtained in the Scopus which is one of the most comprehensive and internationally recognized databases of citation and abstracts of scientific research. Researchers have been using Scopus extensively because it covers most of the peer-reviewed journals, conference proceedings, book chapters, and also has credible bibliometric metadata. It is a plausible source that can be used to carry out a large-scale bibliometric and thematic analysis due to its high indexing standards and multidisciplinary character. In order to get a narrow dataset that would be pertinent to foreign exchange study, the authors used the following search query:

TITLE(("foreign") AND ("exchange"))

The first search resulted in the generation of 3,724 articles. It was necessary to narrow down the dataset and make sure that the data was of quality, so a number of inclusion and exclusion

criteria were used. English language publications were included only, which narrowed the dataset down to 3,605 articles. Articles that were published in journals, conference proceedings, books, and book chapters were maintained. This narrowed down the sample further to 3,389 records. The publications that lacked the necessary metadata, including author details, abstract, source title, or year, were eliminated. Article section process based on PRISMA guidelines are provided in Figure 1.

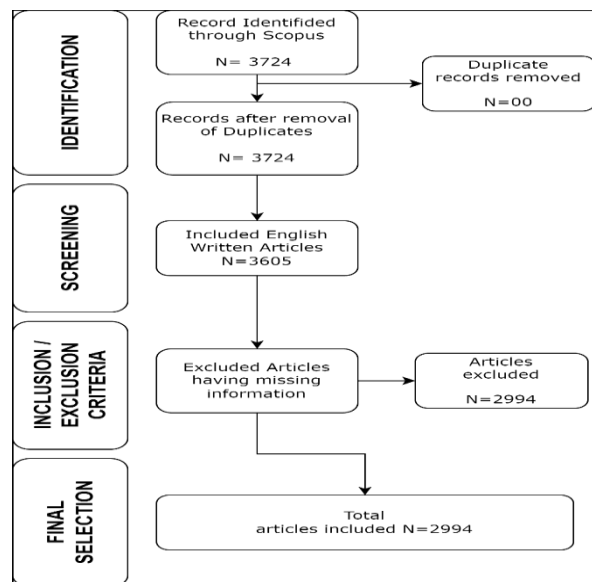


Figure 1: Article Selection Process

Following this, 2,994 articles were left to be analysed. The last data was then exported to an Excel sheet with the title of the article, the publication source, year, keywords, and abstract of the article. These abstracts were used as the language corpus to be analysed further using NLP. Research methodology used in this study is shown in Figure 2.

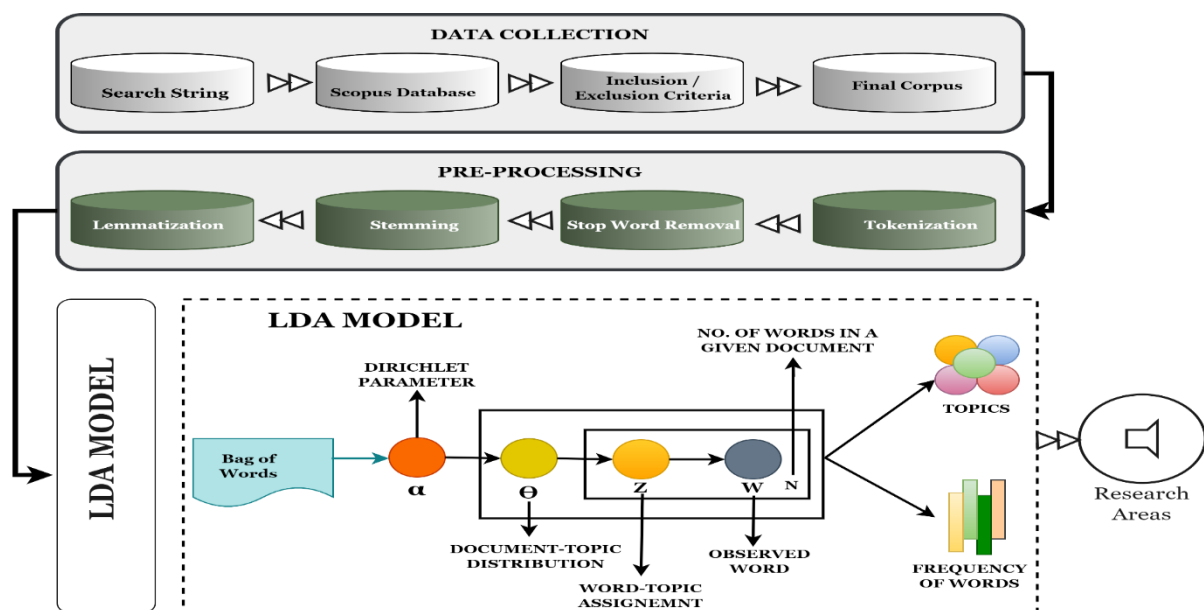


Figure 2: Research Methodology

Corpus Preparation and Text Preprocessing

The textual corpus was then subjected to a systematic preprocessing pipeline before subjecting it to topic modeling so that it could be standardized, noise filtered, and the text transformed into a machine-processable form. The preprocessing steps of NLP included the following [23][24]:

- **Tokenization:** Each abstract was divided into the units (tokens) which are usually the words or significant fragments of words, it is possible to perform computational analysis on the level of these units.
- **Stop-Word Removal:** Non-informative words that are frequent like the, and, is, for, etc. were eliminated. Deleting these high frequency and low-value words improves the product of thematic extraction.
- **Case Normalization:** All of the text was turned down to lowercase so that it would be consistent across the board. This will avoid the model confusing words such as Exchange and exchange to be different terms.
- **Stemming** Words were shortened by deleting suffixes (e.g., trading, traded, trader -> trad). This will decrease the size of vocabulary and categorize similar terms in terms of their semantic meaning.
- **Lemmatization:** Lemmatization, in contrast to stemming, changes words to the dictionary root form of a word depending on the grammatical context (e.g., studies become study; better becomes good). It provides normalization which is linguistically meaningful.

By so doing, a clean and standardized corpus was made, with a reduced number of linguistic variations, and consistency in topic modeling. The next step was Bag-of-Words (BoW) representation after preprocessing. BOW converts text to a numerical matrix that represents the frequency of each word in the corpus. The representation does not take into account grammar and order of words but preserves word occurrence data, which is appropriate to algorithms such as LDA. All abstracts were thus modeled as a document-term matrix of word counts, which are required to extract the topic.

