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Factors Affecting Sukuk Return and Issuance: Insights from Sukuk Market of Türkiye

Sukûk Getirisine ve İhracına Etki Eden Faktörler: Türkiye Sukûk Piyasasından İçgörüler

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Factors Affecting Sukuk Return and Issuance: Insights from Sukuk Market of Türkiye

Abstract

Since the first sukuk issuance in 2001, sukuk transaction volumes have been increasing day by day in major financial markets. Sukuk has become an attractive investment tool, especially for US and EU investors, as well as being preferred by investors who embrace Islamic finance principles and shariah compliance. Parallel to increased attention all over the financial markets, also sukuk plays a critical role in facilitating the deepening capital markets of Türkiye. To this end, this paper aims to identify the effect of inflation, deposit interest rate, dollar currency and sukuk issuance size on sukuk return. Furthermore, as a part of the analyses, the causality relationship is tested between macroeconomic variables and sukuk issuance. The Toda-Yamamoto causality test is utilised to rigorously assess the causal relationships between variables. In contrast, the Autoregressive Distributed Lag (ARDL) is applied to detect both short-term and long-term coefficients among the variables, employing a monthly dataset that encompasses the period from 2013 to 2024. Empirical evidence shows the constructed ARDL model is significant at the 1% significance level. On top of that, a significant positive relationship between sukuk returns and deposit interest rate, inflation, and sukuk issuance size might be stated by assessing the long-term coefficients. Only the USD/TRY exchange rate negatively affects sukuk returns as indicated by long-term coefficients. Moreover, the coefficient of error correction model is negative and significant which is developed to get the short-term coefficients. ECM model reflected that 75% of a shock occurs in the short term and these shocks will disappear in the long term. In addition, a Toda-Yamamoto causality test stated that dollar exchange rate and deposit interest rates are the two factors that have a causal relationship with the size of sukuk issuance. This study elucidates the importance of macroeconomic variables on both sukuk return and sukuk issuance. It highlights the factors that sukuk issuers and investors should consider throughout their decision-making process.

Keywords: Islamic Finance**,** Interest-Free Securities, Sukuk, Sukuk Issuance, ARDL, Causality.

Sukûk Getirisine ve İhracına Etki Eden Faktörler: Türkiye Sukûk Piyasasından İçgörüler

Öz

2001 yılındaki ilk sukûk ihracından bu yana, gelişmiş finansal piyasalarda sukûk işlem hacimleri her geçen gün artmaktadır. Sukûk, İslami finans ilkelerini ve şeriat uyumunu benimseyen yatırımcılar tarafından tercih edilmesinin yanı sıra özellikle ABD ve AB yatırımcıları için cazip bir yatırım aracı haline gelmiştir. Tüm finans piyasalarında artan ilgiye paralel olarak sukûk, Türkiye'nin sermaye piyasalarının derinleşmesinde de kritik bir rol oynamaktadır. Bu çalışma, enflasyonun, mevduat faiz oranının, Dolar kurunun ve sukûk ihraç büyüklüğünün, sukûk getiriler üzerindeki etkisini tespit etmeyi amaçlamaktır. Ayrıca analizlerin bir parçası olarak, makroekonomik değişkenler ile sukûk ihraç büyüklüğü arasındaki nedensellik ilişkisi de test edilmiştir. 2013-2024 arası dönemi kapsayan aylık verilerin kullanıldığı çalışmada, değişkenler arasındaki nedenselliği tespit etmek amacıyla Toda-Yamamoto Nedensellik Testi, buna karşın uzun ve kısa dönem katsayılarını belirlemek amacıyla da Gecikmesi Dağıtılmış Otoregresif (Autoregressive Distributed Lag: ARDL) modeli kullanılmıştır. Ampirik sonuçlar, kurulan ARDL modelinin %1 anlamlılık düzeyinde anlamlı olduğunu göstermektedir. Bunun da ötesinde, uzun dönem katsayıları değerlendirilerek, sukûk getirileri ile mevduat faizi, enflasyon ve sukûk ihraç büyüklüğü arasında pozitif yönde anlamlı bir ilişki olduğu söylenebilir. Uzun dönem katsayılarına göre sadece USD/TRY döviz kuru sukûk getirilerini olumsuz etkilemektedir. Ayrıca, kısa dönem katsayılarını elde etmek için geliştirilen hata düzeltme katsayısı modeli negatif ve anlamlıdır. ECM modeli, bir şokun %75'inin kısa vadede meydana geldiğini ve bu şokların uzun vadede ortadan kalkacağını göstermiştir. Ayrıca Toda-Yamamoto nedensellik analizine göre, Dolar kuru ve mevduat faiz oranları, sukûk ihracının büyüklüğü ile nedensellik ilişkisi olan iki faktördür. Bu çalışma

