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Bibliometric Analysis of Studies on Catastrophic Health Expenditures

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ABSTRACT

According to the World Health Organization, after meeting basic household needs, spending on health that equals or exceeds 40 percent of household income is referred to as catastrophic health expenditures (CHE). Individuals' out-of-pocket expenses for advanced treatments and the risk of being exposed to such financial catastrophe have increased considerably. Consequently, CHE has become a prominent and current topic in scientific research. This study aims to perform a bibliometric analysis of studies related to CHE in order to identify research gaps in the field. A total of 705 studies on CHE, published between 2002 and 2021, were included in the analysis by applying specific search strategies in the Web of Science database. The data were analyzed by dividing them into two periods using the SciMat bibliometric analysis program. As a result of the examinations, it was determined that the themes of 'depression, costs of illness' and 'hemodialysis, aging, direct costs' in isolated themes are areas of study open to further development within the field of CHE. Based on these findings, future researchers may conduct studies to determine the level of CHE exposure, the incidence of CHE, and the determinants of CHE for individuals within specific disease and risk groups.

Keywords: Catastrophic Health Expenditures, Health Policy, Health Economics, Bibliometric Analysis, SciMat.

JEL Classification Codes: I10, I12, I14, I18, C80, D83

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INTRODUCTION

The development of neo-liberal management and policy approaches over the last three decades has also impacted health systems. In this context, it is evident that pro-market policies have been implemented in the health sector in most countries. Health reform programs founded on neo-liberal principles have undergone significant adjustments due to issues such as inefficient resource use, unequal access to healthcare, lack of financial protection, and sustainability challenges in health systems (Burçin et al., 2014). Market-based health policies, which aim to ensure the sustainability of health systems, have successfully reduced health costs, which constitute a sizeable portion of gross domestic product. However, these policies have also led to an increase in out-of-pocket payments for medical treatments. It is widely recognized that under recent health reforms, out-of-pocket expenses for medical treatments now represent a significant portion of the total costs of these services. This burden is particularly high in countries where health insurance coverage is limited, levels of development are low, social assistance frameworks are underdeveloped, and health inequalities are prevalent (Çınaroğlu & Şahin, 2016).

The increase in out-of-pocket payments, which is seen as a means of ensuring household participation in financial risk-sharing for the health system, leads to individuals being unable to access basic health services, a decline in the welfare of disadvantaged and low-income groups, and impoverishment. These findings highlight the issue of catastrophic health expenditures (CHE). The financial difficulty households experience due to medical expenses is measured by CHE (Doshmagir et al., 2021). When individuals are exposed to CHE, they face risks such as losing financial protection, having to limit basic needs like food consumption, depleting deposit accounts, and resorting to borrowing. The World Health Organization (WHO) defines such risks as financial catastrophe caused by out-of-pocket health expenditures. In short, CHE is described as 'the ratio of household income or expenditure on health exceeding a certain percentage at a given time' (Wagstaff & Van

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Doorslaer, 2003). CHE serves as an indicator to assess fairness in healthcare financing and the extent of health insurance coverage for individuals. The 10 percent and 25 percent thresholds of household income or expenditure are commonly used to determine CHE levels (Zhao et al., 2022). nother WHO threshold suggests that healthcare costs exceeding 40% of a household's solvency—solvency being defined as household expenses excluding food—expose a household to CHE (Murray et al., 2003).

A review of the literature reveals numerous studies demonstrating how out-of-pocket medical expenses, when combined with neo-liberal health policies, can lead to catastrophic outcomes by surpassing predetermined thresholds. In addition, it is observed that the effects of health expenditures on the health economy and health systems have been examined using methods such as stochastic frontier analysis and data envelopment analysis (Evans et al., 2001; Özdemir & Bulğurcu, 2015). These studies reveal performance indicators that demonstrate the impact of catastrophic health expenditures on the health economy, as well as the factors that cause such catastrophes (Abou Jaoude et al., 2022). It is argued that the high cost of catastrophic health care, particularly in low- and middle-income nations, is primarily due to insufficient prepayment systems. Furthermore, research has shown that the incidence of CHE is correlated with factors such as household size, income, receipt of social support, having family members over the age of 65, and the working status of the head of the household (Zhao et al., 2022). Research from Mexico (Galárraga et al., 2010), Türkiye (Yardım et al., 2010; Koçkaya et al., 2021), Vietnam (Van Minh et al., 2013), and India (Mondal et al., 2014) have also demonstrated that a household's economic standing significantly affects the CHE level. The primary variables influencing the degree of CHE in terms of health and wellness include the frequency of inpatient, outpatient, and dental care utilization (Doshmangir et al., 2021).

In WHO's 2000 report, it is emphasized that determining CHE, identifying the groups exposed to catastrophe, and understanding the factors that cause such catastrophes are crucial for health policymakers to achieve the goal of ensuring equal access to healthcare for all and equitable participation in health financing. Particularly in recent years, there has been a notable increase in scientific studies on this subject (Yadav et al., 2021; Ravangard et al., 2021; Yang & Hu, 2022; Gummidi et al., 2022).

The aim of this study is to examine the development of scientific publications in the literature on CHE using bibliometric analysis methods. Based on the findings from these examinations, the study will identify the authors, countries, institutions, the most frequently publishing journals and scientific fields, as well as the themes that have developed, emerged, or disappeared over time. In this way, suggestions for potential new research areas for future studies will be provided.

MATERIAL AND METHODS

This descriptive study aims to examine the characteristics of studies on catastrophic health expenditures using bibliometric methods. Bibliometrics is a quantitative scientific analysis methodology that allows for the evaluation of the nature and development of scientific studies. Bibliometric analysis provides a macroscopic overview of the vast amount of academic literature. It sheds light on the research themes that have the most output in a field and identifies influential and leading academics, institutions/universities, publication sources, and countries by considering their outputs and citations (Cobo et al., 2011). By analyzing the entirety or a specific portion of the literature and drawing generalizations, bibliometric analysis offers specific information on the evolution of the relevant field over time and space. It enables the objectification of personal observations and reveals the origins of researchers' influence. Drawing conclusions about a discipline's potential future trajectory is useful for choosing research topics and career planning (Moral-Muñoz et al., 2020). Moreover, bibliometric analysis can uncover the latest developments, research directions, and leading topics in a particular research area (Donthu et al., 2021).

There are many software programs that enable scientific mapping, such as VOSViewer, CiteSpace, Biblioshiny, and Gephi. The reason SciMat software was chosen for this study is that, while it includes the advantages of many similar programs, it also allows for the identification of inter-period themes related to the research topic and the analysis of relationships between these themes. The relationships between the units of analysis—in this study, words—are processed by the program using specific algorithms. It determines the conceptual structures important to the field of interest for each period, visualizes the findings in a way that allows for the evaluation of relationships between periods, and provides quality assessment criteria for the significant structures that emerge. This enables the researcher to evaluate the findings comprehensively. In

this study, SciMat v.1.1.04 software was used (Cobo et al., 2012).

SciMat software is used to conduct conceptual science mapping based on a network of frequently used words. This analysis follows a four-stage approach: research themes are identified, themes (research lines) are visualized, their relationships are shown as a thematic network, new themes are discovered, and performance analysis is conducted. The identified study themes are organized in a strategic diagram. The research is represented as a two-dimensional map, where themes are depicted as globes, with the volume proportional to the total number of publications related to the theme. These themes are categorized into four sections based on their relative relevance: (i) Upper right quadrant: Q1 - Engine Themes, which focus on organizing and expanding the field of study. (ii) Upper left quadrant: Q2 - Advanced and isolated motifs, which are significant but not central to the core research field. (iii) Lower left quadrant: Q3 - Ascending or declining themes, which are weak and may require further investigation or might vanish over time. (iv) Lower right quadrant: Q4 - Basic and cross themes, which, although not highly developed, are fundamental for understanding the subject matter (López-Robles et al., 2019). SciMat, with its advanced algorithms in text mining and theme visualizations, has been used in bibliometric analysis studies on a wide range of topics, including big data (López-Robles et al., 2019), human resources management (Santana & Cobo, 2020), wearable health technologies (Burbano-Fernandez & Ramirez-Gonzalez, 2018), Covid-19 research areas (Herrera-Viedma et al., 2020), emergency health services (Tabur, 2020), sustainability in health services (Morell-Santandreu et al., 2020) . While bibliometric studies using SciMat in the field of health are available, no study has been found on catastrophic health expenditures. Therefore, this study focuses on CHE.

Today, the most preferred databases for science mapping or bibliometric research are WoS, Scopus, Google Scholar, PubMed, and MEDLINE (Chen, 2017). Comparisons between WoS and Scopus have shown that both databases produce similar results in terms of citation counts. However, when examining publication counts by subject categories, it was found that Scopus gives more weight to life and medical sciences, while WoS places greater emphasis on economics and social sciences (Jacso, 2005). Additionally, WoS includes a large number of high-quality journals in the social sciences. This database also provides significant convenience for researchers in conducting analyses and was chosen for this study due to its reputation as one of the most prestigious databases in the world (Demir & Erigüç, 2018).

Web of Science (WoS) was used in this study. WoS is a world-leading scientific database that is frequently preferred in academic research. The data for this research were drawn from the 'Web of Science Core Collection' on January 15, 2022. This core collection includes more than 21,000 peer-reviewed, high-quality scientific journals published across more than 250 scientific disciplines worldwide. Additionally, conference papers and book data are available (Clarivate, 2021).

Since the study aims to identify research related to CHE, the following keywords were used in the search: 'catastrophic health expenditure,' 'catastrophical health expenditure,' 'disastrous health expenditure,' 'devastating health expenditure,' 'catastrophic health spending,' 'catastrophical health spending,' 'disastrous health spending,' 'devastating health spending,' 'catastrophic health spendings,' 'disastrous health spendings,' and 'devastating health spends.' A total of 906 articles were retrieved from the WoS search. Since the search was conducted in January 2022 and publications were still ongoing, 74 publications from 2022 were excluded from the analysis. Only research and review articles indexed in SSCI, SCI, SCI-expanded, and ESCI were included in the study. A total of 127 studies outside this scope were not included in the analysis, leaving 705 publications published between 2002 and 2021. All records and references from these publications were downloaded as plain text files and transferred to the SciMat program. The data were analyzed by dividing it into two periods: 2002-2017 and 2018-2022. The reason for this division was to ensure an equal distribution of articles across the periods. The second period starts in 2018 because there was a significant increase in publications compared to previous years, as seen in Figure 1. This division facilitates better analysis and interpretation of the changes in themes during each period. Additionally, the Excel program was used to gather descriptive information on the number of publications, citations, articles, journals, and authors. The development of themes across the periods and their relationships were analyzed using the SciMat software.

RESULTS

As shown in Figure 1, publications on catastrophic health expenditures began in 2002 and have increased significantly over time. In 2002, there was 1 publication with 123 citations, and in 2003, there were 4 publications with 1,144 citations. In subsequent years, the number of publications remained relatively low but with notable citation counts, such as 2 publications in 2004 with 246 citations, 4 publications in 2005 with 100 citations, 5 publications in 2006 with 601 citations, and 6 publications in 2007 with 620 citations. A substantial increase in publications occurred in 2012 with 21 publications (1,052 citations) and again in 2015 with 39 publications (1,003 citations). Although the number of studies remained low during some years, they garnered significant citation counts. However, in more recent years, interest in the field has surged, as reflected by 121 publications in 2021 (174 citations), 108 publications in 2020 (386 citations), 87 publications in 2019 (534 citations), 94 publications in 2018 (784 citations), and 58 publications in 2017 (690 citations). This demonstrates a growing trend in the number of publications over the years.

In Table 1, it can be observed that the most cited studies on catastrophic health expenditures are from the first period (2002-2017).

The article titled "Household catastrophic health expenditure: a multicountry analysis," published in *The Lancet* in 2003 by Xu, K., Evans, D.B., Kawabata, K., Zeramdini, R., Klavus, J., and Murray, C.J.L., ranks first with 1,120 citations. Additionally, the second most cited study, published in *Health Affairs* in 2002, has 461 citations. The third and fourth studies, published in the *WHO Bulletin* in 2006 and 2012, have high citation counts of 212 and 209, respectively.

Below is a brief summary of the findings from these highly cited studies on catastrophic health expenditures:

Ke et al. (2003) analyze how spending on health services affects households' financial situations and whether these expenditures reach catastrophic levels for households. The research findings indicate that the burden of health expenditures on households varies significantly across countries, with low-income households being particularly at greater risk. Additionally, the study emphasizes the effectiveness of health insurance systems and the role of government investments in health services in protecting households from financial hardship.

Xu et al. (2007) discuss how households can cope with financial difficulties arising from health expenditures. The study states that such expenditures can have devastating effects, especially on low-income households. The article suggests various strategies to prevent catastrophic health expenditures, including establishing effective health insurance systems, providing government-supported health services, and increasing access to healthcare. It also focuses on ways to reduce the impact of health expenditures on households and the role governments play in this process.