3.1.Latent Dirichlet Allocation (LDA) Modeling

Latent Dirichlet Allocation (LDA) is the main tool of analysis in this study. Latent Dirichlet Allocation is a generative probabilistic algorithm used when there is a need to know about the hidden latent thematic configurations of large text sets [25]. LDA assumes that, the individual documents are all a combination of several latent topics and each subject is a pattern of words which appear together with high frequency in the corpus. The hyperparameters that are important to the model are:

- **Topics (k):** This value is set to 10 since it optimizes coherence scores.
- **Iterations:** The model was used to train 1,000 iterations, which was sufficient to stabilize and converge.

- Alpha and Beta (Dirichlet Priors): These are parameters that regulate the distribution of topics per document and distribution words per topic. They are normally optimized to achieve the best topic sparsity and coherence.

Topic coherence compares the semantic similarity of high probability words in a topic. A value of coherence of 0.3 to 0.6 tends to be reasonable and a sign of meaningful contents in huge written materials [26]. The LDA model used in this paper had a 10-topic solution with a coherence score of 0.49 which validated the thematic validity and interpretability of the topics extracted. Thus, 10 thematic clusters were made, and this reflects the prevailing research themes in foreign exchange field. These themes are used as signs of the new and recent directions of research, which can be useful to future researchers and practitioners. Themes of the research is represented in Table 1.

Table 1: Themes based on Keywords

Topic Number	Topic Terms	Topic Labelling	Top Article Loading	Contribution Percentage
Cluster 1	strategy, rule, profit, base, technical, portfolio, performance, period, investor, optimal, hedge, trade, profitability, make, transaction, approach, arbitrage, trader, set, investment	Technical Trading & FX Strategy	[27]	98.96
Cluster 2	firm, exposure, hedge, company, management, derivative, stock, list, hedging, corporate, finding, significant, sample, examine, investor, ownership, level, evidence, multinational, impact	Corporate FX Exposure & Hedging Management	[28]	99.76
Cluster 3	investment, export, run, fdi, trade, relationship, real, long, import, economic, direct, impact, variable, test, short, significant, growth, increase, term, economy	FDI, Trade, and International Investment Flows	[29]	99.74
Cluster 4	forecast, network, prediction, forecasting, method, neural, propose, base, series,	Forecasting & Predictive	[30]	99.76

	performance, predict, accuracy, term, error, machine, approach, learn, learning, use, compare	Modeling in FX Markets		
Cluster 5	international, research, economic, management, system, base, provide, article, development, global, make, change, language, approach, design, project, focus, student, develop, increase	Global Finance, International Economics & Policy	[31]	99.81
Cluster 6	monetary, bank, economy, capital, central, inflation, interest, domestic, regime, shock, money, real, control, inf, increase, asset, debt, cost, target, balance	Monetary Policy, Central Banks & Macroeconomic Effects	[32]	99.69
Cluster 7	stock, spillover, crisis, correlation, period, oil, garch, shock, dynamic, global, index, dependence, relationship, conditional, examine, finding, significant, use, causality, portfolio	Stock Market Linkages & Crisis Spillovers	[33]	99.73
Cluster 8	dollar, news, period, change, announcement, high, impact, yen, event, japanese, jump, use, euro, regime, bank, garch, central, evidence, significant, frequency	USD Movements, News Impact & Announcement Effects	[34]	99.66
Cluster 9	test, option, premium, process, forward, efficiency, estimate, hypothesis, interest, distribution, pricing, imply, long, stochastic, series, empirical, evidence, dynamic, term, variance	Derivatives Pricing, Options & Market Efficiency Tests	[35]	99.63
Cluster 10	information, order, flow, spread, trade, future, dealer,	Market Microstructure,	[36]	99.47

	spot, microstructure, transaction, liquidity, trader, expectation, bid, frequency, high, volume, fundamental, quote, cost	Order Flow & Information Spread		
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The topic modeling findings demonstrate that there are ten different clustering topics that indicate the large research areas in the corpus. Cluster 9 turns out to be the most predominant field of research with its contribution being 17.23 percentage of the total number of studies and represents a high level of concentration of scholarly interest in this field. This is then succeeded by Cluster 6 with account of 13.49 and Cluster 5 with account of 11.29 with both of them indicating considerable research activity. Cluster 3 (10.25) and Cluster 4 (9.25) and Cluster 2 (9.12) are close with the contribution of these themes to the extant literature being high. Cluster 7 (8.55) and Cluster 8 (8.45) are mid-level and Cluster 10 (6.81) and Cluster 1 (5.54) are other relatively small but significant areas of research. On the whole, this cluster-wise distribution shows the thematic organization of the research space and which areas are well-established and which are rather underexplored. This kind of analysis can be useful to the upcoming researchers because it can not only chart out the existing areas of knowledge but also indicate the possible gaps and new opportunities to make new contributions.