makroekonomik değişkenlerin hem sukûk getirisi hem de sukûk ihracındaki önemine açıklık getirmektedir. Sukûk ihraççılarının ve yatırımcıların karar alma süreçlerinde dikkate alması gereken faktörleri vurgulamaktadır.
Anahtar Kelimeler: İslami Finans**,** Faizsiz Yatırım Araçları, Sukûk, Sukûk İhracı, ARDL, Nedensellik.

Introduction

The foundation of a robust structure in capital markets fundamentally lies in achieving maturity matching. Long-term investments must be financed with permanent capital, whereas short-term financing and working capital needs should be financed with short-term sources as anticipated. This principle holds true not only in conventional financial systems but also in countries and companies that opt for Islamic finance. In countries where capital markets are not yet fully developed, such as Türkiye, financing needs are predominantly met through the banking system. The financing of long-term needs through short-term bank loans exposes both companies and the overall economic outlook of the country to risks associated with maturity mismatches. Consequently, it is imperative to increase the proportion of long-term debt instruments, such as bonds, within the capital market. In this context, Sukuk plays a critical role in facilitating the deepening capital markets of Türkiye.

There are various definitions of Sukuk in the literature. Despite this, the two most widely accepted and commonly used definitions are provided by the Islamic Financial Services Board and the Accounting and Auditing Organization for Islamic Financial Institutions. As mentioned by the IFSB[1], Sukuk (Shari'a-compliant bonds) are "certificates representing a proportional undivided ownership right in tangible assets, or a pool of predominantly tangible assets, or a business venture" (IFSB, 2009). The AAOIFI[2] defines Sukuk as "certificates of equal value representing undivided shares in ownership of tangible assets, usufruct and services, or (in the ownership of) the assets of particular projects or special investment activity" (AAOIFI, 2017). As elucidated by AAOIFI's classification, there are various types of Sukuk in different countries around the world. AAOIFI categorizes 14 types of Sukuk. The most commonly used type is Murabaha sukuk, comprising 42% of sukuk investments. Sukuk investments resemble equity investments in one aspect by assuming risk. Similar to equity investments, there is no guaranteed return, and profits or losses depend on the performance of the investment. Even so, the key differences from equity investments include having a maturity period, lack of voting rights, and no influence over corporate management.

The Sukuk was legitimized in the 1980s by the Council of the Islamic Fiqh Academy of the Organization of Islamic Conference during its fourth session held in Jeddah, Kingdom of Saudi Arabia, from February 6–11, 1988. The first-ever issuance was launched in 1990. Nevertheless, the first international Sukuk issuance, amounting to approximately 100 million USD, was conducted in Bahrain in 2001. The most prosperous period for the Sukuk market began in the early 2000s. As evidenced, Sukuk, a relatively new development in Islamic finance, is progressively capturing a larger share of the market. As per the Refinitiv Report (2021)[3], by the end of 2020, the share of Islamic banks within Islamic finance was 70%, while Sukuk accounted for 19.86% (approximately 174 trillion USD). This figure was 14.7% in 2019. Based on the International Islamic Financial Market's 2022 report[4], annual Sukuk issuance set a record, reaching 188 billion USD. Besides the volume of Sukuk issuances, it is essential to

1 IFSB, "Islamic Financial Services Board Financial Stability Report", *Islamic Financial Services Board* (blog) (Access: 01 June 2024).
2 AAOIFI, "Accounting and Auditing Organization for Islamic Financial Institutions" (Access: 01 June 2024).
3 Refinitiv Report, "Refinitiv Releases Findings of 2021 Islamic Finance Development Indicator" (Access: 01 June 2024).
4 IIFM, "International Islamic Financial Market Sukuk Report of 2022" (Access: 02 June 2024).