Li et al. (2012) aimed to assess the extent to which the Chinese population is affected by catastrophic household expenditures and impoverishment due to medical costs and to examine the health system and

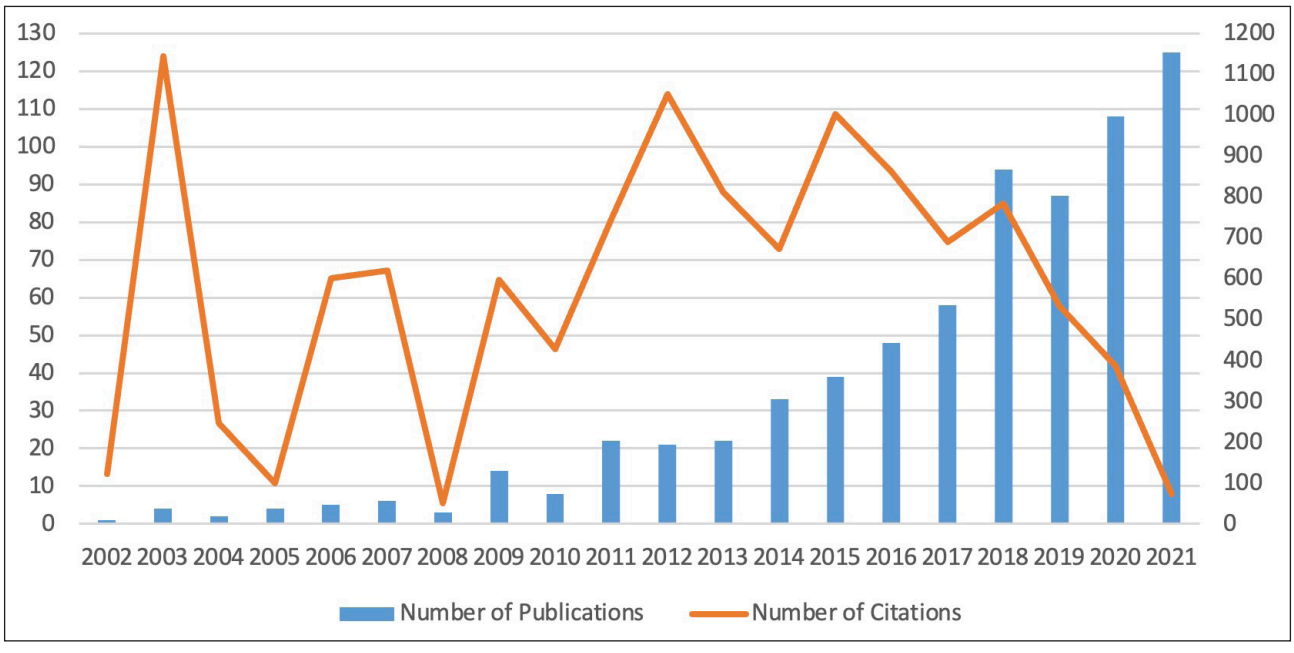

Figure 1: Distribution of Publications and Citations by Years

Table 1: Top 10 Most Cited Studies

No	Article	Author	Year	Citation	Journal
1	Household catastrophic health expenditure: a multicountry analysis (Ke et al., 2003)	Ke, X, Evans, DB, Kawabata, K, Zeramdini, R, Klavus, J, Murray, CJL	2003	1120	Lancet
2	Protecting households from catastrophic health spending, (Xu et al., 2007)	Xu, K, Evans, DB, Carrin, G, Aguilar-Rivera, AM, Musgrove, P, Evans, T	2007	461	Health Affairs
3	Catastrophic household expenditure for healthcare in a low-income society: a study from Nouna District, Burkina Faso (Su et al., 2006)	Su, TT, Kouyate, B, Flessa, S	2006	212	Bulletin Of The World Health Organization
4	Factor saffecting catastrophic health expenditure and impoverishment from medical expenses in China: policy implications of universal health insurance (Li et al., 2012)	Li, Y, Wu, QH, Xu, L, Legge, D, Hao, YH, Gao, LJ, Ning, N, Wan, G	2012	209	Bulletin Of The World Health Organization
5	Understanding the impact of eliminating user fees: Utilization and catastrophic health expenditures in Uganda (Xu et al., 2006)	Xu, K, Evans, DB, Kadama, P, Nabyonga, J, Ogwal, PO, Nabukhonzo, P, Aguilar, AM	2006	187	Social Science & Medicine
6	The financial burden from non-communicable diseases in low- and middle-income countries: a literature review (Kankeu et al., 2013)	Kankeu, HT, Xu, K, Evans, DB, Saksena, P	2013	181	Health Research Policies And Systems
7	Out-of-pocket health expenditure and debt in poor households: evidence from Cambodia (Van Damme et al., 2004)	Van Damme, W, Van Leemput, L, Por, I, Hardeman, W, Meessen, B	2004	167	Tropical Medicine & International Health
8	Catastrophic health expenditure and impoverishment in Türkiye (Yardim et al., 2010)	Yardim, MS, Cilingiroglu, N, Yardim, N	2010	148	Health Policy
9	The new cooperative medical scheme in China (You & Kobayashi, 2009)	You, XD, Kobayashi, Y	2009	137	Health Policy
10	Health system reform in Mexico 5: Assessing the impact of the 2001-06 Mexican health reform: an in term report card (Gakidou et al., 2006)	Gakidou, E, Lozano, R, Gonzalez-Pier, E, Abbott-Klafter, J, Barofsky, JT, Bryson-Cahn, C, Feehan, DM, Lee, DK, Hernandez-Llamas, H, Murray, CJL	2006	135	Lancet

structural factors influencing these expenditures. The survey data were obtained from the Fourth National Health Service Survey. The analysis of impoverishment due to catastrophic health and medical expenditures was conducted using a sample of 55,556 households with varying characteristics located in both rural and urban areas across different regions of the country. Logistic regression analysis was used to identify the determinants of catastrophic health expenditures. The rate of catastrophic health expenditures was 13.0%, while the rate of impoverishment was 7.5%. Households with hospitalized, elderly, or chronically ill members, as well as those in rural and poorer areas, had higher rates of catastrophic health expenditures.

Acombination of adverse factors increases the risk of these expenditures. Families enrolled in insurance plans and living in urban areas had lower rates of catastrophic health expenditures compared to those in rural areas. Finally, it was determined that the need for and use of health services, demographic characteristics, type of insurance package, and payment method to the service provider are key determinants of catastrophic health expenditures.

The aim of the study conducted by Yardım et al. (2010) is to determine the level of CHE in Türkiye and to identify the factors influencing it. CHE was calculated using data from the Household Budget Survey and Consumption Expenditure data of TurkStat from 2006. According to the research findings, the rate of households experiencing CHE is 0.6%. The lowest average out-of-pocket health payment in the lowest quintile is US$7.36, which is approximately one-tenth of that in the highest quintile. The probability of households experiencing CHE increases with each unit increase in per capita expenditures. The health insurance status of the head of the household is closely related to the likelihood of experiencing catastrophic expenditures. Rural households are 2.5 times more likely to experience catastrophic events than urban households. Having a

Table 2: Top 10 Authors with the Most Publications in the Field

Author	Publication	Citation
Ulasi, Ifeoma	13	24
Louis, Siu-Fai	13	12
Garcia-Garcia, Guillermo	13	24
Tangcharoensathien, Viroj	12	289
Strani, Luisa	12	12
Verguet, Stephane	11	174
Prinja, Shankar	11	195
Jan, Stephen	11	238
Wu, Qunhong	10	274
Li, Ye	9	267

preschool child in the household is seen as a protective factor against catastrophic expenses, while having an elderly or disabled person increases the risk.

Table 2 provides information on the top 10 most productive authors in the field of catastrophic health expenditures. In this context, with 11 publications each, Ulasi, F. (Nigeria) and Lui, S.F. (USA) take the top spots. These authors are followed by Garcia-Garcia, Guillermo, Tangcharoensathien, Viroj (Thailand), and Strani, Luisa (Belgium), among others. Additionally, it is noted that Tangcharoensathien, Viroj, Wu, Qunhong (China), and Li, Ye (China) are prolific authors in the field and have high citation counts. The literature review also revealed that all authors listed in Table 2 continue to actively work on catastrophic health expenditures.

In Table 3, the *International Journal for Equity in Health*, with an impact factor of 3.8 in the SSCI index in the field of catastrophic health expenditures, ranks first with 57 publications and 849 citations. It is followed by *PLOS One*, *BMC Health Services Research*, *Health Policy and Planning*, among others. Additionally, although *The Lancet* ranks last with 13 publications, it has 1,460 citations and an impact factor of 70.

In Table 4, it is observed that 85.40 percent of the scientific studies on catastrophic health expenditures are articles, 6.10 percent are compilations, 3.12 percent are meeting summaries, and only 0.42 percent are congress papers.

According to Table 5, 38.58 percent of the studies examined fall under environmental public and occupational health, 19.72 percent under healthcare services and sciences, and health policy, 10.07 percent under general internal medicine, and 6.95 percent under multidisciplinary sciences. Additionally, 6 percent of the studies are categorized under economics.

Table 6 shows the institutions associated with studies on catastrophic health expenditures. In this context, Harvard University, the University of London, and the World Health Organization are the three institutions with the highest number of publications. Johns Hopkins University, Tehran University of Medical Sciences, and Peking University are also on the list of organizations with significant publications in this field.

In Table 7, when examining the distribution of studies on catastrophic health expenditures by country, 24.68 percent are from the USA, 19.14 percent from China, 14.61 percent from England, and 8.22 percent from Iran.

Table 3: Information on Journals with the Most Publications in the Field

Journal	Publication	Citation	Quarter	Impact Factor	Index
International Journal For Equity In Health	57	849	Q2	3.8	SSCI
Plos One	46	952	Q2	3.78	SCI - Expanded
Bmc Health Services Research	44	660	Q3	3.29	SCI - Expanded
Health Policy and Planning	23	501	Q1	3.9	SSCI
Bmj Open	20	82	Q2	3.42	SCI - Expanded
Bmc Public Health	18	240	Q2	4	SCI - Expanded
Bulletin Of The World Health Organization	15	853	Q1	10	SCI - Expanded
Social Science & Medicine	15	397	Q2	5.2	SSCI
Tropical Medicine & International Health	15	492	Q2	3.08	SCI - Expanded
Lancet	13	1460	Q1	70	SCI - Expanded

Table 4: Information on Publication Types of Studies

Type	Number	Percent
Research Article	602	85.40%
Review	43	6.10%
Meeting summary	22	3.12%
Editorial Studies	18	2.55%
Congress Proceeding	3	0.42%
Others	17	2.41%

Table 5: Information on Science Categories Published by Studies

Category	Number	Percent
Public Environmental Occupational Health	272	38.58%
Health Care Sciences and Services	139	19.72%
Health Policy Services	139	19.72%
Medicine General Internal	71	10.07%
Multidisciplinary Sciences	49	6.95%
Economics	44	6.24%
Tropical Medicine	28	3.97%
Social Sciences Biomedical	19	2.69%
Surgery	18	2.55%
Medicine Research Experimental	17	2.41%

Table 6: Number of Publications From Institutions

Institution	Publication	Percent
Harvard University	57	8.08%
University of London	55	7.8%
World Health Organization	37	5.25%
London School Of Hygiene Tropical Medicine	33	4.68%
Harvard TH Chan School Of Public Health	32	4.54%
University Of California System	31	4.39%
University Of Nigeria	25	3.55%
Peking University	21	2.97%
Tehran University Of Medical Sciences	21	2.97%
Johns Hopkins University	19	2.69%

Table 7: Number of Publications From Countries

Country	Publication	Percent
USA	174	24.68%
China	135	19.14%
India	113	16.02%
England	103	14.61%
Iranian	58	8.22%

Table 8: Languages of Publications

English	687	97.45%
Spanish	13	1.85%
Other (French, Korean, Portuguese, Russian, Turkish)	1	0.5%

According to Table 8, 97.45 percent of the studies on catastrophic health expenditures were published in English, 1.85 percent in Spanish, and 0.5 percent in other languages, including French, Korean, Portuguese, Russian, and Turkish.

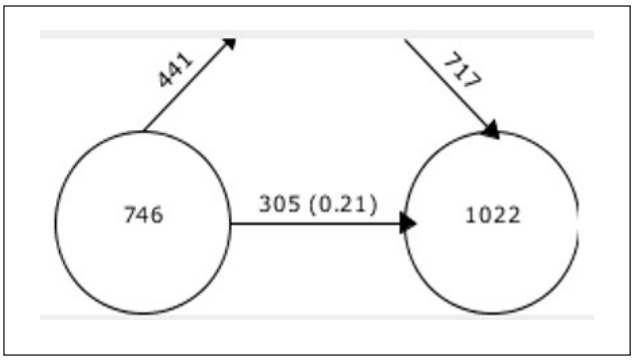

Figure 2: Graph of Development of Keywords

When Figure 2 is examined, the number of keywords and their changes during the 2002-2017 and 2018-2021 periods can be observed. This figure allows for the identification of increases and decreases in the number of keywords in a particular field, providing insights into the breadth and development of the field (Morell-Santandreu et al., 2020). In this context, 746 keywords were used in the first period, 441 of which disappeared without being used in the second period, 305 continued to be used, and 717 of the 1,022 keywords were newly introduced in the second period. Consequently, the recent increase in keywords used in CHE studies indicates that the field is current and continues to evolve.

When the theme map of the first period is examined in Figure 3, four motor themes are identified (Thailand, insurance, financial protection, households), along with seven main themes (HIV/AIDS, financial burden, Mexico, determinants, healthcare, poverty, access to healthcare). Additionally, there are three emerging or disappearing themes (coping strategies, services, health economics) and seven isolated themes (near-miss, lymphedema, being registered, results, economic evaluation, service use, cost-effectiveness analysis).

When Figure 4 is analyzed, it can be observed that there are more studies on catastrophic health expenditures in the 2018-2021 period compared to the first period. During this period, five engine themes were identified (catastrophic health expenditures, middle income, differences, status, equality), along with ten main themes (access to healthcare, health inequality, disease, population, inequality, services, health policy, Iran, expenditures, India). Additionally, there were five emerging or absent themes (depression, association, prevalence, disease cost, financial risk protection) and ten isolated themes (savings, random forest, health deprivation, financial value, direct costs, hemodialysis, household spending, aging, meta-analysis).

In Figure 5, it can be seen that the first period's themes of insurance, financial protection, households, and poverty—also present in the second period—strongly contributed to the development of catastrophic health expenditure studies. The second period theme of illness was further developed, being heavily influenced by the themes of consequences, coping strategies, and financial burdens. The services theme, in turn, significantly evolved with themes such as service proximity and economic evaluation analysis. The population theme has been associated with studies on determinants and service use. Meanwhile, the hemodialysis theme has a strong network relationship with the economic evaluation theme. Additionally, a close relationship exists between the themes of Thailand, healthcare, service use, and financial risk protection. Specifically, numerous themes from the previous period connect with the theme of inequality, considered one of the primary determinants of CHE. Themes such as determinants, household, financial protection, insurance, and financial burden are among these connections. It should also be noted that health policy studies are related to themes of health economics, financial protection, and insurance. However, themes like indirect costs, public health financing, financial value, health deprivation, meta-analyses, old age, health inequalities, prevalence, and disease costs do not interact with the themes from the previous period. This suggests that current studies can be developed around these themes.