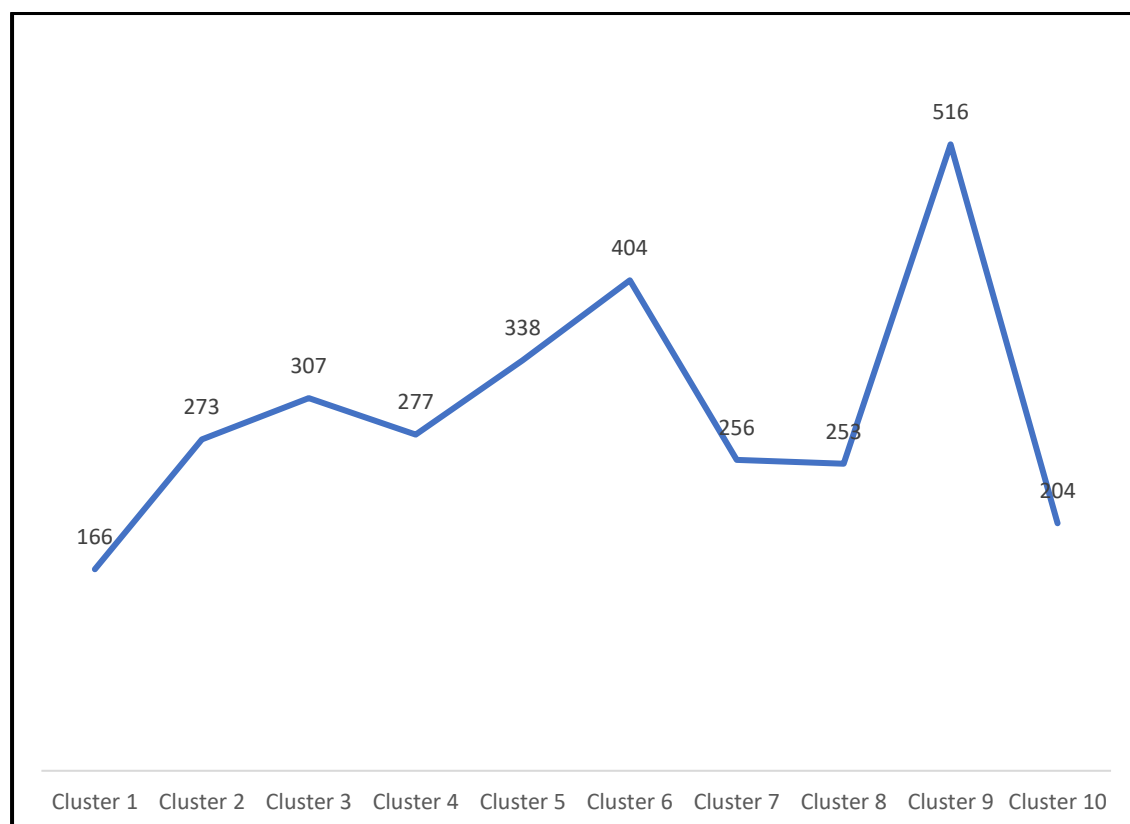


Figure 3: Clusterwise count of the Study

3.2.Meta Analysis

The analysis of the years shows that the contributions of the research have changed significantly over time. The 1919-2000 covers the smallest part of the total publications, at 12.4 per cent, which is indicative of the sluggish rate of scholarly output in the initial years of the discipline. In 2001-2015, there is a significant change and it represents the 65.8% of the entire research, which is a significant increase in the research activity caused by globalization, technology, and the growing access to digital data and analysis tools. Since 2016, the percentage of contribution has been markedly high, with an average of 0.4 to 9.5 per cent added to the total corpus every year since 2016.

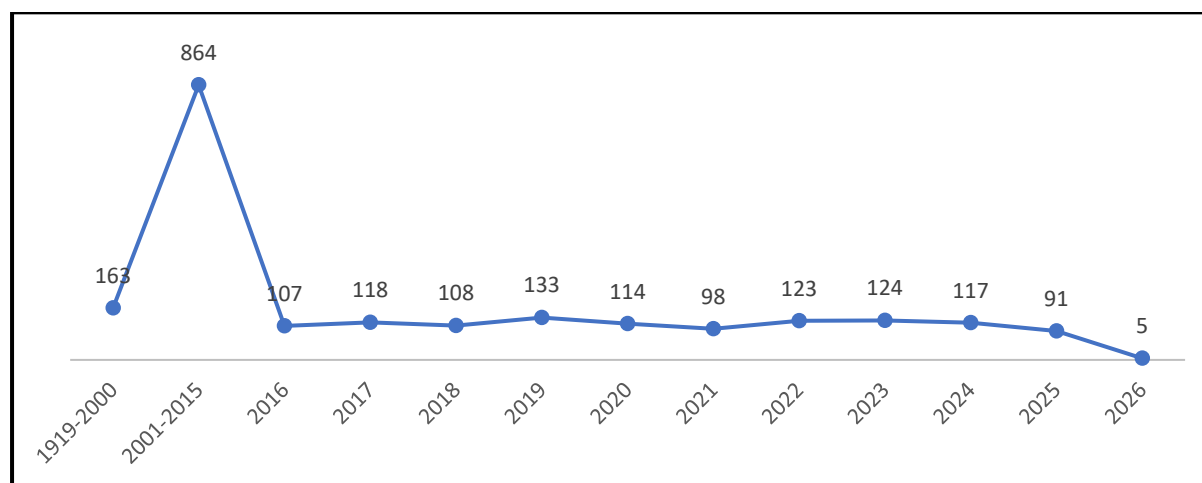
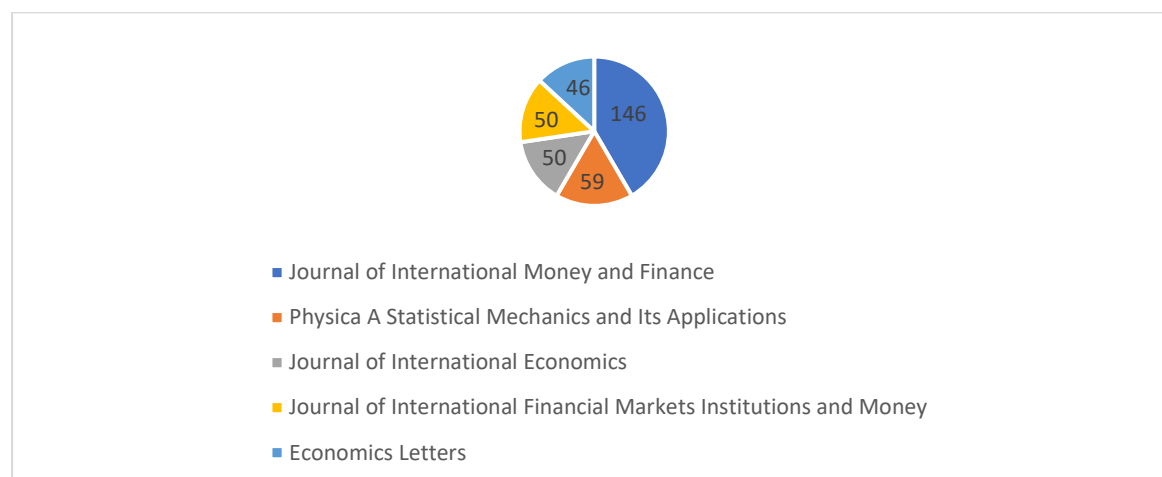


Figure 4 : Year wise growth Analysis

The 2022 and 2023 are the most productive years in the modern research, but the minor down-trend in the years 2024 and 2025 indicates that the productivity remains on the level and does not diminish the interest. The 2026 contribution is in the lower range because the data is on a partial year basis. Altogether, this discussion can establish that the transformation of research in this field has been not only toward a slow-growing field but also a highly active and a quickly growing field of academic research. It indicates growing worldwide applicability, growing academic concern and ongoing improvements in computational and empirical techniques that have contributed to more regular and thorough research performances.

The journal-by-journal analysis demonstrates the fact that the research on this field is being concentrated on a limited number of highly respected academic sources represented in Figure 5. The Journal of International Money and Finance has the largest number of publications, which has contributed to its high level of disciplinary focus, great credibility, and broad readership; it has a h- index of over 130 and an impact factor of more than 3.5 indicates that it is a dominant international financial studies publication. The Physica A: Statistical Mechanics and Its Applications with the second-largest number of publications is reputed by its interdisciplinary quantitative methods and an impressive h-index of over 200, with an impact factor between 2.5 and 3.0.