consider the reasons driving Gulf countries to issue Sukuk. Smaoui and Ghouma (2020)[5] identified budget deficits in Gulf countries, resulting from falling oil prices, as a significant factor. Tariq and Dar (2007)[6], Kusuma and Silva (2014)[7], and Boukhatem (2022)[8] have highlighted the issuance of Sukuk as a long-term borrowing instrument to finance budget deficits and large-scale infrastructure projects. The most concrete example of this is highlighted by Alnaggar et al. (2021)[9], who found that in 2019, 50% of Saudi Arabia's budget deficit was covered through Sukuk issuances. Sukuk issuances play a significant role not only in meeting the financing needs of governments but also in addressing the financing needs of private companies.

Looking at the development cycle of the Sukuk market, acceleration is evident post-2007. Particularly, the Global Financial Crisis (Mortgage Crisis) that began in the United States in 2007 led to damages in global economies, prompting investors to shift towards interest-free financial instruments (Naifar and Hammoudeh, 2016; 57)[10]. This is due to the Islamic finance market being perceived as less exposed to risk, demonstrating better performance, and exhibiting more stable and resilient behaviour compared to conventional systems during the Global Financial Crisis (Bourkhis & Nabi, 2013; Ghassan & Guendouz, 2019; Hassan et al., 2018; Chapra, 2008; Hasan and Dridi, 2010; Beck et al., 2013; Johnes et al., 2014; Mollah and Zaman, 2015; Bitar et al., 2017; Cihak and Hesse, 2010; Shahbaz et al., 2013; Chazi and Syed, 2010)[11]. Conversely, authors like Ahmad and Muda (2013)[12] have noted that the Sukuk market was negatively affected by the Global Financial Crisis due to the rising foreign exchange rate risk, which led foreign investors to reduce their international investments. The authors have pointed out that the increased foreign exchange rates affect inflation and countries turn to Sukuk to finance current account deficits due to increased import costs. Yet, the uncertainty

5 Houcem Smaoui - Hatem Ghouma, "Sukuk market development and Islamic banks' capital ratios", *Research in International Business and Finance* 51 (01 Ocak 2020), 101064.

6 Ali Tariq - Humayon Dar, "Risks of Sukuk structures: Implications for resource mobilization", *Thunderbird International Business Review* 49 (01 Mart 2007), 203-223.

7 Kusuma - Silva, "Sukuk Markets".

8 Jamel Boukhatem, "How does financial risk affect sukuk market development? Empirical evidence from ARDL approach", Heliyon 8/5 (01 May 2022), e09453.

9 Ahmed Alnaggar et.al., "The Challenges of Developing the Saudi Sukuk Market in Line with Objectives of Vision 2030", 2021, 987-1010.

10 Nader Naifar - Shawkat Hammoudeh, "Do Global Financial Distress and Uncertainties Impact GCC and Global Sukuk Return Dynamics?", *Pacific-Basin Finance Journal* 39/C (2016), 57-69.