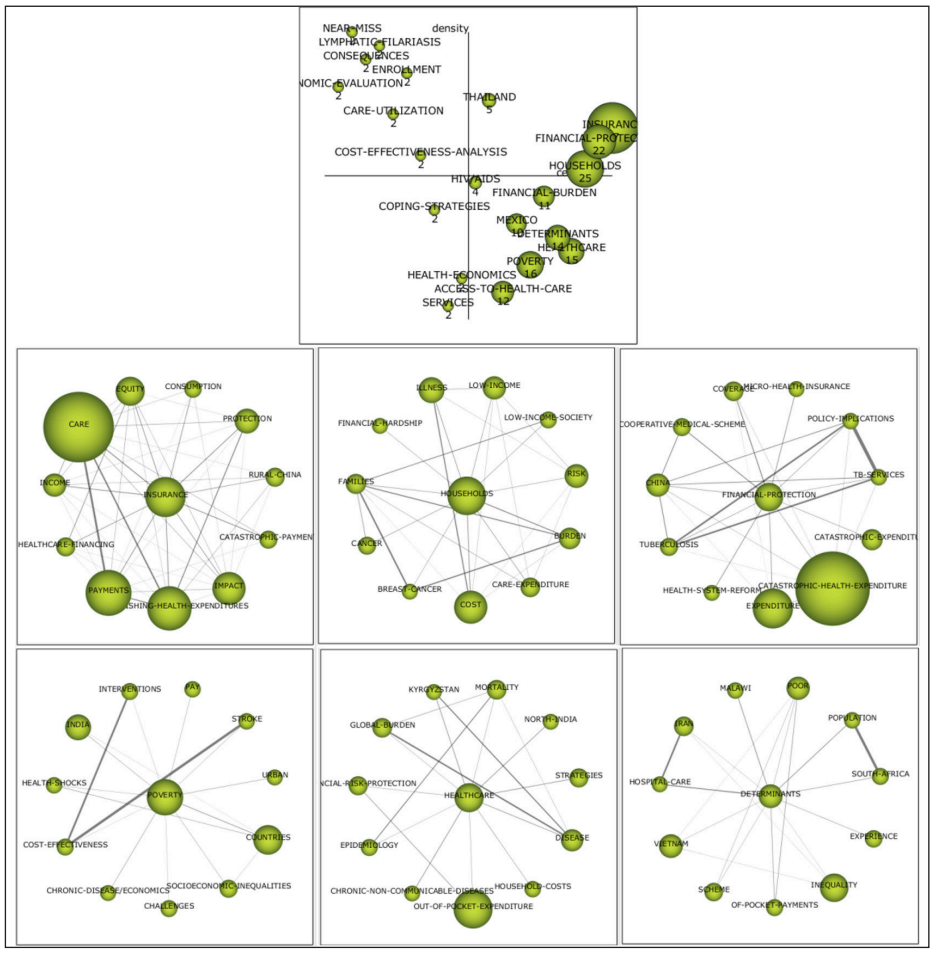

Figure 3: 2002-2017 Period Theme Map

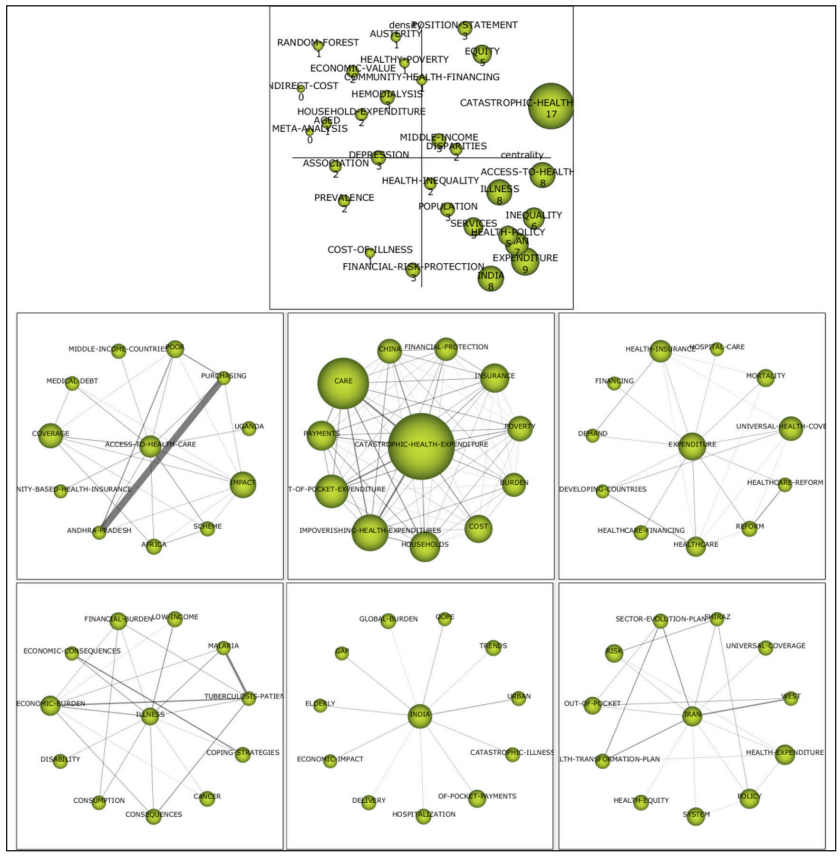

Figure 4: 2018-2021 Period Theme Map

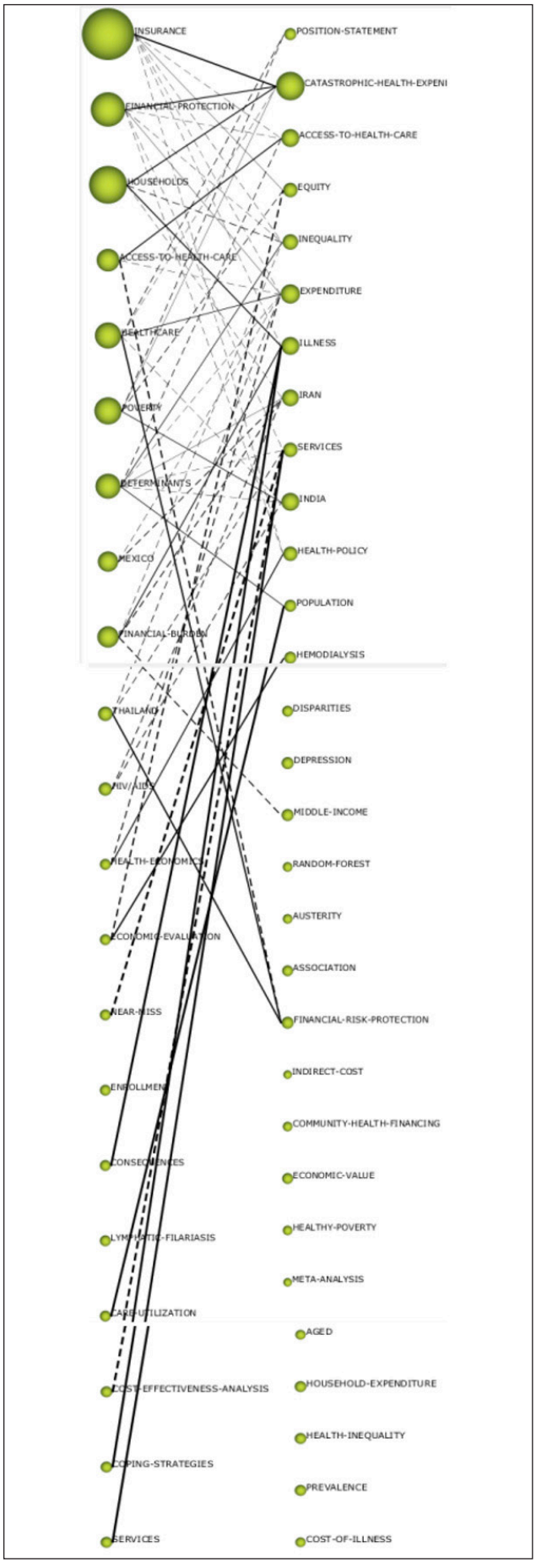

Figure 5: Longitudinal Structure Analysis for the Relationship Between Themes Across Periods

CONCLUSION

A bibliometric analysis was conducted on studies published in the SSCI, SCI, and ESCI indexes in the WoS database from 2002 to 2021 to provide an overview of academic publications on catastrophic health expenditures, a topic that has gained significant attention in health policies and financing. In this context, 705 publications were included in the study. The analysis revealed that the first study on CHE was published in 2002, and research in this field continues today. The most publications were made in 2021, while the most cited studies were published in 2003. Of the studies, 91 percent are research articles and reviews, and 98 percent are published in English or Spanish. In terms of WoS science categories, the studies have been published in fields such as public, environmental, and occupational health, health services, health policies, medicine, and economics, indicating that CHE is a multidisciplinary research area. Additionally, it was found that CHE studies are conducted intensively in countries such as the United States, China, India, and the United Kingdom. Institutions like Harvard University, the University of London, and the World Health Organization (WHO) have made significant contributions to the field in these countries.

Among the studies on CHE, the research article titled *Household CHE: A Multicountry Analysis* was the most prominent in the field, with 1,120 citations. Additionally, authors such as Ulasi, I., Lui, S.F., and Garcia, G. have been the most prolific in the field of CHE, each with 13 publications. Wu, Q., who is also among the prolific authors, has garnered the most attention, with 274 citations for their publications. When examining the journals that publish on CHE, the journal with the highest number of publications in the field is the SSCI-indexed *International Journal for Equity in Health*, which has an impact factor of 3.8.

Important results of the research are related to the strategic theme and thematic network maps obtained using the SciMat program. In this context, it was determined that themes such as depression, disease costs, hemodialysis, aging, and direct costs—categorized as isolated themes in the recent theme map—are areas open to further development in the field of CHE. Additionally, sub-themes like financial protection, financial burden, and impoverishment, which have a weaker relationship with CHE, are less developed. Based on these findings, future researchers may conduct studies to determine the level of CHE exposure, its incidence, and the determinants of CHE for individuals within specific disease and risk groups.

This study has some limitations. The study data were obtained solely from the WoS database, and studies from other academic databases, such as Google Scholar and Scopus, could not be examined. Additionally, SciMat was used as the bibliometric analysis program. Since SciMat does not provide visual mapping methods for author, journal, and institution information, the findings related to these aspects are presented in tables.

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Exchange Rate Bubble Formation in Türkiye: Revealing the Dance Between Reality and Speculation with Empirical Evidence from the Sequential ADF Tests

Gökhan KARTAL[1]

ABSTRACT

This study investigates speculative bubble formations in Türkiye's foreign exchange market from February 2001 to September 2024, utilizing the GSADF and BSADF methods. Through empirical analysis, the study identifies three significant bubble periods—May 2018 to October 2018, September 2020 to November 2020, and November 2021 to March 2022—each shaped by unique economic and geopolitical pressures. In the context of these findings, while some fluctuations in the exchange rate align with fundamental economic indicators, a segment of volatility remains unexplained, indicating the presence of speculative bubbles. This unexplained volatility suggests that traditional indicators alone are insufficient to account for currency valuations, underscoring the need for policy approaches that consider both macroeconomic fundamentals and speculative influences. Notably, the rapid surge in the exchange rate observed in late 2021, culminating in a peak in December, was followed by a dramatic decline precipitated by the announcement of the exchange rate-protected deposit account by economic authorities. This sequence of events highlights the significant impact of policy interventions on speculative activities, as evidenced by the empirical analysis indicating that the exchange rate bubble, which peaked during this period, began to deflate rapidly thereafter, ultimately dissipating entirely by March 2023. The findings emphasize the critical importance of sustainable, structural economic reforms in stabilizing exchange rates, advocating for long-term policies that address root causes of volatility rather than relying solely on short-term interventions.

Keywords: Türkiye Economy, Exchange Rate, Exchange Crisis, Bubbles, GSADF, BSADF.

JEL Classification Codes: C22, F31, O24

Referencing Style: APA 7

INTRODUCTION

The exchange rate is a crucial macroeconomic variable, capable of inducing severe economic crises if not managed effectively, particularly in developing countries like Türkiye. Given its significance, a substantial body of literature exists on the factors influencing the exchange rate, known as exchange rate determinants. These determinants include inflation, interest rates, foreign trade deficits, foreign direct investments, political stability, exchange rate regimes, and speculation. It is worth noting that fluctuations in exchange rates can, in turn, influence these variables, indicating a mutual interaction among them. For instance, during a period of foreign trade deficit, other things being constant, the local currency's value tends to decrease as the country's foreign exchange reserves dwindle. However, this depreciation can render exported goods relatively cheaper, thus setting off a cycle that positively impacts the foreign trade balance by stimulating export growth, assuming the validity of the Marshall-Lerner condition. Consequently, at times, governments allow for currency depreciation to boost foreign trade. Nevertheless, such exchange rate increases can also escalate the prices of imported inputs and other consumer products, leading to an inflationary effect and a chain reaction of rising domestic prices. If this inflation surge surpasses the inflation rate in the country producing the foreign currency, it may further devalue the local currency. On the other hand, raising interest rates can indeed strengthen the local currency's value by increasing foreign exchange availability, thus enticing international capital inflows—a crucial factor in stabilizing the exchange rate. However, this strategy is not without its risks, as evident in the potential for economic crises triggered by sudden shifts in global fund movements, particularly observable in hedge funds' reactions. Moreover, rapid political instabilities can swiftly lead to the exodus of global funds, intensifying the demand for foreign currency and exposing vulnerabilities within the economy, potentially leading to a currency crisis. During periods marked by extreme volatility, the speculative use of the exchange rate becomes more pronounced, potentially uncovering underlying bubbles in the foreign exchange

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market. This speculative behavior can exacerbate the macroeconomic-driven surge in the exchange rate, creating a self-reinforcing cycle that further inflates the bubble and heightens market uncertainties.

When the Türkiye economy is analyzed from the point of view of the exchange rate movements, especially the recent sharp upward trend in the exchange rate has made the economic programs also implemented debatably. In this context, the dollar exchange rate, which was at 7.44 at the beginning of 2021, surpassed the 10 TL threshold in November, subsequently escalating uncontrollably to reach a historic peak of 18 TL in December 2021. Simultaneously, spurred by rising global inflation, Türkiye experienced an inflation rate exceeding 36% in 2021, influenced by fluctuations in the exchange rate. During this period, economic authorities intervened with measures such as introducing currency-protected time deposits announced on the evening of December 20, 2021, which temporarily curbed the increase in the exchange rate. After this intervention, which is effective for a certain period, the exchange rate resumed its upward trajectory and surpassed the 32 TL mark in 2024. Concurrently, inflation reached unprecedented levels in recent years, registering at 64% in 2023. While some circles associate this situation with bad economic policies, some circles argue that these fluctuations are not related to macroeconomic indicators but an artificial situation, in a sense, the existence of a bubble in the exchange rate market.