**Figure 5: Source Wise Analysis**

Ranked equally in terms of publication strength are the Journal of International Economics and the Journal of International Financial Markets Institutions and Money which provide rigorous platforms, supported by strong scholarly metrics on the former with an h-index well above 180 and impact factor typically well above 4.0, and on the latter an h-index of around 90 and impact factor typically of between 2.0 and 3.0. Finally, Economics Letters is a well-known source of high-quality research in economics, brief, but with an h-index of over 120 and an impact factor near to 2.0. Journal analysis is important because it determines the credibility, scholarly impact and disciplinary focus of the research corpus. It assists in determining publications sources that influence the knowledge in the field, direct future researchers towards the sources of influence, and show how the dataset aligns with quality and peer-reviewed scholarship.

4. Research Areas

Cluster1: Technical Trading & FX Strategy

The history of research on technical trading in foreign exchange (FX) markets dates back to the assumption that historical price patterns and statistical indicators can be used to come up with profitable trading rules. Initial experiments were based on the simple moving averages, filter rules and momentum strategies to determine whether there were predictable patterns in exchange rates [37]. The practice of trend-following had been shown in a number of classical literature to have a short-term payoff, and most notably during inefficient market periods. Subsequent studies extended to algorithmic trading, machine learning-based strategies, and systems based on neural networks and proved to possess better predictive properties than traditional rules. Another approach that has been investigated is a portfolio-based approach that incorporates the principles of risk management and optimization to maximize returns and minimize volatility utilizing technical indicators. Regardless of decades of studies, outcomes have been mixed because of the changing market efficiency, structural discontinuities and because of the impact of macroeconomic news. The recent literature underlines the importance of regime-switching behavior, according to which technical strategies are only effective in a high-volatility or trending environment. Furthermore, the high-frequency trading (HFT) has

shifted the microstructure of the market, where the usefulness of older rule-based systems is in question. [38]

Future studies can consider the incorporation of deep learning systems- LSTM, GRU, or transformer models to be more effective in capturing sequential dependencies in FX data. The other prospective path is hybrid modeling, in which technical indicators are integrated with underlying variables such as interest rate differentials, order flow, or sentiment derived out of news and social media. Another area that researchers can consider is explainable AI (XAI) to comprehend why some strategies are effective in a particular situation. Trading agents based on reinforcement learning provide additional prospects of optimization of dynamic decisions made in real time [39]. Also, the effect of interventions by the central bank, macroeconomic uncertainties and geopolitical risks on the profitability of technical strategies can be examined in future studies. The opportunities in this field are still abundant, particularly due to the growing access to high-frequency data and the progress and development of computational finance.

Cluster 2: Hedging Management and Corporate FX Exposure

The corporate foreign exchange exposure literature is dedicated to the way companies cope with risks, which are caused by currency changes. Transaction, translation, and economic exposures and the levels at which firms hedge their exposure using financial instruments like forwards, futures, options, and swaps were studied at an early stage [40]. According to corporate financial management literature, unhedged exposure may impact on valuation of firms, cash flow, competitiveness and investment. Research also reveals that the efficiency of hedging technique depends on industry, size of firm, financial limitation, and market fluctuation. Recent studies are not just limited to financial hedges but put more focus on operational hedging, including geographical diversification, invoicing in foreign currencies and changes in supply chain. Comprehensive risk management strategies that incorporate both financial and operational hedges have become very popular. The other important area is looking at the determinants of hedging behavior, which could include managerial incentives, corporate governance, and regulatory environments [41]. There is empirical evidence that suggests that the firms that have improved governance tend to have advanced FX risk management policies.

The existing research can be expanded in the future through investigating the effects of the digital transformation on corporate hedging efficiency, along with the use of real-time data analytics and AI-based risk forecasting. The impact of the ESG (Environmental, Social, and Governance) criteria on the development of hedging policies is a developing field as well. Alternatively, it is possible to study hedging strategies of multinational companies regarding the aspects of geopolitical risks, supply chain disruption, and times of excessive volatility, such as the pandemic or financial crisis. The way in which firms change hedging strategies to macroeconomic uncertainty, inflation shocks or changes in central banks policies provide new areas to explore. Opportunities also exist in behavioral finance approaches such as risk perception and managerial overconfidence that have not been explored.

Cluster 3: FDI, Trade and International Investment Flows

The studies in this field look at the effects of foreign exchange movements on foreign direct investment (FDI), international trade as well as cross-border capital flows. The initial literature was concerned with exchange rate volatility and its impact on export competitiveness and investment choices. Research also shows that a stable exchange rate will promote multinational companies to invest in foreign countries and volatility will tend to discourage investment since there is more uncertainty [1]. Asymmetrical effects are also noted in empirical evidence—currency depreciation is likely to increase exports but deter foreign investors because of increased risk premia. More recent studies have extended to global value chains (GVCs), focusing on the strategic location of production by multinational companies in terms of exchange rate processes, labor sectors and trade agreements. Further, research investigating the FDI movements in the emerging economies demonstrates that institutional quality, financial development, and macroeconomic stability are significant factors in reducing the risk associated with currency [42]. The researchers also analyze the impact of bilateral exchange rate deviations on the trade between two countries.

The effects that digital trade, e-commerce and virtual market places have on the competitiveness of currency can be examined in future research. One more new opportunity is the research of ways in which cryptocurrencies and central bank digital currencies (CBDCs) alter international trade and investment choices. It is also possible that researchers study how geopolitical tensions, near-shoring and friend-shoring strategies affect FDI patterns. Green FDI and environmental policies are currently becoming topical, whereas it is important to research the way financial risks associated with climate factors can be combined with currency volatility. Furthermore, the interaction between exchange rate regimes (fixed and floating) and inflation dynamics, as well as restructuring of the global supply chain, provides a promising future research.

Cluster 4: Forecasting and predictive modelling in the FX market

One of the key fields of research has been forecasting of exchange rates, as the issues revolve around the problem of infrequent, yet extremely volatile FX movements. Models like ARIMA, GARCH and the vector autoregression (VAR) were popular in the past. These classical theories emphasized the volatility clustering, the reversion to the mean and the macroeconomic fundamentals [43]. They were however limited in terms of their predictive accuracy particularly against the random walk benchmark. Machine and deep learning models have become recognizable over the last ten years. Predictive performance is better in neural networks, random forests, SVMs, and hybrid models because they are able to capture a nonlinear pattern. In particular, LSTM and transformer-based models have shown good performance in the modeling of sequential FX time-series data. Combining the variables of market microstructure (order flow and liquidity measures) with forecasting models has also been studied.