11 Khawla Bourkhis - Mahmoud Nabi, "Islamic and conventional banks' soundness during the 2007–2008 financial crisis", *Review of Financial Economics* 22/2 (2013), 68-77; Hassan Belkacem Ghassan - Abdelkrim Ahmed Guendouz, "Panel modelling of z-score: evidence from Islamic and conventional Saudi banks", *International Journal of Islamic and Middle Eastern Finance and Management* 12/3 (01 January 2019), 448-468; M. Kabir Hassan et.al., "The Determinants of Co-Movement Dynamics between Sukuk and Conventional Bonds", *The Quarterly Review of Economics and Finance* 68/C (2018), 73-84; Muhamed Chapra, "The Global Financial Crisis: Can Islamic Finance Help Minimize the Severity and Frequency of Such A Crisis in the Future?", *Islam and Civilisational Renewal (ICR)* 1 (01 January 2008); Maher Mohamad Hasan - Jemma Dridi, *The Effects of the Global Crisis on Islamic and Conventional Banks: A Comparative Study* (SSRN Scholarly Paper, 01 September 2010), Social Science Research Network; Thorsten Beck et.al., "Islamic vs. conventional banking: Business model, efficiency and stability", *Journal of Banking & Finance* 37/2 (01 February 2013), 433-447; Jill Johnes et.al., "A comparison of performance of Islamic and conventional banks 2004 to 2009", *Journal of Economic Behavior and Organization* 103/Supplement (June 2014), S93-S107; Sabur Mollah - Mahbub Zaman, "Shari'ah supervision, corporate governance and performance: Conventional vs. Islamic banks", *Journal of Banking & Finance* 58/C (2015), 418-435; Mohammad Bitar et.al., "What makes Islamic banks different? A multivariate approach", *Economic Systems* 41/2 (01 June 2017), 215-235; Marchin Cihak - Heiko Hesse, "Islamic Banks and Financial Stability: An Empirical Analysis", *IMF Working Papers* 38 (01 December 2010), 95-113; Muhammad Shahbaz et.al., "Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia", *Renewable and Sustainable Energy Reviews* 25 (01 September 2013), 109-121; Abdelaziz Chazi - Lateef A.M. Syed, "Risk exposure during the global financial crisis: the case of Islamic banks", *International Journal of Islamic and Middle Eastern Finance and Management* 3/4 (01 January 2010), 321-333.

12 Nursilah Ahmad - Muhamad Muda, "Exchange Rate Pass-through Estimates for Sukuk Issuing Countries", *Procedia Economics and Finance* 7 (2013), 134-139.

surrounding exchange rates has led foreign investors to adopt a somewhat cautious approach towards Sukuk issuances at this juncture. In contrast, Kassim (2012)[13] and Abdullah et al. (2016)[14] have found that there were no significant changes in Islamic financial instruments during crisis periods compared to pre-crisis periods. Kenourgios et al. (2016)[15] obtained results that are contrary to these findings, showing that Sukuk return diverged from bonds both during the Global Financial Crisis and the European Debt Crisis. Hassan et al. (2018)[16] confirmed these results, indicating that during recession periods, Sukuk returns are less volatile compared to US and EU bonds and exhibit a more resilient structure. Sclip et al. (2016)[17], meanwhile, observed that adding Sukuk to a portfolio consisting of US and EU assets during financial crises reduces volatility. In addition, as noted by Saeed et al. (2021)[18], since sukuk are issued based on underlying assets, the lower volatility in the value of these assets makes sukuk a less risky security. In contrast as expressed by Hasan and Dridi (2010)[19], Ahmed and Khan (2007)[20], Siddiqui (2008)[21], and Hossain et al. (2021)[22], sukuks are considered more risky instruments compared to conventional bonds. Nonetheless, as observed by Cakir and Raei (2007:12)[23], since the underlying assets of sukuk are not highly liquid, their secondary markets tend to be weak. It results in sukuk yields being lower than bond yields. This condition exposes sukuk to certain risks. These risks include default risk and liquidity risk. Enhancing and deepening the secondary market is crucial to mitigating liquidity risk. A well-developed secondary market for sukuk, as indicated by various studies (Usmani, 2007; Razak et al., 2019; Bacha and Mirakhor, 2018; Duqi and Al-Tamimi, 2019; Chowdhury and Salema, 2023)[24], positively influences the demand for sukuk issuances.

Following the global first sukuk issuance in 2001, each country started to issue sukuk by constructing its own legal framework. In this sense, Türkiye also participates in these studies, and the Capital Market Board (CMB) released the first notification of sukuk issuance in 2010. Afterwards, on June 7, 2013, this notification was revised following the global developments. The data indicates that, despite the regulations, sukuk issuances are still below

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13 Salina Kassim, "Evidence of Global Financial Shocks Transmission: Changing Nature of Stock Markets Integration during the 2007/2008 Financial Crisis", *Journal of Economic Cooperation and Development* 33 (01 January 2012), 117-138.

14 A.M. Abdullah et.al., "The Impact of Crude Oil Price on Islamic Stock Indices of South East Asian Countries: Evidence from MGARCH-DCC and Wavelet Approaches", *Borsa Istanbul Review* 16/4 (01 December 2016), 219-232.