In this context, while the exchange rate's dynamics unveil intricate relationships with various economic variables, it is equally crucial to delve into the phenomenon of economic bubbles, which can significantly impact financial stability and market dynamics. Economic bubbles, often labeled as "speculative bubble," "market bubble," "price bubble," "financial bubble," or "speculative mania," delineate periods characterized by speculative investment leading to an overvaluation of securities within specific sectors (Chang, Newman, Walters, & Wills, 2016, p. 497; Girdzijauskas et al., 2009, p. 269). This concept has spurred debates among economists, with some attributing bubble occurrences to inflationary factors. In contrast, others argue for an inherent value in assets, portraying bubbles as escalations beyond this fundamental worth (Girdzijauskas et al., 2009, p. 269). Over time, the escalation of asset prices creates anticipations for further escalations, drawing in new investors primarily focused on trading profits rather than the assets' intrinsic utility or income potential. However, such upward trends are typically followed by a reversal in expectations and a sharp price decline, culminating in financial crises (Kindleberger, 1991). Key aspects defining bubble formation and its subsequent collapse include rapid price escalations, unrealistic future price expectations, a detachment of prices from fundamental values, or a substantial price drop post-bubble burst (Smith & Smith, 2006, p. 2).

Building upon the theoretical insights of Minsky's (1992) Financial Instability Hypothesis and Scherbina's (2013) analysis of speculative bubble dynamics, Kartal (2024) provides a general framework for understanding speculative bubble formation. Adapting this framework to exchange rate markets, this study identifies four fundamental mechanisms that drive speculative currency bubbles, offering a structured approach to analysing how psychological biases, market inefficiencies, external shocks, and theoretical modelling contribute to speculative deviations in exchange rates:

Psychological Factors

- Herding Behaviour: Investors, rather than relying on economic fundamentals, react to the movements of others, collectively amplifying speculative pressures. During periods of uncertainty, such as policy shifts or geopolitical tensions, sudden shifts in sentiment trigger large-scale herd behaviour, leading to self-reinforcing speculative buying. In Türkiye, historical episodes of rapid exchange rate depreciation have shown that both retail and institutional investors often rush into foreign currency assets simultaneously, exacerbating volatility.
- Overconfidence: Some market participants believe they can accurately predict exchange rate movements, assuming that rising trends will persist indefinitely. This leads to excessive speculation, where investors continue to buy foreign currency even when prices deviate significantly from economic fundamentals. Such behaviour was particularly evident in Türkiye during speculative surges, as many investors bet against policy interventions aimed at stabilizing the exchange rate.
- Anchoring Bias: Investors tend to base their exchange rate expectations on past price levels, normalizing sharp increases. When a currency depreciates rapidly, market participants may recalibrate their expectations, assuming that the new higher exchange rate is the 'new normal' rather than a temporary mispricing. This tendency reinforces speculative momentum, as investors continue buying foreign currency in anticipation of further depreciation.

Table 1. The Main Economic Indicators

Series Name	2001	2005	2010	2015	2018	2019	2020	2021	2022	2023
GDP [a, b]	201.8	506.3	777.0	864.3	779.0	761.0	720.3	819.9	907.1	1,000
GDP per capita [a, b]	3.10	7.37	10.62	11.05	9.57	9.22	8.64	9.74	10.67	13.38
Real GDP [a, b]	390.0	525.5	614.2	864.3	989.0	997.1	1,015.6	1,131.8	1,194.4	1,242
Growth (%) [a, b]	-5.75	8.99	8.43	6.08	3.01	0.82	1.86	11.44	5.53	4.00
Exports (X) [c]	31.3	73.5	113.9	151.0	177.2	180.8	169.7	225.2	254.2	255.8
%Change [e]	-42.51	134.4	54.99	32.58	17.34	2.07	-6.18	32.75	12.86	0.63
Imports (M) [c]	41.4	116.8	185.5	213.6	231.2	210.3	219.5	271.4	363.7	361.8
%Change [e]	49.05	182.06	58.90	15.13	8.21	-9.00	4.36	23.65	34.00	-0.53
Balance (X-M) [c]	-10.07	-43.29	-71.66	-62.64	-53.98	-29.51	-49.86	-46.21	-109.5	-106.0
%Change [e]	-	330.14	65.52	-12.59	-13.82	-45.33	68.93	-7.31	137.04	-3.24
%GDP	-4,99	-8,55	-9,22	-7,25	-6,93	-3,88	-6,92	-5,64	-12,08	-10,60
Imp. Cov. by Exp [e]	75.69	62.92	61.38	70.68	76.65	85.97	77.29	82.97	69.88	70.70
Balance of Payments [d]	12.92	-23.20	-14.97	11.83	10.38	-6.32	31.86	-23.33	-12.31	2.03
%GDP	6.41	-4.58	-1.93	1.37	1.33	-0.83	4.42	-2.85	-1.36	0.20
Unemployment	8.37	10.63	10.66	10.24	10.89	13.67	13.11	11.98	10.43	9.90
CPI	31.8	65.9	100.0	146.1	203.5	234.4	263.2	314.8	542.4	889.6
Inflation	54.40	8.18	8.57	7.67	16.33	15.18	12.28	19.60	72.31	64.00
Interest Rate [d]	-	-	6.50	7.50	24.00	12.00	17.00	14.00	9.00	42.50
Real Interest Rate [e]	-	-	-2.07	-0.17	7.67	-3.18	4.72	-5.60	-63.31	-21.50
External debt	112.95	178.26	316.66	399.58	425.78	414.62	429.42	437.51	458.70	-
%Change [e]	32.84	57.82	77.64	26.19	6.56	-2.62	3.57	1.88	4.84	-
%GDP	57.41	35.58	41.10	46.75	55.48	55.42	60.34	54.12	51.11	-
FDI (Net)	-2.86	-8.97	-7.62	-14.17	-8.85	-6.58	-4.45	-6.87	-8.17	-
Exchange [d, *]	1.23	1.35	1.51	2.72	4.82	5.68	7.02	8.90	16.59	23.79
Exchange [d, **]	1.46	1.35	1.52	2.92	5.32	5.85	7.73	13.55	18.67	29.07
Real Exchange [e ***]	0.97	1.29	1.42	2.72	4.68	5.17	6.97	11.86	11.70	18.28
Real Effec Exchange [d]	89.64	119.43	120.17	98.98	76.27	76.00	61.88	47.61	54.88	55.33

Notes: : FDI: Foreign direct investment; %Change: shows the % change of the relevant value compared to the previous year; Imp.Cov.byExp: proportion of imports covered by exports (X/M); * annual average dollar exchange rate; **annual closing dollar exchange rate as of December 31st.; ***calculated by the author based on the year-end closing rate.

Source: [a] World Bank (2024); [b] 2023 data are IMF (2024) estimates.; [c] UN Comtrade Database (2024); [d] Central Bank of the Republic of Türkiye (2020); [e] calculated by the author based on the data in the table.

Market Inefficiencies

- Limited Short-Selling and Market Constraints: In many emerging markets like Türkiye, short-selling mechanisms in the foreign exchange market are either weak or actively restricted. Unlike stock markets, where short positions can counteract speculative excesses, limited short-selling in FX markets allows price distortions to persist longer. Additionally, regulatory interventions such as capital controls, foreign exchange transaction limits, or liquidity restrictions can inadvertently fuel speculation by distorting price discovery mechanisms. In Türkiye, restrictions on offshore swap transactions and sudden regulatory changes have historically created conditions where speculative actors dominate market pricing.
- Information Asymmetries: Unequal access to information regarding central bank interventions, monetary policies, and foreign exchange reserves fosters uncertainty and speculation. Large institutional investors may have superior insights into market dynamics, while retail investors operate with limited data, leading to mispricing and speculative surges.
- Market Frictions: Liquidity constraints, high transaction costs, and abrupt policy shifts distort market dynamics, causing price momentum to accelerate. For instance, when a central bank intervenes in currency markets without clear forward guidance, it can unintentionally signal distress, prompting further speculative demand for foreign currency.

External Shocks and Macroeconomic Factors

- Monetary and Fiscal Policy Interactions: Low interest rates, coupled with geopolitical crises, can lead to capital outflows, increasing speculative demand for foreign currency and exacerbating depreciation pressures. In Türkiye, aggressive rate cuts in an environment of rising global interest rates intensified speculative currency demand, reinforcing exchange rate misalignments.
- Global Economic Conditions: External shocks such as Federal Reserve rate hikes, global recession risks, and capital flight from emerging markets can heighten speculative pressures. When major global financial events coincide with domestic vulnerabilities, speculative attacks on local currencies become more intense.
- Geopolitical Uncertainty: Diplomatic crises, sanctions, and regional conflicts often heighten risk perceptions, leading to self-fulfilling speculative runs on the currency. In Türkiye, past exchange rate volatility has frequently been linked to periods of heightened geopolitical uncertainty, triggering capital flight and speculative hoarding of foreign currency.

Theoretical Perspectives on Speculative Bubbles

- Rational Bubble Models: Investors, anticipating future exchange rate increases, may drive up currency demand despite the lack of economic justification. This self-reinforcing speculation creates a scenario where market participants knowingly engage in overvaluation, assuming they can exit before the bubble bursts.
- Behavioural Finance Models: Psychological biases such as overconfidence, herd behaviour, and loss aversion lead to irrational speculative surges, where investors continue buying foreign currency even when market fundamentals do not support such moves.
- Fundamental Value Models: When exchange rates deviate significantly from their underlying economic fundamentals, speculative feedback loops push valuations to unsustainable levels, fostering currency bubbles. In Türkiye, such misalignments have historically coincided with periods of aggressive monetary easing, external funding pressures, and regulatory uncertainty.
- These mechanisms provide a structured framework for understanding speculative exchange rate bubbles, offering critical insights into the forces driving currency mispricing in Türkiye. In the subsequent empirical analysis, this framework will be applied to assess speculative surges and their underlying drivers, shedding light on the mechanisms contributing to bubble formation in the foreign exchange market.

In analyzing the surge in the exchange rate and determining if it reflects a speculative bubble, it is crucial to connect economic indicators directly to exchange rate dynamics. This includes understanding the mechanism of currency bubble formation, which often initiates a disruption in one of the determinants of the exchange rate, such as inflation or interest rates. For instance, the sharp rise in inflation observed post-2021could contribute to nominal and real exchange rate increases, indicating a direct

impact on currency values. Similarly, negative real interest rates can incentivize capital outflows, leading to currency depreciation and heightened exchange rate fluctuations, especially during economic uncertainty. Furthermore, the discussions on various economic indicators, such as trade balances and external debt levels, serve as additional drivers to influence the exchange rate significantly. These indicators are crucial in shaping market sentiments and investor behaviors, contributing to the speculative dynamics observed in the foreign exchange market. The mechanism of currency bubble formation highlights how market reactions can fuel speculative attacks, amplifying what would have been a manageable increase in the exchange rate into a more severe bubble formation. The mechanism of currency bubble formation often initiates a disruption in one of the determinants of the exchange rate, leading to an initial increase in the exchange rate. Subsequently, market reactions fuel speculative attacks, amplifying what would have been a manageable increase in the exchange rate into a more severe bubble formation. This is particularly evident during economic disruptions or geopolitical tensions, where sudden political instabilities can trigger a rapid exodus of global funds, exacerbating the demand for foreign currency in the economy and unveiling a currency crisis.

Moreover, examining the trade balances represented by exports and imports provides insights into the overall balance of payments and its influence on the exchange rate. Persistent trade deficits and increasing external debt levels can impact investor sentiment, prompting capital movements that affect currency values. While relatively stable, the proportion of external debt to GDP remains a point of consideration for currency stability and investor confidence. High levels of external debt can pose risks to currency resilience, requiring prudent fiscal management and monitoring to mitigate potential exchange rate volatility. In this context, some macroeconomic indicators regarding the Türkiye Economy are given in Table 1.

Table 1 provides a comprehensive overview of Türkiye's leading economic indicators over the years. These indicators play a crucial role in understanding the exchange rate dynamics, especially concerning factors like inflation, interest rates, trade balances, and foreign direct investments. One notable observation from the data is the significant increase in inflation, particularly post-2021, which has implications for the exchange rate. A sharp rise in inflation can contribute to both nominal and real exchange rate increases. In a scenario where inflation was the sole determinant of exchange rates, substantial changes in the real exchange rate would not be anticipated. Nevertheless, the data suggests that both nominal and real exchange rates have experienced significant appreciation, implying the presence of additional factors beyond inflation.

Moreover, a closer look at the trade balances, indicated by the Exports (X) and Imports (M) columns, provides crucial insights. The trade deficit, indicated by the negative values in the Balance (X-M) column, has fluctuated over the years, impacting the overall balance of payments and subsequently influencing the exchange rate. However, it is noteworthy that while the trade deficit has been consistently negative, its share in GDP (%GDP) has varied between 4% to 10%. This variation suggests that while the absolute trade deficit figures may be substantial, their relative impact on the economy has shown some degree of stability within a certain range.

Another important factor to consider is the potential influence of negative real interest rates on exchange rate dynamics. Negative interest rates can incentivize investors to seek higher returns elsewhere, including foreign currencies, thereby putting downward pressure on the local currency. This phenomenon can exacerbate exchange rate fluctuations, particularly during periods of economic uncertainty. In addition, negative interest rates can incentivize capital outflows, leading to a depreciation of the currency.

Furthermore, Table 1 data underscores a notable rise in Türkiye's external debt throughout the years, indicating potential implications for the country's economy and exchange rate dynamics. However, it's essential to note that while external debt levels have risen notably, the proportion of total external debt to GDP has not shown a significant change. This observation suggests a relatively stable relationship between Türkiye's external debt burden and its economic output, at least regarding their proportional impact on the economy. A consistent or slightly changing share of external debt to GDP indicates that despite the increasing debt levels, Türkiye's economy has also been expanding, potentially mitigating concerns about the debt burden's immediate impact on currency stability. Nevertheless, the absolute increase in external debt remains a point of consideration for policymakers and investors. High levels of external debt can still pose risks to currency stability and investor confidence, especially if not managed effectively. Concerns about the sustainability of debt repayment and the country's ability to service its obligations can lead to fluctuations in the exchange rate as investors assess the economic risk. Therefore, while the proportional share of external debt to GDP may not have changed significantly, the absolute increase in external debt warrants ongoing monitoring

and prudent fiscal management to ensure long-term economic stability and currency resilience.