Further studies can be conducted on combining sentiment data that has been obtained with NLP in financial news, social media, and central bank communication and improving the forecasting accuracy [44]. Complex models may be interpreted using explainable AI and understand the

factor behind exchange rate movements. New directions include high-frequency forecasting, real-time predictive analytics and trading agents based on reinforcement learning. Also, we can examine how prediction models perform in times of crisis, extreme volatility, or macroeconomic shocks to test the strength of the models. There are other models that can be used to enhance this field, hybrid models that incorporate fundamentals, technical indicators, and machine learning.

Cluster 5: Financing all over the world, international economics and policy

The studies within this topic concern macroeconomic and policy determined aspects of the world financial system. Research investigates the influence of exchange rates on international capital movement, world financial cycles, economic integration and coordination of policies. The theories that form the basis of this area are classical theories, i.e., the Mundell-Fleming model, purchasing power parity (PPP), and interest rate parity (IRP) [45]. The impact of trade policies, exchange rate pass-through, international competitiveness, balance-of-payments adjustments are investigated in empirical research. The recent research also emphasizes the contribution of global financial interconnectedness, capital movement and spillovers of the large economies. Studies are also done on the effects of unorthodox monetary policies like quantitative easing on the exchange rates and international capital flows. Exchange rate models are becoming increasingly important in guiding policymakers to implement interventions in order to stabilize financial market, enhance growth, and price stability [46]. The impact of digital currencies, global regulatory coordination, and macroprudential policies on the international financial stability can be explored in future research. Green finance programs and climate-related financial risks can also transform the world capital flows. Scientists are able to investigate the impacts of demographic changes, technological shocks, and geopolitical fragmentation on the dynamics of exchange rates. In addition, investigating how financial systems worldwide can cope with such massive upheavals as pandemics, wars, and supply chain disruptions provides useful information to policymakers.

Cluster 6: Central Banks and Macroeconomic Effects, Monetary Policy

This topic discusses the studies that investigated the impacts of monetary policy decisions on the exchange rates, inflation and the macroeconomic stability. Classical literature puts emphasis on the association between interest rate differentials and currency valuation, which is based on IRP theory. Communication, credibility, and expectations of central bank makes important roles in determining market responses to policy announcements [47]. The empirical research studies the effects of inflation targeting, exchange rate interventions and macroprudential regulations on currency behavior. Recent work includes the communication of the central bank that is central to the digital format; that is, social media statements and press releases with the help of sentiment analysis to comprehend the reaction of the market. It is also noted in the studies that there are nonlinear effects in which the shocks in monetary policy have asymmetric effects based on the economic conditions, financial stability, and uncertainty levels. The contribution of unconventional policies, including the asset purchase programs, to the exchange rate adjustments has also been researched on.

The future studies may explore the effects of CBDCs on the mechanisms of monetary transmission and the dynamics of exchange rates [48]. The other potential future direction is to examine how inflation shocks, global disruptions in the supply chain, and currency stability interact. Researchers are also able to examine the interaction of monetary policies with fiscal interventions, geopolitical conflicts and fluctuation of commodity prices. More dimensions to study the policy-induced exchange rate effects include behavioral aspects, including investor sentiment, uncertainty indices, and risk perceptions.

Cluster 7: Crisis Spillovers and Stock Market Linkages

The topic of research is the interdependence between FX markets and international equity markets. As indicated in the literature, stock market volatility is frequently passed on to FX markets in times of crisis, as well as when market prices are volatile. Research shows a high spillovers in times of events like the Asian Financial Crisis, Global Financial Crisis and COVID-19 pandemic. Cross market contagion, volatility clustering and safe-haven behavior in the currency market (e.g. USD, JPY, CHF) are well known [49]. Multivariate GARCH models, copulas, and network analysis are recent models which are used to map interconnectedness across markets. High-frequency data has already made possible more in-depth examination of the synchronization between FX and equity volatility. There is also an examination of the intensification of correlations across markets by the scholars reducing the benefits of diversification.

The dynamics of contagion can be investigated with the help of machine learning-based network models and high-dimensional time-series methods in future studies. The cross-market spillovers caused by the effect of climate risks, geopolitical shocks, and cyber threats are relatively understudied [50]. Also, this area can be expanded by studying the transmission of the crisis through the prism of investor sentiment, media discourse, and global uncertainty indices. There are also new opportunities involved in cryptocurrencies and digital assets integrated into a spillover analysis.

Cluster 8: USD Movements, News Impact and Announcement Effects

This theme discusses the research on the impact of the macroeconomic announcements, news events, and information shocks on the exchange rate changes, especially the USD fluctuations. Preliminary research revealed that anticipated announcements, including interest rate announcements, employment updates, and inflation announcements, produce a lot of volatility. According to the high-frequency studies of events, the FX market responds quickly to both anticipated and unanticipated elements of the news [51]. New studies incorporate the sentiment analysis of news pieces, central bank speeches, and geopolitical events to measure the information shocks. The contribution of uncertainty indices, e.g. VIX and economic policy uncertainty are also becoming more accepted. The empirical studies demonstrate that news may be asymmetric in its impacts, whereby bad news tends to attract more responses as compared to good news.

In future studies, real-time sentiment analysis of the social media, financial blogs and communication between central banks can be combined to develop a more precise model of

market reactions [52]. Event prediction and volatility forecasting with the help of AI can be helpful in understanding the behavior of the market under the impact of news. One more possible research topic is cross-country differences in news sensitivity and the role of market microstructure (liquidity and order flow) in influencing announcement spillovers.

Cluster 9: Pricing of Derivatives, Options and Tests of the Market Efficiency

The subject is on the FX derivatives markets, options, forwards, and swaps among other hedging tools. The studies analyze option pricing models, volatility smiles, risk premia as well as arbitrage opportunities. The classical models like black-Scholes have been generalized to include stochastic volatility and jumps in the exchange rates [53]. The efficiency of markets studies examine whether forward rates can be used as unbiased predictors of the future spot rates and the null hypothesis is commonly rejected since risk premia tend to persist. The recent literature discusses the derivatives pricing based on machine learning, volatility forecasting by utilizing implied and realized volatility, and the contribution of liquidity to option price. Efficiency is also studied by analyzing tests of covered and uncovered interest parity.

Future studies can look into the derivatives pricing when the markets are extreme, financial risk in climate, and geopolitical uncertainty [54]. The introduction of sentiment-based volatility features and the use of the pricing of the currency-based derivatives of digital assets or CBDCs are the fruitful avenues. Scholars can also create novel arbitrage-testing models based on nonlinear models and high-frequency data.