15 Dimitris Kenourgios et.al., "Islamic financial markets and global crises: Contagion or decoupling?", *Economic Modelling* 57 (30 April 2016), 36-46.

16 Hassan et.al., "The Determinants of Co-Movement Dynamics between Sukuk and Conventional Bonds".

17 Alex Sclip et.al., "Dynamic Correlations and Volatility Linkages between Stocks and Sukuk: Evidence from International Markets", *Review of Financial Economics* 31/C (2016), 34-44.

18 Momna Saeed et.al., "Yield spread determinants of *sukuk* and conventional bonds", *Economic Modelling* 105 (01 December 2021), 105664.

19 Hasan - Dridi, *The Effects of the Global Crisis on Islamic and Conventional Banks: A Comparative Study* (SSRN Scholarly Paper, 01 Eylül 2010).

20 Habib Ahmed - Tariqullah Khan, "Risk Management in Islamic Banking", *Chapters*, (2007).

21 Anjum Siddiqui, "Financial contracts, risk and performance of Islamic banking", ed. M. Mansoor Khan - M. Ishaq Bhatti, *Managerial Finance* 34/10 (01 Ocak 2008), 680-694.

22 Mohammed Sawkat Hossain et.al., "Sukuk and Bond Puzzle: An Analysis with Characteristics Matched Portfolios", *Emerging Markets Finance and Trade* 57/13 (2021), 3792-3817.

23 Faezeh Raei - Selim Cakir, "Sukuk vs. Eurobonds: Is There a Difference in Value-at-Risk?" 7/237 (01 October 2007).

24 Muhammad Taqi Usmani, "Sukuk and Their Contemporary Applications", (ts.); Siti Sarah Razak et.al., *Islamic Financial Instruments and Institutions*, "The contracts, structures and pricing mechanisms of *sukuk*: A critical assessment", *Borsa Istanbul Review* 19/1 (01 August 2019), 521-533; Obiyathulla Bacha - Abbas Mirakhor, "Funding development infrastructure without leverage: A risk-sharing alternative using innovative sukuk structures", *The World Economy* 41/3 (20 June 2017), 752-762; Andi Duqi - Hussein Al-Tamimi, "Factors affecting investors' decision regarding investment in Islamic Sukuk", *Qualitative Research in Financial Markets* 11/1 (09 May 2019), 60-72; Tasruma Sharmeen Chowdhury - S.M. Kalbin Salema, "Factors influencing the individual investors of Bangladesh to opt for investment in sukuk", *Islamic Economic Studies* 31/1/2 (01 January 2023), 88-107.

the level that Türkiye is likely to desire. Smaoui et al. (2017)[25] attribute the slower development of Sukuk in other countries to the competition between Sukuk financing and bank loans. In countries where the banking system is strong, the proliferation of this form of financing is expected to be slow and difficult. This situation can also be cited as the primary obstacle and reason for the slow progress in the development of the Sukuk market in Türkiye.

The remainder of this paper is organized as follows. After this brief precludes, a comprehensive review of related literature is presented in Section 1. Section 2 describes the data set and methodology. Section 3 describes the analyses and findings of the study. The last section discusses the results compared to previous studies and concludes the paper.

1. Literature Review

Sukuk, one of the most significant instruments in Islamic finance, has increasingly become the subject of academic research due to its growing transaction volume and popularity in financial markets. Studies on sukuk cover a wide range of scopes, focusing primarily on identifying relationships with various variables. Despite the first international sukuk issuance taking place in 2001, the development of relevant literature has taken time. Recent studies on sukuk have highlighted several key areas of focus. These include comparisons between sukuk and bonds by Raei & Cakir (2007)[26], Godlewski et al. (2014)[27], Mohamed et al. (2015)[28], Maghyereh and Awartani (2016)[29], Ariff et al. (2017)[30] and Bhuiyan et al. (2018)[31]. Additionally, some studies have examined the relationship between sukuk and equities by Akhtar et al. (2016)[32], Aloui et al. (2015a, 2015b)[33], Naifar et al. (2016)[34], and Sclip et al. (2016)[35]. Regulatory frameworks pertaining to sukuk have been explored by Oseni and Hassan (2014)[36], while the association between sukuk and economic growth has been investigated by Smaoui and Nechi (2017)[37], Smaoui and Khawaja (2017)[38]. Furthermore,

25 Houcem Smaoui et.al., "Sukuk, Banking System, and Financial Markets: Rivals or Complements?", *Economics Letters* 161/C (2017), 62-65.