Moreover, the sharp increase in inflation, negative real interest rates, and rising external debt likely contributed to upward pressure on the exchange rate. Furthermore, persistent trade deficits and a relatively elevated external debt may have influenced investor sentiment, prompting capital outflows and currency depreciation. Nevertheless, it is crucial to acknowledge that speculative movements, driven by market sentiment and expectations, can magnify exchange rate fluctuations beyond what can be solely explained by fundamental economic factors. Speculative activities, especially during periods of heightened volatility, can lead to rapid and exaggerated movements in the exchange rate, potentially creating a bubble-like scenario.

Considering these factors, it becomes apparent that the sharp increase in the exchange rate, particularly in the latter months of 2021, even partially, can be attributed to variables such as inflation, interest rates, foreign trade deficits, external debt levels, and other macroeconomic indicators. However, this surge in the exchange rate has garnered significant attention and debate, with some arguing that it cannot be fully rationalized by real economic factors alone. Accordingly, it is noteworthy that following the sharp increase in the exchange rate, the announcement on December 20, 2021, regarding the Foreign Exchange-Protected Turkish Lira Deposit (where the Treasury pledged to cover the difference if the return on TL-denominated accounts falls below the exchange rate), led to a drastic drop in the dollar rate from 18 TL to 12 TL overnight. This event serves as a crucial indicator of market dynamics and speculative influences. In this context, this situation was seen by many as evidence that there were no real macroeconomic reasons behind the sharp rise in the exchange rate. Therefore, while macroeconomic variables provide a foundational understanding of exchange rate movements, the presence of speculative elements and market dynamics cannot be overlooked in explaining the sharp increase in the exchange rate observed in late 2021. A comprehensive analysis that considers both fundamental economic drivers and speculative influences is necessary to grasp the complexities of exchange rate dynamics in Türkiye fully. Therefore, it is essential to delve deeper into whether this entire surge in the exchange rate stems solely from these macroeconomic variables or if speculative activities have also contributed, leading to artificial factors such as a bubble formation in the exchange rate. That is, validating or refuting the presence of a speculative bubble during this period holds significant implications for understanding exchange rate dynamics and market behavior in Türkiye. This study is specifically designed to address these critical aspects. In this regard, the primary objective of this study is to investigate whether the exchange rate appreciation observed after 2021 is driven by speculative activity, that is, a bubble formation.

This study is expected to make significant contributions to the existing literature on exchange rate dynamics, especially during periods of rapid volatility and potential speculative activities. Utilizing robust methodologies like the GSADF and BSADF methods, the research aims to unveil a comprehensive analysis of exchange rate movements, revealing the complex interplay between fundamental economic drivers and speculative influences. The anticipated outcomes of this study include not only a deeper understanding of exchange rate dynamics in Türkiye but also valuable insights for policymakers, investors, and researchers addressing similar challenges in other economies. In the following sections of this study created in this direction, firstly a literature review on the exchange rate bubble is be performed, and the added value of this study compared to other studies is be revealed. In subsequent sections, after introducing the GSADF and BSADF methods used to detect bubble formation in the study, then the results are evaluated by reporting the results obtained from the empirical application.

LITERATURE REVIEW

Exchange rate dynamics are a central factor in shaping macroeconomic stability, particularly in emerging markets like Türkiye. In particular, the impact of exchange rate increases on inflation stands out as a critical issue in foreign-dependent economies such as Türkiye. In this context, İlhan et al. (2022) and Akdeniz et al. (2022) emphasize that Türkiye's high dependence on imported inputs amplifies the cost-push inflation triggered by exchange rate increases. İlhan et al. (2023) note that the exchange rate pass-through (ERPT) to consumer prices surged significantly during sharp currency depreciations, particularly after structural problems and inconsistent monetary policies began to undermine the credibility of inflation-targeting frameworks. These inflationary effects were further exacerbated by external shocks, such as fluctuations in global risk sentiment and commodity prices, creating additional challenges for policymakers. Beyond inflationary pressures, exchange rate volatility has broader economic repercussions. Helmi et al. (2023) underline the destabilizing effects of currency fluctuations on trade balances, capital flows,

Table 2. Literature Review

Autor(s)	Exchange Rate	Periods	Methods	Results
Wu (1995)	USD and GBP JPY, and DEM	1974:1-1988:12	Kalman filter	There are no exchange rate bubbles.
Norden (1996)	JPY, DEM, and CAD	1977:09 to 1991:10	A new test developed by Norden (1996)	There are no exchange rate bubbles in many cases.
Elwood et al. (1999)	JPY and DEM	1984:12-1998:11	State-space models	Substantial a evidence supports the existence of a stochastic rational bubble, estimated to have collapsed between the end of March and the end of April 1990.
Chan et al. (2003)	Germany, Hungary, and Poland	during the interwar	Extended Durlauf–Hooker approach	No evidence of price or exchange rate bubbles was found in the three countries under investigation.
Jirasakuldech et al. (2006)	USD and GBP, CAD, DKK, JPY, and ZAR	1989:01-2004:12	GSADF	There are no exchange rate bubbles.
Bettendorf and Chen (2013)	GBP/USD	1972:1-2012:6	SADF and GSADF	There is evidence of exchange rate bubbles.
Jiang et al. (2015)	RMB/USD	1995:7-2013:10	GSADF	No evidence of bubbles was detected prior to 2005, during the fixed exchange rate regime. However, strong evidence of bubbles has been found since 2006.
Rasekhi et al. (2016)	Iran's four main asset markets, including the exchange rate	2002:03-2015:06	Sigma-Point Kalman Filter	there are bubbles spillover among asset markets.
Hu and Oxley (2017)	Some G10, Asian, and BRICS Countries	1991:03-2014:10	GSADF	While the 1994-1995 Mexican currency crisis led to a bubble in the US Dollar-Mexican Peso exchange rate, no such evidence exists for G10 countries.
Maldonado et al. (2018)	BRICS countries' currency relative to USD	1999:03 to 2013:06	Models proposed by Maldonado et al. (2012)	There are speculative exchange rate bubbles, and the bubbles are detected to be cointegrated.
Yildirim et al. (2022)	USD/BRL, USD/RUB, USD/INR, USD/CNY, USD/ZAR, USD/TRY	2002:01 - 2019:08	SADF and GSADF	Price bubbles were detected in all currencies except USD/INR, with speculative movements in exchange rates causing potential problems for national economies.
Özdemir (2021)	EUR/USD	02.12.2019-04.12.2020	SADF and GSADF	There are exchange rate explosive bubbles.
Özdemir (2022)	USD/TRY, GBP/TRY, EUR/TRY, CNY/TRY, RUB/TRY	January 2, 2015, to November 15, 2019, and; November 18, 2019, to February 12, 2021	SADF and GSADF	There is significant bubble activity in all five exchange rates, especially during the COVID-19 period, indicating more inefficiency in forex markets during this time.
Ural (2021)	USD/KZT	23.08.2015-04.04.2021	GSADF	There are two explosive bubbles in 2018 and 2020.
Maldonado et al. (2021)	BRICS countries' currency relative to USD	1999.03-2017.10 for BIS and 2005.07-2017.12 for CR	GSADF, RTADF, Evans, and Froot and Obstfeld	Countries outside China have observed at least one of four distinct bubble types: single explosive, multiple periodically collapsing, periodically collapsing, and intrinsic.

Autor(s)	Exchange Rate	Periods	Methods	Results
Deviren et al. (2014)	TRY/USD, TRY/EUR, TRY/JPY, and TRY/CHF	01.01.2005-20.12.2013	Watanabe et al. (2007)	Multiple instances of bubble formation have been identified. Moreover, the duration of collapses in the TRY/CHF rate is generally shorter. In contrast, the duration of collapses in the TRY/EUR rate is generally longer than in other exchange rates.
Korkmaz et al. (2016)	TRY/USD, TRY/Euro	2002:1-2016:5	SADF and GSADF	Despite detecting a bubble formation in the dollar exchange rate during the specified period, empirical analysis suggests that this bubble had no significant impact on the performance of the BIST-100 index.
Korkmaz (2018)	Euro/TRY, USD/TRY	01.08.2011-23.03.2018	SADF and GSADF	Euro/TRY bubbles: 10.05-15.07.2013, 05.08-28.10.2013, 13.12-14.03.2013. USD/TRY bubbles: 12.08.-03.09.2013, 30.12.2013-18.02.2014, 4.03-13.03.2015, 14.04-20.05.2015, 10.06-16.06.2015, 19.08-19.10.2015, 26.12.2016-09.02.2017.
Afşar et al. (2019)	USD/TRY and EURO/TRY	2005:01 to 2018:11	GSDF	USD/TRY experienced bubble periods in the last quarter of 2008, early 2014, the last quarter of 2015, and from the last quarter of 2016 to mid-2017. Similarly, EUR/TRY exhibited bubble periods during May-October 2011, mid-2012, the third quarter of 2013 to early 2014, and from the end of 2017 to the fourth quarter of 2018.
Gülcan et al. (2021)	03.01.2005 and 20.11.2019 for the USD/TRY, EUR/TRY, GBP/TRY, and CNY/TRY, and 28.08.2013-20.11.2019 period for JPY/TRY		GSADF and SADF	Empirical evidence suggests the formation of financial bubbles within Türkiye's foreign exchange market.
Gök (2021)	USD/TRY	2005 and 2021	GSADF and BSADF	There is evidence of two long bubble periods (02.2015–03.2016 and 09.2016–06.2021) and six short bubble periods (05.2006–07.2006, 08.2011 covering 5 weeks, 08.2013 covering 3 weeks, 01.2014 covering 7 weeks, 05.2016 covering 8 weeks, and 07.2016 covering 4 weeks).

Source: Author.

and investment decisions, particularly in economies with structural vulnerabilities. The study reveals that during periods of heightened uncertainty, such as the COVID-19 pandemic, exchange rate shocks contributed to elevated market volatility, disrupting financial stability and creating spillover effects across global markets. İlhan et al. (2022) further observe that speculative dynamics driven by high exchange market pressure (EMP) intensified currency depreciation, highlighting the interplay between external shocks and domestic vulnerabilities. Moreover, empirical findings from these studies offer critical insights. İlhan et al. (2022) and Helmi et al. (2023) demonstrate that the effects of exchange rate volatility are dynamic and evolve over time, reflecting shifts in global conditions and policy responses. For instance, Türkiye's ERPT surged during specific shocks, such as the May 2006 exchange rate crisis, with İlhan et al. (2023) documenting pass-through rates exceeding 15%. These findings underscore the need for adaptive and consistent monetary policies, alongside structural reforms, to mitigate the inflationary and destabilizing effects of exchange rate volatility effectively. Such measures are essential to enhance macroeconomic stability and resilience against external and internal shocks.

On the other hand, although exchange rate increases have important macroeconomic effects on inflation, trade balance, capital flows, and investment decisions, this study focuses on speculative bubble formations, which refer to unrealistic increases in exchange rate markets, and the dynamics of this bubble formation, rather than on these macroeconomic effects. In this context, numerous studies have focused on various types of speculative bubbles in the empirical literature, especially stock market bubbles, asset market bubbles (real estate bubbles, exchange rate, cryptocurrency markets, etc.), credit bubbles, and commodity bubbles (oil prices, precious metals, agricultural crops, etc.). While most empirical studies on bubble formation tend to focus on stock and real estate markets, fewer have examined speculative bubbles in currency markets, including the Turkish Lira. Table 2 presents a curated selection of studies that have contributed significantly to the discourse on exchange rate bubbles. These studies are included based on their methodological rigor, relevance to the Turkish exchange rate context, and their novel insights into bubble detection and analysis. When the relevant literature is examined, it is seen that many different empirical methods are used to detect bubble formation. However, following the introduction of the GSADF and BSADF methods by by Phillips et al. (2015) and Phillips et al. (2011), these techniques have become the primary tools for detecting speculative bubbles in exchange rate markets. In this context, this study extends their application to the Turkish Lira, offering a novel perspective on bubble formation in the context of Türkiye's recent currency fluctuations. Moreover, while the BSADF curve is primarily utilized to detect speculative bubbles in asset pricing, this study proposes an additional interpretation. Specifically, in examining exchange rates, while not a definitive measure, the BSADF curve may serve as an indicative benchmark for the 'fair price' of the currency. This perspective suggests that observed exchange rates aligning with the BSADF curve could reflect the currency's inherent value, with deviations potentially indicating overvaluation or undervaluation. Extending this concept, similar applications could inform pricing insights in other asset markets, such as equities or real estate, where the BSADF curve could signify the degree of divergence from an implied fair value.

When empirical studies on Türkiye are examined, nominal exchange rates are used as the exchange rate variable in most studies. However, the use of the nominal exchange rate in empirical analyses of exchange rate bubbles may lead to the mistaken identification of exchange rate increases driven primarily by inflationary pressures as speculative bubbles, potentially resulting in inaccurate conclusions about exchange rate market efficiency and stability. Actually, a significant increase in the exchange rate that outpaces the rate of inflation can be interpreted as a sign of a potential bubble, suggesting that market expectations and sentiment may be driving the exchange rate to levels that are not justified by underlying economic fundamentals. Consequently, using the nominal exchange rate in empirical analyses of exchange rate bubbles may lead to identifying a larger number of bubbles than may actually exist, potentially overstating the extent of speculative activity in the foreign exchange market. On the other hand, while existing studies have primarily analyzed the behavior of a few specific currencies, such as the Dollar and the Euro, there is a lack of research exploring the dynamics of the effective exchange rate, which provides a more comprehensive measure of the overall value of the Turkish Lira relative to the currencies of Türkiye's significant trading partners. Additionally, while existing studies on Türkiye's exchange rate dynamics have focused on various periods, none have specifically addressed the potential speculative bubbles during the significant exchange rate movements in the final quarter of 2021. This study aims to fill this gap by applying advanced bubble detection methods to the Turkish Lira during this period, thereby contributing to a more nuanced understanding of exchange rate volatility in Türkiye.