Cluster 10: Market Microstructure, Order flow and information dispersal

The investigation of the market microstructure studies the processes of trading, the flow of orders, liquidity and information asymmetry and their impact on the exchange rates. Classical studies have set up the idea that a significant part of short-term exchange rate movements is due to the order flow, but not to macroeconomic news published publicly. The next study examines dealer behavior, bidask spreads, revised quotes and liquidity shocks [55]. New literature uses high-frequency and tick data to study the importance of algorithmic trading, HFT, and electronic communication networks (ECNs). Researchers study the nature of price formation in the FX and the role of liquidity fragmentation, transaction costs, and the diffusion of information in the formation. Future studies can study the impact of market microstructure in decentralized markets, cryptocurrency markets, and CBDC-based payment systems. Deep learning as a model to simulate order book dynamics, liquidity risk, and information arrival has some promising opportunities. The impact of geopolitical risks, cyber threat and international macroeconomic uncertainty on microstructure behavior can also be researched.

5. Practical Implications of the Study

The results of this research have some significant practical implications on the policymakers, financial institutions, the multinational corporations, market analysts and the academic researchers. To begin with, the ten clearly defined thematic clusters identified give practical ideas that can be used in the process of strategic decision making. The monetary policy, economic interconnection on the globe and price of derivatives are some of the clusters that

demonstrate that the exchange-rate behavior is very dependent on macroeconomic announcements, central bank interventions and volatility in the global markets. This is specifically applicable to central banks that aim to develop efficient communication strategies, intervention policies, and inflation-targeting models as it is indicated that the policy shocks and announcement effects have high spillover effects across FX markets. The clusters that concentrate on hedging, exposure management and international flows of investment can also bring value to corporate managers. As it can be seen in the analysis, companies are increasingly using advanced financial and operational hedges to manage FX risks. The knowledge of such research patterns can thus assist organizations to adjust their risk-management structures, maximize their currency invoicing choices as well as hedge against the extreme instances of volatility. Equally, the experience of forecasting, technical-strategy groups can inform traders and quantitative analysts with evidence of emerging predictive models, ranging between classical econometric models to machine learning and neural networks. This can assist financial institutions to upgrade the trading algorithms plus enhance the decision systems in real-time.

Moreover, the findings underscore the role of increasing importance of technology, information analytics driven by data and high frequency flows of information as a defining force of currency movements. This has an implication on the creation of digital trading platforms, regulatory aspects over algorithmic trading and future structuring of FX governance schemes. Lastly, the cluster structure itself shows research gaps; in particular within the new areas of behavioral FX, climate-related currency risks, and the effects of digital currencies, providing a signal of where new challenges might emerge to practitioners and regulators.

6. Limitations of the Study

Although the given research provides a comprehensive thematic mapping of the FX research, a number of limitations are to be mentioned. Originally, the dataset is limited to publications indexed by Scopus, thus, whereas this option is rather comprehensive, it may not be able to cover pertinent literature in non-indexed journals, working papers, policy briefs, or industry reports. Second, the analysis is based only on abstracts of articles, not on the full texts; although abstracts provide the summary of the key findings, they might not be able to reflect all the methodological peculiarities, theoretical or argumentation, and the context of the issue. Third, LDA topic modeling method like the other topic modeling methods like LDA are strong but require subjective choices on topic number (k), preprocessing parameters and interpretation of output. These selections are capable of affecting the clusters that get created although the model has a coherence score that suggests the thematic quality to be acceptable. Fourth, the textual patterns are of primary concern in the analysis, and citation networks, authorship collaborations, geographical patterns are not directly included, which may provide further structural information on the global FX scholarship. Lastly, FX markets are changing very fast as a result of geopolitical shocks, changes in technology, and policy reforms. Therefore, even though the dataset covers over a century, the thematic representation might not be a complete reflection of the latest events that took place following the period covered by the dataset. Such limitations imply avenues through which future research can build on the existing research.

7. Conclusion and Future Directions

This paper is a systematic, data-driven research on the state of foreign exchange research by using more powerful Natural Language Processing algorithms on a huge dataset of approximately 3,000 Scopus-indexed papers. Using the Latent Dirichlet Allocation, the analysis manages to find ten prominent thematic clusters that altogether constitute the fundamental intellectual framework of the FX scholarship. These groups capture the ahistoriographical development of the contemporary research in the history of classical macroeconomics, and its development to more current computational and inter-disciplinary methods. The results show that the problem of pricing derivatives and market efficiency (Cluster 9) has been the focus of academic research since, which suggests that the issue of risk premium and arbitrage, and the complexity of option pricing in FX markets, have remained of interest. There are other key themes like monetary policy (Cluster 6) and linkages in the global economy (Cluster 5) that stress on the importance of macroeconomic shocks, interventions of central banks, and international capital flows in the determination of currency behavior. The temporal analysis indicates that there is dramatic increase in FX research after 2000 which is due to globalization, high rate of digitization and development of high frequency market environments. This rush highlights how the FX markets have evolved to be highly networked and technologically sophisticated systems, which demand advanced analytical systems. This change is manifested by the emergence of machine learning and deep learning in forecasting studies, which suggests a methodological change in the analysis of volatility, news reactions, and dynamic dependencies by scholars. The journal analysis also shows that the leading research is localized on a few high-impact outlets, which validates the credibility and scholarship of input in this area. Taken together, these findings do not only trace patterns of research that occurred in the past, but they also shed some light on the emergent themes and uncharted aspects. The findings demonstrate that FX research is becoming more interdisciplinary and incorporates the views of machine learning, behavioral finance, global value chains, policy studies, and market microstructure. The research supports the need to perform systematic, computational analysis in unifying massive amounts of literature, especially in areas where the market develops rather quickly and data are becoming more and more complex. All in all, the work may be seen as a valuable addition of knowledge to the body of works that can help future researchers, policymakers, and practitioners to cope with the changing world of FX research.

Findings of this study demonstrate a number of opportunities in the future research. To begin with, the fast expansion of digital technologies, such as, cryptocurrencies, Central Bank Digital Currencies (CBDCs), and decentralized finance, opens new opportunities to investigate currency dynamics, with the help of alternative data sources and new theories. Second, in the future, real-time news, social media and central bank communication sentiment analysis can be combined with this work to learn how information shocks contribute to FX volatility. Third, the researchers can investigate climate-related financial risks, geopolitical tensions, cyber threats, and supply-chain disruptions as the new type of determinants of the exchange-rate behavior, which are not sufficiently studied in the existing literature. Fourth, new approaches

to models in NLP including transformer, high-frequency deep learning models, and network-based spillover models can also be very helpful to improve predictive accuracy and thematic discovery. The data can be further extended by adding citation networks and geographical contributions to enhance the knowledge of the global FX scholarship.