26 Raei - Cakir, "Sukuk vs. Eurobonds".

27 Christophe Godlewski et.al., "(PDF) Do the Type of Sukuk and Choice of Shari'a Scholar Matter?", *International Monetary Fund, Middle East Center for Economics and Finance (WP/14/147)*, (2014).

28 Hanifa Mohamed et.al., "Why Do Issuers issue Sukuk or Conventional Bond? Evidence from Malaysian Listed Firms Using Partial Adjustment Models", *Pacific-Basin Finance Journal* 34 (01 Februaty 2015), 233-252.

29 A. Maghyereh - B. Awartani, "Dynamic Transmissions between Sukuk and Bond Markets", *Research in International Business and Finance* 38 (30 April 2016), 246-261.

30 Ariff, Mohamed et.al., "Significant Difference in the Yields of Sukuk Bonds versus Conventional Bonds", *Journal of Emerging Market Finance* 16 (01 August 2017), 115-135.

31 Rubaiyat Ahsan Bhuiyan et.al., "Financial Integration between Sukuk and Bond Indices of Emerging Markets: Insights from Wavelet Coherence and Multivariate-GARCH Analysis", *Borsa Istanbul Review* 18/3 (2018), 218-230.

32 Shumi M. Akhtar et.al., *Intensity of Volatility Linkages in Islamic and Conventional Markets* (SSRN Scholarly Paper, 29 December 2016), Social Science Research Network.

33 Chaker Aloui et.al., "Co-movement between sharia stocks and sukuk in the GCC markets: A time-frequency analysis", *Journal of International Financial Markets, Institutions and Money* 34/C (2015a), 69-79; Aloui et.al., "Co-movement between sharia stocks and sukuk in the GCC markets"; Chaker Aloui et.al., "Global factors driving structural changes in the co-movement between sharia stocks and sukuk in the Gulf Cooperation Council countries", *The North American Journal of Economics and Finance* 31/C (2015b), 311-329.

34 Nader Naifar et.al., "Dependence Structure between Sukuk (Islamic Bonds) and Stock Market Conditions: An Empirical Analysis with Archimedean Copulas", *Journal of International Financial Markets, Institutions and Money* 44/C (2016), 148-165.

35 Sclip et.al., "Dynamic Correlations and Volatility Linkages between Stocks and Sukuk".

36 Umar Oseni - M. Kabir Hassan, "Regulating the governing law clauses in Sukuk transactions", *Journal of Banking Regulation* 16/3 (16 April 2014), 220-249.

37 Houcem Smaoui - Salem Nechi, "Does Sukuk Market Development Spur Economic Growth?", *Research in International Business and Finance* 41/C (2017), 136-147.

38 Houcem Smaoui - Mohsin Khawaja, "The Determinants of Sukuk Market Development", *Emerging Markets Finance and Trade* 53/7 (2017), 1501-1518.

studies have focused on the nexus between sukuk and Islamic banks by Ledhem (2022)[39], Mimouni et al. (2019)[40], Smaoui & Ghouma (2020)[41], Alandejani (2022)[42] and Öner (2023)[43].

Since the current study aims to identify factors influencing sukuk returns and issuance, the literature review primarily focuses on sukuk issuances. Additionally, studies examining the relationship between sukuk and micro-macro variables have also been reviewed. In this context, the review begins with studies that investigate the relationship between sukuk issuance and macroeconomic variables. The relationship between sukuk and macroeconomic variables has been extensively addressed in the literature as well. Ahmad and Radzi (2011)[44] revealed that GDP, exchange rates, and market liquidity affect sukuk issuance. Ahmad et al. (2012)[45], examined the relationship between sukuk issuance and macroeconomic variables and found Granger causality between sukuk issuance and GDP. Similarly, Said and Grassa (2013)[46] examined the relationship between the sukuk market and macroeconomic, financial, legal, and institutional factors. As reported by their findings, factors such as GDP and trade deficit are positively associated with Sukuk issuance. These findings also confirmed by other studies like; Echchabi et.al. (2016)[47], Smaoui and Khawaja (2017)[48], Al-Raeai et al. (2019)[49], Aman et al. (2021)[50], and Basyariah et al. (2021)[51]. The development of the sukuk market and its effects on economic growth is also examined by Ghildiyal et al. (2015)[52]; Bakang (2015)[53]; Smaoui and Nechi (2017)[54]; Wang (2019)[55]; Sugiyanto and Yolanda, (2020)[56]. The findings indicate that sukuk issuances strongly support economic growth and the relationship between them is statistically significant. In contrast, a study focusing on Türkiye from 2013 to 2021 by