DATA and METHODOLOGY

The study delves into an examination of the potential bubble within the foreign exchange market from February 2001 to September 2024, encompassing the notable surge in exchange rates witnessed in late 2021. A pivotal aspect of the methodology lies in the deliberate choice of the effective real exchange rate, which shows the weighted average value of the Turkish lira obtained from the CBRT (The Central Bank of the Republic of Türkiye), as the primary variable. This decision is not arbitrary but is based on a meticulous consideration of the intricacies inherent in exchange rate dynamics. Had the nominal exchange rate variable been chosen, the influence of inflation-driven fluctuations in exchange rates could have been inadvertently magnified. Such inflation-induced spikes could have falsely contributed to the perception of bubble formation, even during periods devoid of actual bubbles. This would have led to erroneous conclusions, suggesting bubble formation even in non-bubble periods. The effective real exchange rate variable has been judiciously selected to circumvent these pitfalls and ensure precision in the analysis. This

Table 3. The Generalized Sup ADF and Backwards Sup ADF Test Results

GSADF Statistics	Bubbles Periods obtained from the BSADF Sequence
2,959***	**First Bubbles Period** May 2018-October 2018
	Second Bubbles Period September 2020-November 2020
	Third Bubbles Period November 2021-March 2022

Note: The symbols ***, **, and * indicate bubble formation at the 1%, 5%, and 10% significance levels, respectively. The critical values for the GSADF statistic are 1.909, 2.135, and 2.792, corresponding to the 1%, 5%, and 10% significance levels, respectively. Critical values have been obtained with a 2000 replicate Monte Carlo simulation for 284 observations, with a minimum estimation window size of 32 months.

choice is underpinned by the recognition that non-real increases, particularly those fueled by inflation, can artificially inflate the perception of bubbles. By focusing on the real effective exchange rate, a clear lens is maintained on genuine exchange rate movements, untainted by inflationary distortions, thus enhancing the accuracy and reliability of the findings. The study employed the recursive and right-tailed unit root tests proposed by Phillips et al. (2015) as the empirical method for bubble detection. These tests are widely recognized and utilized in the literature to identify potential bubbles within financial markets.

The GSADF test, a generalized form of the SADF test proposed by Phillips et al. (2011), is utilized in this study. Phillips et al. (2011) propose an empirical model (namely SADF: The Supremum Augmented Dickey-Fuller) that uses recursive regression and right-tailed unit root tests to test for bubbles at stock prices on the US Nasdaq stock market. Unlike left-tailed unit root tests, such tests often focus on the alternative hypothesis (rather than the unit root hypothesis) due to the concern for possible deviations from fundamentals and market excesses or mispricing (Phillips et al., 2015, p. 1047). The SADF test starts with estimating equation (1) by using the least-squares method (Phillips et al., 2011, p. 206):

$$x_t = \mu_x + \delta x_{t-1} + \sum_{j=1}^{j} \phi_j \Delta x_{t-j} + \varepsilon_{x,t},\ \varepsilon_{x,t} \sim NID(0, \sigma_x^2) \quad (1)$$

Here, j represents the lag parameter, and NID denotes an independent and normally distributed error term. While the unit root null hypothesis is H_0: $\delta=1$, the right-tailed alternative hypothesis is H_1: $\delta > 1$. The SADF test is based on the repeated prediction of the ADF model on a forward-expanding set of samples, and the test is obtained as the sup value corresponding to the ADF test sequence (Phillips et al., 2011, p. 207):

$$ADF_r \Rightarrow \frac{\int_0^r \tilde{w} dw}{\left(\int_0^r \tilde{w}^2\right)^{1/2}},\ \text{and}\ \sup_{r\in[r_0,1]} ADF_r \Rightarrow \sup_{r\in[r_0,1]} \frac{\int_0^r \tilde{w} dw}{\left(\int_0^r \tilde{w}^2\right)^{1/2}} \quad (2)$$

Here, w is the standard Brownian motion, also known as the Wiener Method. In this case, the window size r_w expands from r_0 to 1. The parameter r_0 denotes the smallest window width fraction used to initiate the test statistic calculation, while 1 represents the largest window fraction, corresponding to the total sample size. The parameter $r1$, which denotes the starting point of the array, is fixed to 0. Thus, the endpoint of each sample (r_2) is equal to r_w, it changes from $r0$ to 1. ADF statistic is indicated by the statistic for a sample running from 0 to r_2. Accordingly, the SADF test, a sup statistic derived from forward recursive regression, is formally defined as (Phillips et al., 2015, p. 1048):

$$SADF_{(r_0)} = \sup_{r_2\in[r_0,1]} ADF_0^{r_2} \quad (3)$$

Phillips et al. (2011), following the SADF test developed by Phillips et al. (2015) proposed a new recursive test procedure (GSADF: The Generalized Supremum Augmented Dickey-Fuller) and dating algorithm (BSADF: Backwards Supremum Augmented Dickey-Fuller) used to detect multiple bubbles. The GSADF test developed here is constructed recursively on sub-samples of the data, much more comprehensively than the SADF test, based on repeated ADF test regressions in Equation (4) (Phillips et al., 2015, pp. 1047–1048):

$$\Delta y_t = \hat{a}_{r_1,r_2} + \hat{\beta}_{r_1,r_2} y_{t-1} + \sum_{i=1}^{k} \hat{\psi}^i_{r_1,r_2} \Delta y_{t-i} + \hat{\varepsilon}_t \quad (4)$$

Besides adjusting the endpoint of the r_2 regression from r_0 (the minimum window width) to 1, the GSADF test permits the starting point $r1$ in Equation (4) to vary within an appropriate range (from 0 up to r_2-r_0, in contrast to the SADF test). Consequently, the GSADF

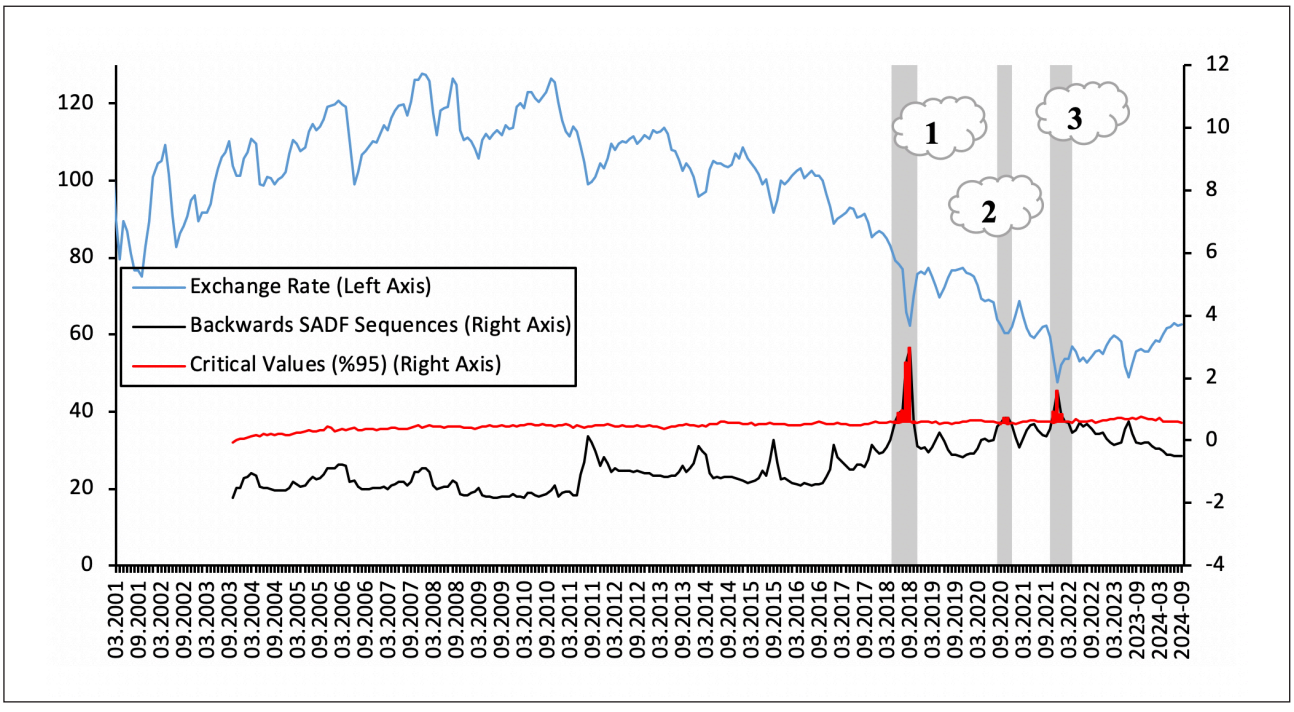

Figure 1. Periods of Bubbles in the Türkiye Exchange Rate Market

statistic is defined as the largest ADF statistic obtained from this double recursion across all feasible r_1 and r_2 ranges, and it is represented as GSADF(r_0). The GSADF statistic is formally defined in Equation (5) (Phillips et al., 2015, pp. 1048–1049):

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0, 1] \\ \eta \in [0, r_2 - r_0]}} \left\{ \frac{\frac{1}{2} r_w \left[W(r_2)^2 - W(r_1)^2 - r_w \right] - \int_{r_1}^{r_2} W(r) dr \left[W(r_2) - W(r_1) \right]}{r_w^{1/2} \left\{ r_w \int_{r_1}^{r_2} W(r)^2 dr - \left[\int_{r_1}^{r_2} W(r) dr \right]^2 \right\}^{1/2}} \right\} \quad (5)$$

Also, the GSADF statistic is simply defined in Equation (6) as follows (Phillips et al., 2015: 1049):

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0, 1] \\ r1 \in [0, r_2 - r_0]}} ADF_{r_1}^{r_2} \quad (6)$$

In this context, in contrast to the SADF test (Phillips et al., 2011), the GSADF test (Phillips et al., 2015) identifies multiple bubble episodes by allowing the window size to vary from 0 to $r_2 - r_0$. In this respect, this test provides a great advantage (Phillips et al., 2015, p. 1048).

To identify bubble start and end dates, Phillips et al. (2015) introduce the Backwards Sup ADF (BSADF) sequence immediately following the calculation of the GSADF test statistic. The Backwards Sup ADF (BSADF) test is a sup ADF test conducted on an expanding sample set. The endpoint of each sample is fixed at the fraction r_2 of the total sample size, while the starting point of the sample is allowed to vary from 0 to r_2-r_0, corresponding to the formation of the window (Phillips et al., 2015, p. 1051).

$$BSADF_{r2}(r_0) = \sup_{r_2 \in [0, r_2 - r_0]} \left\{ ADF_{r_1}^{r_2} \right\} \quad (7)$$

The point where the BSADF sequence first cuts the critical value is the point the bubble formation starts. Points in the BSADF sequence that exceed the critical value indicate bubble zones. Finally, the bubble is considered to have ended at the endpoint where the BSADF sequence falls below the critical value. This endpoint indicates a return to more rational market behavior. In this context, the BSADF curve could also be interpreted as a benchmark for identifying the currency's 'implied fair value.' While not a definitive representation of the fair price, the BSADF curve provides a reference against which the exchange rate's proximity can suggest its relative valuation status. Such an interpretation enriches the bubble detection framework, allowing for the BSADF curve to indicate whether observed exchange rate levels align with fundamental economic factors.

EMPIRICAL FINDINGS

The study delved into the intricate dynamics of Türkiye's foreign exchange market spanning from February 2001 to September 2024. Initially, the Generalized Sup Augmented Dickey-Fuller (GSADF) test unveiled potential bubble formations within this extensive period. Remarkably, the findings illuminated bubble formations in Türkiye's foreign exchange market during this timeframe. Following identifying these bubbles, the Backwards Sup Augmented Dickey-Fuller (BSADF) test was subsequently administered to pinpoint the exact periods of bubble formations, and its corresponding critical values were derived. These pivotal insights from both the GSADF and BSADF tests are meticulously presented in Table 3, encapsulating the nuanced dynamics of bubble formations within Türkiye's foreign exchange landscape.

The empirical analysis spans 284 months; however, due to the minimum window width, the calculation of the BSADF Sequence initiated in July 2003. During the specified periods, the observed exchange rates closely tracked the BSADF curve; in a sense indicating that the currency's valuation was near its theoretical 'fair value'. Periods where significant deviations occur may indicate speculative pressures or mispricing. This finding supports the notion that the BSADF curve can serve as a valuable indicator of the exchange rate's fair valuation, providing insights into when the currency aligns or strays from its economically justified level. Based on the BSADF test outcomes, bubble formations have been identified in the exchange rate market during three distinct periods: May 2018 to October 2018, September 2020 to November 2020, and November 2021 to March 2022. Notably, the longest period of bubble formation is observed from May 2018 to October 2018, encompassing a duration of 6 months. This suggests a more pronounced bubble formation in 2018 than in 2022. The identified bubble formation periods are visually represented in Figure 1, where the left axis showing the "Exchange Rate," the right axis displaying "Backwards SADF Sequences" and "Critical Values (%95)," and the bubble periods shaded in grey for better clarity.