Reference

- [1] C. M.-G. Umeaduma and A. N. Dugbartey, “Effect of exchange rate volatility on export competitiveness and national trade balances in emerging markets,” *Int. J. Comput. Appl. Technol. Res.*, vol. 12, no. 11, pp. 57–71, 2023.
- [2] R. E. Daraojimba, O. A. Farayola, F. O. Olatoye, N. Mhlongo, and T. T. Oke, “Forensic accounting in the digital age: a US perspective: scrutinizing methods and challenges in digital financial fraud prevention,” *Financ. & Account. Res. J.*, vol. 5, no. 11, pp. 342–360, 2023.
- [3] M. N. Jamil, A. Rasheed, A. Maqbool, and Z. Mukhtar, “Cross-cultural study the macro variables and its impact on exchange rate regimes,” *Futur. Bus. J.*, vol. 9, no. 1, p. 9, 2023.
- [4] A. Akarli, “A Modern Economic History of Emerging Markets (1950--2020),” *Palgrave Stud. Econ. Hist.*, 2024.
- [5] T.-Y. Liu and C.-C. Lee, “Exchange rate fluctuations and interest rate policy,” *Int. J. Financ. & Econ.*, vol. 27, no. 3, pp. 3531–3549, 2022.
- [6] M. A. Khan, H. Ali, H. Shabbir, F. Noor, and M. D. Majid, “Impact of Macroeconomic Indicators on Stock Market Predictions: A Cross Country Analysis,” *J. Comput. & Biomed. Informatics*, vol. 8, no. 01, 2024.
- [7] D. K. Jain, N. Ur-Rehman, O. Ganiev, and K. Arora, “Currencies of greater interest for central Asian economies: an analysis of exchange market pressure amid global and regional interdependence,” *Financ. Innov.*, vol. 9, no. 1, p. 46, 2023.
- [8] M. G. Nejad, “Research on financial innovations: an interdisciplinary review,” *Int. J. Bank Mark.*, vol. 40, no. 3, pp. 578–612, 2022.
- [9] K. Beck, “Capital mobility and the synchronization of business cycles: Evidence from the European Union,” *Rev. Int. Econ.*, vol. 29, no. 4, pp. 1065–1079, 2021.
- [10] V. Gupta, K. C. Santosh, R. Arora, T. Ciano, K. S. Kalid, and S. Mohan, “Socioeconomic impact due to COVID-19: An empirical assessment,” *Inf. Process. & Manag.*, vol. 59, no. 2, p. 102810, 2022.
- [11] Z. Kastrati, F. Dalipi, A. S. Imran, K. Pireva Nuci, and M. A. Wani, “Sentiment analysis of students’ feedback with NLP and deep learning: A systematic mapping study,” *Appl. Sci.*, vol. 11, no. 9, p. 3986, 2021.
- [12] C. Sharma and N. Chanana, “The intersection of artificial intelligence and human resources: transforming journey using natural language processing,” *Iran J. Comput. Sci.*, 2025, doi: 10.1007/s42044-025-00261-9.
- [13] S. Bahoo, M. Cucculelli, X. Goga, and J. Mondolo, “Artificial intelligence in Finance: a comprehensive review through bibliometric and content analysis,” *SN Bus. & Econ.*, vol. 4,

no. 2, p. 23, 2024.

- [14] D. P. Neghab, M. Cevik, M. I. M. Wahab, and A. Basar, “Explaining exchange rate forecasts with macroeconomic fundamentals using interpretive machine learning,” *Comput. Econ.*, vol. 65, no. 4, pp. 1857–1899, 2025.
- [15] A. Ali, R. M. A. Anjum, and M. Irfan, “Impact of exchange rate regimes on financial stability in developed and developing economies,” *Adv. J. Econom. Financ.*, vol. 3, no. 2, pp. 236–246, 2025.
- [16] H. Gupta, “Analysing volatility patterns in emerging markets: symmetric or asymmetric models?,” *J. Econ. Adm. Sci.*, 2023.
- [17] K. Balaji, “Revolutionizing High-Frequency Trading: The Impacts of Financial Technology and Data Science Innovations,” *Mach. Learn. Model. Tech. Financ. Data Sci.*, pp. 103–124, 2025.
- [18] B. Nyagadza, R. Pashapa, A. Chare, G. Mazuruse, and P. K. Hove, “Digital technologies, Fourth Industrial Revolution (4IR) \& Global Value Chains (GVCs) nexus with emerging economies’ future industrial innovation dynamics,” *Cogent Econ. \& Financ.*, vol. 10, no. 1, p. 2014654, 2022.
- [19] C. Sharma, S. Sharma, V. Bhardwaj, and B. K. Dhaliwal, “Generative artificial intelligence for sustainable development: predictive trend analysis in key sectors using natural language processing,” *Discov. Appl. Sci.*, vol. 7, no. 6, p. 596, 2025.
- [20] S. Sharma *et al.*, “Navigating the Frontiers of Industry 5.0: Predictive Analysis Using Natural Language Processing,” in *Operations Research Forum*, 2025, vol. 6, no. 3, p. 93.
- [21] Y. Sinjanka, U. S. Ibrahim, and F. Malate, “Text analytics and natural language processing for business insights: A comprehensive review,” *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 11, no. 9, pp. 1626–1651, 2023.
- [22] C. Sharma, S. Sharma, and others, “Latent DIRICHLET allocation (LDA) based information modelling on BLOCKCHAIN technology: a review of trends and research patterns used in integration,” *Multimed. Tools Appl.*, pp. 1–27, 2022, doi: <https://doi.org/10.1007/s11042-022-13500-z>.
- [23] K. Karunarathna and R. Rupasingha, “Learning to use normalization techniques for preprocessing and classification of text documents,” *Int. J. Multidiscip. Stud.*, vol. 9, no. 2, pp. 69–81, 2022.
- [24] V. K. Pant, R. Sharma, and S. Kundu, “An overview of stemming and lemmatization techniques,” *Adv. Networks, Intell. Comput.*, pp. 308–321, 2024.
- [25] U. Chauhan and A. Shah, “Topic modeling using latent Dirichlet allocation: A survey,” *ACM Comput. Surv.*, vol. 54, no. 7, pp. 1–35, 2021.
- [26] “Coherence Score.” 2019. Accessed: Mar. 20, 2021. [Online]. Available: <https://stackoverflow.com/questions/54762690/what-is-the-meaning-of-coherence-score-0-4-is-it-good-or-bad>