Interpretation of the underlying causes of the first bubble formation is important to consider the events and policy implementations that may have influenced the exchange rate movements during this period. In the first bubble period, it is notable that a crisis involving the threat of sanctions with the USA coincided with the case of Priest Andrew Brunson, who faced accusations of espionage and was sentenced to house arrest. This event potentially played a significant role in the exchange rate dynamics. Donald Trump's remarks during his October 7, 2019, press briefing provide compelling evidence of the critical role geopolitical tensions played in shaping exchange rate movements during this period. Referring to the Brunson case, Trump stated: "*They could suffer the wrath of an extremely decimated economy, and I've done it once. I did it with Pastor Brunson. You remember the Pastor Brunson? And they wouldn't give Pastor Brunson back, and they ended up giving Pastor Brunson back pretty quickly. The currency fell at record levels, and lots of other things happened.*" (For the full video of this press briefing, see Euronews, 2019). These remarks underline the direct correlation between political actions and their economic consequences, particularly in the context of the sanctions imposed by the United States. During the escalation of the crisis, the Turkish lira faced unprecedented speculative pressures, amplifying the depreciation in its value. The sanctions and the accompanying rhetoric, as exemplified by Trump's statements, not only heightened market uncertainty but also served as a catalyst for speculative behavior, further exacerbating the volatility in the exchange rate. These events provide a clear example of how external political pressures can trigger significant market reactions, contributing to the formation of financial bubbles. For instance, the dollar exchange rate, which stood at 4.05 TRY at the beginning of this period, rapidly increased, peaking at over 7.20 TRY in international markets on August 12, 2018 (In this context, see the news article Euronews, 2018). The tensions eased after Brunson's release in October 2018, leading to a regression in the dollar exchange rate above the 5 TRY level, with the year-end rate settling at 5.29 TRY. The convergence of geopolitical tensions, particularly those involving the USA and Türkiye during the Brunson incident, alongside market reactions and investor sentiment, suggests a possible connection to the bubble observed during this period. These events underscore the intricate relationship between political developments, policy responses, and exchange rate movements, highlighting the complexities of identifying and analyzing bubble formations in currency markets. It is worth emphasizing that while these observations may not conclusively prove causation, they provide substantial context and potential explanations for the observed exchange rate dynamics. Furthermore, the analysis supports that speculative factor, rather than purely economic indicators, played a significant role in driving exchange rate fluctuations during the identified bubble periods. This study's identification of these

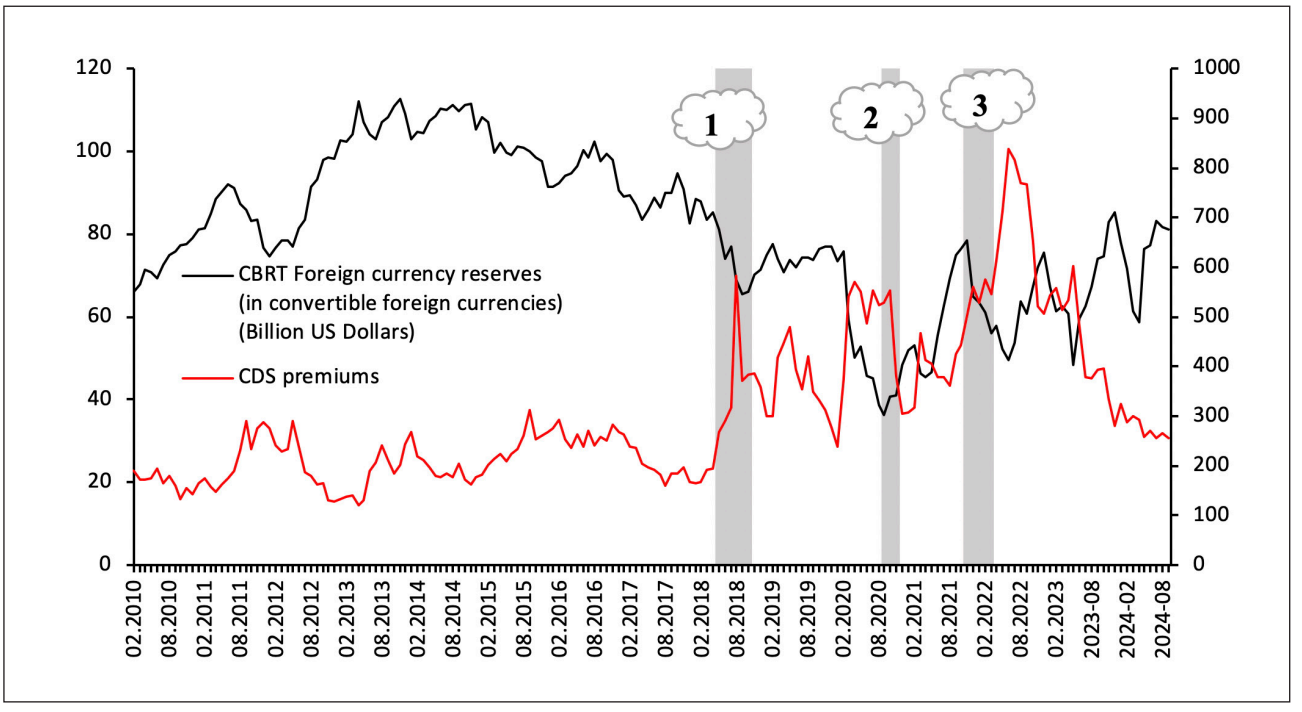

Figure 2. Reactions of CDS Premiums and Central Bank Currency Reserves During Exchange Rate Bubble Formation Periods

Source: CDS Premiums data were obtained from Investing.com, while CBRT Currency Reserves data were sourced from the Central Bank of the Republic of Türkiye (CBRT) EVDS Data Central.

bubble periods provides valuable insights into the dynamics of exchange rate movements, emphasizing the importance of considering non-traditional drivers such as geopolitical tensions and market sentiment in understanding currency market behaviors. By acknowledging these speculative influences, this study contributes to a more comprehensive understanding of the factors influencing exchange rate dynamics and the potential impact of speculative activities on currency markets.

Upon closer examination of the second bubble period spanning from September 2020 to November 2020, it becomes evident that a relatively minor and short-lived bubble formation occurred during this time frame. This period coincided with the global economic challenges posed by the Covid-19 pandemic. The initial six months of 2021, preceding the bubble formation, witnessed a significant both global and national trade slowdown, with many factories and workplaces halting operations. This economic contraction was not unique to Türkiye but was a global phenomenon affecting economies worldwide. Despite the initial economic downturn, various measures were implemented to stabilize and support the economy. Government interventions and public support initiatives, coupled with normalization efforts starting from the end of June, aimed to mitigate the impact of the pandemic on economic activities. However, despite these efforts, the dollar exchange rate, which stood at 5.96 TRY at the beginning of the year, surged to 7.35 TRY in September 2020, when the bubble formation commenced. The escalation of the dollar rate, peaking around the 8.50 levels towards the end of the detected bubble in November 2020, reflected the speculative pressures and uncertainties prevailing in the foreign exchange market. Subsequently, following the conclusion of the bubble formation period, the dollar rate gradually declined to 7.36 TRY. This fluctuation underscores the influence of speculative factors and market sentiment on exchange rate dynamics, particularly during periods of economic uncertainty and crisis such as the Covid-19 pandemic.

Finally, the empirical analysis reveals a particularly notable discovery regarding the presence of a bubble in Türkiye's exchange rate market during the latter months of 2021, coinciding with a sharp upward trend in exchange rates. This result is also the most striking result of the empirical analysis. The study's findings specifically for this period align with claims that at least some of the sharp increase in the exchange rate doesn't align with macroeconomic indicators. The subsequent sharp decline in the exchange rate following the announcement of the Foreign Exchange-Protected Turkish Lira Deposit further underscores this observation. It can be argued that while this instrument may not entirely eliminate the bubble, it impedes its

growth or contributes to its decrease. Accordingly, Figure 1 illustrates this bubble formation, which commenced in November 2021, peaked in December 2021, and concluded in March 2022. Examining the bubble period in detail, we observe a significant decline in the effective real exchange rate, from 63.02 in September 2020 to 47.82 by December 2021. Delving into the dollar exchange rate dynamics during this bubble period, we note a remarkable surge. The dollar exchange rate, 8.90 TRY on October 1, 2021, surged to historic highs, surpassing 10 TRY on November 16, 2021, 17 TRY on December 17, 2021, and 18 TRY on December 20, 2021. Subsequently, following the announcement of the Foreign Exchange-Protected Turkish Lira Deposit, introduced to mitigate the depreciation of the TRY from its historical peak, a reversal in trend is observed. As depicted graphically in Figure 1, the BSADF curve starts to trend downward after this intervention. This new policy instrument not only alleviated the excessive demand for foreign currency but also instigated a notable recovery, dispelling concerns of continued exchange rate escalation.

Following the last identified bubble period, it is observed that there has been a visible decrease in exchange rates in Türkiye, particularly after the introduction of the Foreign Exchange-Protected Turkish Lira Deposit as a significant policy measure. This decrease appeared to contribute to the bubble's deflation by March 2022. On the other hand, it's essential to recognize that the exchange rate, which was 14.66 TRY against the dollar in March 2022 (the period when the last bubble formation deflated), rose to 31.22 TRY by February 2024. Although there was a period of relative stability after the Foreign Exchange Protected Turkish Lira Deposit was introduced, the notable rise in the exchange rate stands out. Interestingly, the BSADF curve did not identify a bubble at the 5% significance level during this time, indicating that the factors driving this upward trend are grounded in real circumstances. In this sense, the rise in exchange rates in this period can be attributed to several factors. In this sense, the extensive economic and humanitarian aftermath of the devastating earthquakes on February 6-7, along with the uncertainties surrounding the 2023 Presidential elections, contribute to elucidating the increase in the exchange rate during that period for real economic reasons. The absence of an explosive surge in the exchange rate during the specified periods, unlike the previous period, and the non-conversion of this increase into a bubble can partly be attributed to the reimplementation of orthodox policies, particularly the reintroduction of interest rate hikes, led by Mehmet Şimşek and Cevdet Yılmaz. Similar to how the bubble in 2021 dissipated following the introduction of the foreign exchange-indexed deposit account, it can be posited that this significant shift in economic management represents a crucial policy measure aimed at mitigating potential foreign exchange bubbles. These observations highlight the dynamic nature of exchange rate fluctuations and the various factors influencing market sentiment and currency valuation. However, it's worth mentioning that the BSADF curve indicated the presence of a bubble at a 10% significance level from May 2022 to September 2022 and June 2023 to July 2023. These observations highlight the dynamic nature of exchange rate fluctuations and the various factors influencing market sentiment and currency valuation. In conclusion, despite the absence of a new bubble formation at a 5% significance level following the last identified bubble period, the exchange rate dynamics remain influenced by many economic, political, and social factors. This underscores the complexity of exchange rate movements and the ongoing challenges in maintaining stability in Türkiye's foreign exchange market.

On the other hand, in the graphical analysis of Turkey's CDS premiums (Credit Default Swap Premiums) and foreign exchange reserves during the bubble periods (see Figure 2. Reactions of CDS Premiums and Central Bank Currency Reserves During Exchange Rate Bubble Formation Periods), it is evident that the behaviour of these variables aligns with the formation of exchange rate bubbles identified through the GSADF and BSADF tests. The three bubble periods—May 2018 to October 2018, September 2020 to November 2020, and November 2021 to March 2022—demonstrate notable trends in both the CDS premiums and foreign exchange reserves.

May 2018 – October 2018 Bubble: During this period, Turkey's CDS premiums sharply increased from around 267 to 383, indicating rising investor concerns regarding the country's economic stability. Simultaneously, foreign exchange reserves fell from 81.2 billion USD to 66.2 billion USD, reflecting a depletion in reserves amid the speculative pressures on the currency. These developments align with the identified bubble period, which is visually highlighted in grey in the graph.

September 2020 – November 2020 Bubble: In this phase, there is a notable spike in CDS premiums from 527.96 to 552.24, signifying heightened risk perception by international markets. The reserves also show some fluctuation, though less drastic than in 2018. The bubble formation period is again marked in grey on the graph, illustrating that this was a period of significant speculative activity in the foreign exchange market.

November 2021 – March 2022 Bubble: The period from November 2021 to March 2022 saw another surge in CDS premiums from 500.72 to 612.88, highlighting a persistent perception of elevated economic risks. At the same time, foreign exchange reserves decreased from 78.5 billion USD to 56.1 billion USD, confirming the intensifying pressure on the country's currency and reserves. This bubble formation is clearly marked in the graph, indicating another period of speculative behaviour.

The graph not only visually supports the occurrence of these bubbles but also strengthens the empirical findings of the GSADF and BSADF tests, providing a clear connection between the CDS premiums, foreign exchange reserves, and the speculative forces driving the exchange rate bubbles. The use of grey shading effectively highlights the bubble periods, offering a comprehensive view of how macroeconomic variables interact during times of market instability.

Building on the theoretical insights derived from Minsky's (1992) Financial Instability Hypothesis and Scherbina's (2013) analysis of speculative bubble dynamics, Kartal (2024) developed a general framework for understanding the formation of speculative bubbles. This study adapts this framework specifically to foreign exchange markets, applying it to Türkiye's exchange rate market to examine the psychological, market-based, and macroeconomic forces that triggered speculative surges. The empirical findings reveal three distinct speculative bubble periods—May 2018 to October 2018, September 2020 to November 2020, and November 2021 to March 2022—each driven by a combination of these mechanisms. The following section analyses how these forces shaped speculative behaviour in each bubble period:

The 2018 Bubbles: The Pastor Brunson Crisis and Speculative Attacks

- Psychological Factors: The diplomatic crisis between Türkiye and the U.S., particularly centred around Pastor Andrew Brunson's detention, triggered an aggressive herding behaviour among both institutional and retail investors. Concerns over potential sanctions led to a rush into foreign currency, as market participants anticipated further depreciation of the Turkish lira. This collective panic, rather than fundamental economic weaknesses, drove excessive speculative demand. At the same time, investors exhibited overconfidence, believing that the TRY would continue depreciating indefinitely, despite Türkiye's Central Bank's (CBRT) attempts to stabilize the currency. This overestimation of risk led to persistent speculative positioning, further accelerating the exchange rate surge. Additionally, anchoring bias played a role as investors adjusted their expectations based on previous currency shocks, normalizing the sharp devaluation instead of recognizing it as an overreaction.
- Market Inefficiencies: Information asymmetries intensified the bubble, as conflicting government statements and uncertainty surrounding potential U.S. sanctions heightened speculation. Moreover, Türkiye's regulatory measures, including restrictions on offshore swap transactions, further distorted price discovery, exacerbating volatility. Market frictions also played a role, as capital controls and liquidity constraints in domestic financial markets made it difficult for rational investors to counteract speculative pressures.
- External Shocks and Macroeconomic Factors: Prior to the crisis, the CBRT maintained a relatively low interest rate of 7.25% to stimulate growth. However, as the lira came under intense pressure with Pastor Brunson Crisis, low interest rates had negative pressure on the exchange rate and further triggered the increase in the exchange rates (monetary and fiscal policy interactions). Then, the CBRT implemented a sharp increase in the policy rate, raising it to 22.5% by September to stabilize the currency. This tightening had limited effectiveness in addressing the underlying causes of the speculative bubble since the main reason for the currency crisis was geopolitical risks and uncertainties regarding Türkiye's foreign relations. Foreign capital flight, driven by concerns over economic stability, pushed CDS premiums higher, while deteriorating global risk sentiment, exacerbated by U.S. trade policies and emerging market sell-offs, further fuelled the speculative bubble.
- Theoretical Model Alignment: The rapid depreciation of the TRY despite CBRT's interventions suggests that speculative sentiment overrode economic fundamentals, aligning with rational bubble models. The mass movement into foreign currency during the crisis exemplifies behavioural finance models, as investors engaged in herd-driven speculation, assuming further depreciation was inevitable. The TRY's deviation

from its theoretical fair value, evident in extreme volatility, further supports the fundamental value model perspective.

- Dissipation of Speculative Bubbles: Following the sharp depreciation of the Turkish lira, the CBRT took decisive action by raising interest rates from 7.25% to 22.5% in September 2018, aiming to restore confidence and curb speculative activity. The resolution of the diplomatic crisis with the release of Pastor Brunson, combined with a significant interest rate hike by the Turkish Central Bank, played a crucial role in stabilizing the exchange rate and reducing speculative demand. As a result, speculative demand for foreign currency subsided, leading to a gradual revaluation of the lira.

The 2020 Bubbles: The COVID-19 Shock and Liquidity Pressures

- Psychological Factors: The global financial uncertainty caused by the COVID-19 pandemic led to heightened speculative sentiment. As economies locked down and global trade slowed, investors rushed into safe-haven assets, contributing to a speculative surge in the exchange rate. Amid global uncertainty and concerns over Türkiye's foreign exchange reserves, both individual and corporate investors engaged in herding behaviour foreign currency purchases, fearing continued depreciation. Overconfidence was also prevalent, as some market participants incorrectly anticipated a prolonged devaluation due to economic contraction.

- Market Inefficiencies: Information asymmetries became more pronounced as inconsistent policy responses from global central banks created confusion, leading to speculative trading strategies. Additionally, liquidity shortages (market frictions) in emerging markets, including Türkiye, intensified volatility, exacerbating mispricing in exchange rates.

- External Shocks and Macroeconomic Factors: The global demand collapse and supply chain disruptions earlier in 2020 triggered heightened risks and capital outflows from emerging markets. Thus, in Türkiye, foreign exchange reserves declined sharply, increasing investor concerns and accelerating speculative positioning (global economic conditions). As global economic conditions worsened, Türkiye's fiscal and monetary challenges, compounded by the pandemic-driven expansionary policies, exposed its economic fragilities. This environment, marked by declining foreign exchange reserves and rising inflation expectations, intensified capital flight and exchange rate instability. In this context, the expansive fiscal and monetary measures, including credit incentives and accommodative interest rate policies, further deepened public finance stress, contributing to a self-reinforcing cycle of depreciation and inflationary pressures (monetary and fiscal policy interactions).

- Theoretical Model Alignment: The strong deviation of the exchange rate from macroeconomic fundamentals, despite temporary improvements in global market conditions, aligns with the rational bubble model. Behavioural biases, such as herding behaviour and overconfidence, dominated market reactions, reinforcing speculative pressures (the behavioural finance models). During this period, the deviation from fair value of the exchange rate is also consistent with fundamental value models.

- Dissipation of Speculative Bubbles: As the global economy began recovering from the initial shocks of the COVID-19 pandemic, risk appetite improved, and speculative pressure on emerging market currencies, including the Turkish lira, gradually declined. The stabilization of global trade and the partial recovery of Türkiye's foreign exchange reserves contributed to the correction of the exchange rate. Additionally, as economic contraction eased, the speculative demand for safe-haven assets weakened, leading to a stabilization in foreign exchange markets. Furthermore, the appointment of a new CBRT governor and a shift in monetary policy direction following Berat Albayrak's resignation restored some market confidence, reinforcing the stabilization of the exchange rate.

The 2021 Bubbles: Monetary Policy Shifts and Credibility Concerns

- Psychological Factors: The CBRT's unexpected rate cuts in late 2021 triggered widespread herd behaviour, as market participants rushed to hedge against further depreciation, with large corporations and exporters increasing their foreign currency demand, further amplifying speculative pressures in the exchange rate market. This speculative momentum intensified

as investors interpreted policy shifts as a loss of monetary credibility, exacerbating capital flight. Overconfidence also played a role, as many market participants assumed that the TRY would continue depreciating at an accelerated pace, dismissing potential corrective interventions. In fact, the sudden wave of falling exchange rates that emerged with the introduction of the exchange rate-protected deposit account dealt a major blow to those who had made investments based on this assumption.

- Market Inefficiencies: Severe information asymmetries emerged as frequent changes in economic leadership and contradictory policy signals created confusion in the market. Investors lacked clear forward guidance on exchange rate policy, leading to heightened speculative trading. Meanwhile, declining foreign exchange reserves further eroded confidence in the CBRT's ability to stabilize the currency, reinforcing speculative positioning (market frictions).

- External Shocks and Macroeconomic Factors: The 2021 bubble coincided with rising global inflation and expectations of Federal Reserve interest rate hikes, both of which fuelled emerging market capital outflows (global economic conditions). CBRT's rate cuts, despite rising inflationary pressures, significantly eroded market confidence, reinforcing speculative demand for foreign currency and accelerating exchange rate misalignments (monetary and fiscal policy interactions).

- Theoretical Model Alignment: The extreme price movements observed in the exchange rate align with rational bubble models, where market participants continue purchasing foreign currency despite the absence of a proportional macroeconomic justification. Additionally, the speculative rush into foreign assets closely follows behavioural finance models, particularly herding behaviour. Moreover, during this period, the deviation from fair value of the exchange rate is also consistent with fundamental value models.

- Dissipation of Speculative Bubbles: Unlike previous bubbles, which primarily ended due to external stabilization factors or policy rate adjustments, the 2021 speculative surge was abruptly reversed by the introduction of the Foreign Exchange-Protected Turkish Lira Deposit (KKM) scheme on December 20, 2021. This policy instrument initially curbed speculative pressures and triggered a sharp exchange rate correction by reassuring domestic investors and reducing foreign currency demand. As a result, the Turkish lira experienced a significant revaluation, with the BSADF curve reflecting a downward shift following the policy intervention. However, the effectiveness of KKM waned over time as concerns over its long-term sustainability grew, leading to the resurgence of structural pressures on the exchange rate. Despite this, the absence of a new speculative bubble in the subsequent period suggests that the transition to orthodox policies than heterodox policies following the 2023 presidential elections, particularly the initiation of interest rate hikes, played a pivotal role in preventing the formation of another speculative surge. CBRT's decisive return to conventional monetary tightening helped restore investor confidence, curb speculative pressures, and reinforce exchange rate stability. This shift highlights the fundamental role of credible and consistent monetary policies in mitigating excessive exchange rate volatility and reducing the risk of recurrent speculative bubbles.

CONCLUSION and EVALUATION

While some exchange rate movements align with macroeconomic indicators, a volatility segment remains unexplained, indicating bubble presence. This underscores the need for nuanced analysis considering economic fundamentals and speculative influences. Factors like interest rate policies, investor sentiment, and global economic conditions also impact currency fluctuations, as seen in Türkiye's experience post-2018. In this context, the empirical analysis conducted from February 2001 to September 2024 aimed to identify and interpret currency bubbles within Türkiye's foreign exchange market. Employing the Generalized Sup Augmented Dickey-Fuller (GSADF) and Backwards Sup Augmented Dickey-Fuller (BSADF) tests, the study revealed multiple bubble formations, with a notable focus on the period from November 2021 to March 2022. These findings contribute significantly to understanding the complex dynamics of exchange rate movements and the impact of speculative factors on currency valuations.

The mechanism of currency bubble formation often initiates a disruption in one of the determinants of the exchange rate, leading to an initial increase in the exchange rate. Subsequently, market reactions fuel

speculative attacks, amplifying what would have been a manageable increase in the exchange rate into a more severe bubble formation. In essence, this study accepts that exchange rate fluctuations are influenced by many factors, including economic fundamentals, geopolitical events, and market sentiment. However, it claims that at least part of the increase in the exchange rate cannot be explained by macroeconomic reasons. While some movements align with traditional indicators, there remains a segment of volatility unexplained by these factors, indicating the presence of a bubble. In this regard, the study claims that there is a speculative bubble formation in this unexplained section, as proven by empirical findings. Accordingly, the study emphasizes the need for a nuanced understanding of exchange rate dynamics, considering both economic fundamentals and speculative influences. Moreover, this study offers a novel perspective by suggesting that the BSADF curve may serve as an indicator of 'fair value' in currency markets, especially when exchange rates align with the curve during non-speculative periods. While the BSADF curve does not conclusively determine fair value, its role as a benchmark for assessing deviations offers a valuable tool for policymakers. Extending this approach to other markets could also provide insights into mispricing across financial assets, encouraging further exploration into the broader applications of the BSADF test.

The analysis identified three distinct periods of bubble formations, each corresponding to unique economic and geopolitical contexts: May 2018 to October 2018, September 2020 to November 2020, and November 2021 to March 2022. The first bubble period coincided with a crisis involving the threat of sanctions from the USA and geopolitical tensions surrounding Priest Andrew Brunson's case. The subsequent easing of tensions post-Brunson's release resulted in a regression in the exchange rate, highlighting the sensitivity of currency markets to geopolitical developments. The detected bubble during this phase serves as a stark indicator of the artificiality of the exchange rate surge. It highlights how market perceptions, influenced by geopolitical factors, can lead to speculative increases that are not necessarily grounded in fundamental economic realities. Detecting a bubble in this context underscores the need for a nuanced understanding of market dynamics, considering both external geopolitical pressures and internal economic fundamentals.

The most notable bubble formation was observed during the latter months of 2021, and compatibility with macroeconomic fundamentals has been questioned many times. This period was characterized by heightened market uncertainties, investor sentiment fluctuations, and policy interventions aimed at stabilizing the exchange rate. Notably, introducing the "exchange rate-protected deposit," announced on December 20, 2021, led to a rapid decrease in the dollar exchange rate from 18 TRY to 12 TRY overnight, highlighting the market's sensitivity to policy interventions. This intervention underscores the effectiveness of policy measures in addressing speculative activities and promoting market stability.

The analysis confirmed the presence of a bubble during the specified periods; on the other hand, it should be particularly highlighted that the complexity of the exchange rate increases beyond attributing it solely to the bubble. Following 2018, particularly during the recent bubble formation period, Türkiye's macroeconomic indicators showed no significant signs of major deterioration except for inflation. However, the inflation rate in Türkiye, significantly higher than the global average, hinted that factors beyond inflation played a role in the rise of both nominal and real exchange rates. The expectation was that the rise in inflation would primarily affect the nominal exchange rate, with a more constrained impact on the real exchange rate. However, contrary to this expectation, both the nominal and real exchange rates experienced an increase. This indicates that the exchange rate surged beyond the inflation rate.

Moreover, there's a possibility that the inflation surge in countries like Türkiye could be attributed to exchange rate movements. These observations suggest that factors beyond inflation are driving the exchange rate increase. In this context, various factors such as the economic repercussions of the Covid-19 pandemic, global and local inflation expectations, FED's statements on asset purchase tapering, market pricing of FED's rate hike expectations, misapplications of Central Bank policies, and Türkiye's underlying structural challenges have significantly impacted exchange rate fluctuations. Factors such as interest rate policies and investor sentiment also played significant roles in influencing currency fluctuations. Despite Türkiye grappling with high inflation, the persistent reduction in interest rates led to real interest rates falling well below inflation rates, prompting potential foreign investor fund withdrawals and resulting in a decline in the exchange rate.

While these factors may have triggered increases in exchange rates, they also underscore a more nuanced understanding. Some increases in exchange rates

can be justified by macroeconomic reasons; however, there remains a segment of volatility unexplained by traditional indicators, indicating the presence of a bubble. This study reveals bubbles that are the reason for the increases in exchange rates unexplained by macroeconomic indicators in the given period. The study's findings support claims that at least some of the sharp increase in the exchange rate doesn't align with macroeconomic indicators. The subsequent sharp decline in the exchange rate following the announcement of the Foreign Exchange-Protected Turkish Lira Deposit further emphasizes this observation.

Before the Foreign Exchange-Protected Turkish Lira Deposit announcement on the night of December 20, 2021, the dollar exchange rate had soared above 18 TL. Notably, the rate plummeted to 12 TL after the announcement, showcasing a remarkable turnaround. The recent bubble formation culminated in December 2021, marked by a notable decline in the BSADF curve, signaling the impact of the Foreign Exchange-Protected Turkish Lira Deposit on mitigating the exchange rate bubble. This decline underscores that some of the exchange rate surge can be attributed to speculative bubbles. Furthermore, this development serves as a crucial validation supporting the empirical findings of this study during the specified period.

The introduction of the "exchange rate-protected deposit" policy in December 2021 is a prime example of effective policy intervention, as it mitigated the bubble's growth and helped stabilize the market in the short term. However, while this measure temporarily curbed the speculative surge and led to a sharp decline in the exchange rate, its long-term sustainability remains questionable. Relying on such temporary policy instruments can provide immediate relief, but it does not address the underlying vulnerabilities contributing to bubble formations. Therefore, while the exchange rate-protected deposit was crucial in preventing further escalation, it should not be viewed as a comprehensive solution. The true strength of a stable and resilient foreign exchange market lies in the implementation of structural reforms that address the root causes of economic instability. Proactive measures, such as enhancing monetary policy frameworks, improving fiscal discipline, fostering political stability, and addressing structural economic imbalances, are essential for creating a more robust and resilient currency market.

By focusing on long-term structural reforms rather than short-term fixes, policymakers can build a stronger economic foundation, reducing the likelihood of speculative bubbles and fostering sustainable economic growth. Particularly, focusing on structural reforms related to key determinants of exchange rates such as inflation, interest rates, foreign trade deficits, foreign direct investments, political stability, exchange rate regimes, and speculation is essential. Moreover, this approach not only enhances market stability but also boosts investor confidence, attracting foreign investment and promoting a healthier economic environment. The study's findings highlight the critical need for such comprehensive reforms, emphasizing that sustainable stability in the exchange rate market can only be achieved through a multifaceted strategy that addresses both immediate challenges and long-term economic health. Furthermore, the paper emphasizes the impact of recent economic policies on bubble formation. Notably, the absence of a new bubble formation in the exchange rate, despite continued increases, points to the effectiveness of policy measures implemented by Türkiye's economic management and the Central Bank. This observation is particularly relevant following the 2023 elections and the subsequent shift to orthodox economic policies under the guidance of Mehmet Şimşek and Cevdet Yılmaz. This aligns with the conclusion drawn from the analysis, highlighting the need for long-term structural reforms rather than short-term fixes to ensure sustainable stability in Türkiye's foreign exchange market. By acknowledging the role of policy interventions in mitigating speculative activities and promoting market stability, the study emphasizes the critical importance of a comprehensive approach to economic management. In conclusion, the analysis underscores the importance of understanding the nuanced dynamics of exchange rate movements and the impact of policy interventions on mitigating speculative bubbles. The empirical findings support the need for a comprehensive approach to economic management, focusing on long-term structural reforms rather than short-term fixes to ensure sustainable stability in Türkiye's foreign exchange market.

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