- [27] F. Zafari, G. M. Khan, M. Rehman, and S. Ali Mahmud, “Evolving recurrent neural network using cartesian genetic programming to predict the trend in foreign currency exchange rates,” *Appl. Artif. Intell.*, vol. 28, no. 6, pp. 597–628, 2014.
- [28] T. Chen, “Applying a fuzzy and neural approach for forecasting the foreign exchange rate,” in *computer engineering: Concepts, methodologies, tools and applications*, IGI Global Scientific Publishing, 2012, pp. 412–425.
- [29] S. Ghosh, “Volatility spillover in the foreign exchange market: the Indian experience,” *Macroecon. Financ. Emerg. Mark. Econ.*, vol. 7, no. 1, pp. 175–194, 2014.
- [30] Z. Zhang, “An agent-based hybrid intelligent system for foreign exchange trading,” in *Active Media Technology*, World Scientific, 2003, pp. 83–93.
- [31] T. Maserumule and P. Alagidede, “Impact of macroeconomic announcements on foreign exchange volatility: Evidence from South Africa,” *South African J. Econ.*, vol. 85, no. 3, pp. 405–429, 2017.
- [32] T. Bollerslev and M. Melvin, “Bid—ask spreads and volatility in the foreign exchange market: An empirical analysis,” *J. Int. Econ.*, vol. 36, no. 3–4, pp. 355–372, 1994.
- [33] S.-Z. Zhu, J. Wu, and Z.-P. Li, “Research on The Volatility Spillover Effect among Foreign Exchange Market Stock Market and Bond Market in China: Based on VS-MSV and CoVaR Models,” in *Proceedings of the 2nd International Conference on Information Technologies and Electrical Engineering*, 2019, pp. 1–5.
- [34] J.-M. Kim, Y.-S. Jung, and E. A. Sungur, “Truncation invariant copulas for modeling directional dependence: Application to foreign currency exchange data,” *Model Assist. Stat. Appl.*, vol. 9, no. 4, pp. 309–324, 2014.
- [35] E. Kocenda and T. Poghosyan, “Macroeconomic Sources of Foreign Exchange Risk,” 2008.
- [36] K. Narusawa, “The Foreign Exchange Market in Japan,” in *Japan’s Response to Crisis and Change in the World Economy*, Routledge, 2018, pp. 44–50.
- [37] H. Tadas, J. Nagarkar, S. Malik, D. K. Mishra, and P. Dipen, “The effectiveness of technical trading strategies: Evidence from Indian equity markets,” *Invest. Manag. & Financ. Innov.*, vol. 20, no. 2, p. 26, 2023.
- [38] P. Devi *et al.*, “A Study of Stock Market Dynamic: Exploring the Impact of High Speed Algorithms and AI Technologies on High Frequency Trading in India,” in *2025 International Conference on Next Generation Communication & Information Processing (INCIP)*, 2025, pp. 298–303.
- [39] R. Machlev *et al.*, “Explainable Artificial Intelligence (XAI) techniques for energy and power systems: Review, challenges and opportunities,” *Energy AI*, p. 100169, 2022.
- [40] P. G. Ogundu, “The strategic implications of financial derivatives in hedging corporate exposure to global economic volatility,” 2025.
- [41] L. Valdés and R. Caldentey, “Financial hedging of operational risk constraints: A general framework,” *Prod. Oper. Manag.*, vol. 33, no. 9, pp. 1912–1930, 2024.

- [42] R. Abaidoo and E. K. Agyapong, “Financial development and institutional quality among emerging economies,” *J. Econ. Dev.*, vol. 24, no. 3, pp. 198–216, 2022.
- [43] M. Akkaya, “Vector autoregressive model and analysis,” in *Handbook of research on emerging theories, models, and applications of financial econometrics*, Springer, 2021, pp. 197–214.
- [44] A. Petropoulos and V. Siakoulis, “Can central bank speeches predict financial market turbulence? Evidence from an adaptive NLP sentiment index analysis using XGBoost machine learning technique,” *Cent. Bank Rev.*, vol. 21, no. 4, pp. 141–153, 2021.
- [45] H. Issahaku, A. Kabiru, and D. A. Basit, “Patterns and causal connections between changes in exchange rates and interest rates in Ghana,” *Ghana J. Dev. Stud.*, vol. 20, no. 1, pp. 1–19, 2023.
- [46] Z. Yildirim and M. Ivrendi, “Spillovers of US unconventional monetary policy: quantitative easing, spreads, and international financial markets,” *Financ. Innov.*, vol. 7, no. 1, p. 86, 2021.
- [47] A. Kadić, M. Ganić, A. Mamuti, and S. Grima, “The Effects of Euroization on Monetary and Financial Stability: Empirical Evidence from Five Countries,” *Econ. Altern.*, no. 2, pp. 275–294, 2025.
- [48] P. P. Kolozsi, K. Lehmann, and Z. Szalai, “Is CBDC strengthening the monetary transmission mechanism?,” in *Central Banking, Monetary Policy and the Future of Money*, Edward Elgar Publishing, 2022, pp. 94–119.
- [49] S. Gunay and G. Can, “The source of financial contagion and spillovers: An evaluation of the covid-19 pandemic and the global financial crisis,” *PLoS One*, vol. 17, no. 1, p. e0261835, 2022.
- [50] E. Calefariu Giol, O. Panazan, and C. Gheorghe, “Cyber, Geopolitical, and Financial Risks in Rare Earth Markets: Drivers of Market Volatility,” *Risks*, vol. 13, no. 3, p. 46, 2025.
- [51] C. May and T. Ngandu, “Central bank policy rate announcements and high-frequency intra-day benchmark stock returns reaction dynamics: Evidence from South Africa,” *Invest. Anal. J.*, vol. 52, no. 1, pp. 19–39, 2023.
- [52] C. Saravanos and A. Kanavos, “Forecasting stock market volatility using social media sentiment analysis,” *Neural Comput. Appl.*, vol. 37, no. 17, pp. 10771–10794, 2025.
- [53] R. V Ivanov, “On the stochastic volatility in the generalized Black-Scholes-Merton model,” *Risks*, vol. 11, no. 6, p. 111, 2023.
- [54] F. Wang, W. Ma, N. Mirza, and M. Altunta\cs, “Green financing, financial uncertainty, geopolitical risk, and oil prices volatility,” *Resour. Policy*, vol. 83, p. 103716, 2023.
- [55] S. Li, “Momentum, volume and investor sentiment study for us technology sector stocks—A hidden markov model based principal component analysis,” *PLoS One*, vol. 20, no. 9, p. e0331658, 2025.