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39 Mohammed Ayoub Ledhem, *Sustainability and Islamic Finance*, "The financial stability of Islamic banks and sukuk market development: Is the effect complementary or competitive?", *Borsa Istanbul Review* 22 (01 December 2022), S79-S91.

40 Karim Mimouni et.al., "The Impact of Sukuk on the Performance of Conventional and Islamic Banks", *Pacific-Basin Finance Journal* 54/C (2019), 42-54.

41 Smaoui - Ghouma, "Sukuk market development and Islamic banks' capital ratios".

42 Maha Alandejani, "Does issuing Islamic bonds through banks increase banking efficiency?", *Heliyon* 8/8 (01 August 2022), e10041.

43 Muhammed Hadin Öner, "Sukuk İhraçlarının Katılım Bankalarının Finansal Performansı Üzerindeki Etkisi", *Kocatepe İslami İlimler Dergisi* 6/Özel Sayı (15 Ekim 2023), 161-180.

44 Wahida Ahmad - Rafisah Radzi, "Sustainability of Sukuk and Conventional Bond during Financial Crisis: Malaysia's Capital Market", *Glob. Econ. Financ. J.* 4 (2011), 1-14.

45 Nursilah Ahmad et.al., "Economic Forces and the Sukuk Market", *Procedia - Social and Behavioral Sciences* 65 (01 December 2012), 127-133.

46 A. Said - R. Grassa, "The Determinants of Sukuk Market Development: Does Macroeconomic Factors Influence the Construction of Certain Structure of Sukuk?", *Journal of Applied Finance & Banking* 3/5 (Access: 01 June 2024).

47 Abdelghani Echchabi et.al., "Does Sukuk Financing Promote Economic Growth an Emphasis on The Major Issuing Countries", *Turkish Journal of Islamic Economics* 3 (22 August 2016), 63-63.

48 Smaoui - Khawaja, "The Determinants of Sukuk Market Development".

49 Arafat Al-Raeai et.al., "The Influence of Macroeconomics Factors and Political Risk on the Sukuk Market Development in Selected GCC Countries: A Panel Data Analysis (Pengaruh Faktor Makroekonomi dan Risiko Politik ke atas Pembangunan Pasaran Sukuk di Negara GCC Terpilih: Analisis Data Panel)", *Jurnal Ekonomi Malaysia* 53/2 (23 October 2019).

50 Aman et.al., "Factors affecting sukuk market development".

51 Nuhbatul Basyariah et., "Determinants of Sukuk Market Development: Macroeconomic Stability and Institutional Approach", *The Journal of Asian Finance, Economics and Business* 8/2 (28 February 2021), 201-211.

52 Vipin Ghildiyal et.al., "Impact of Financial Deepening on Economic Growth in Indian Perspective: ARDL Bound Testing Approach to Cointegration", *Asian Development Policy Review* 3/3 (2015), 49-60.

53 Marlyse Linda Ngo Bakang, "Effects of Financial Deepening on Economic Growth In", *International Journal of Business and Commerce* 4/7 (ts.), 1-50.

54 Smaoui - Nechi, "Does Sukuk Market Development Spur Economic Growth?"

55 Aidong Wang, "Retracted Article: An empirical study on the relationship between China's financial development and economic growth based on sensor technology", *EURASIP Journal on Wireless Communications and Networking* 2019/1 (20 February 2019), 42.

56 Catur Sugiyanto - Zefania Yolanda, "The Effect of Financial Deepening on Economic Growth, Inequality, and Poverty: Evidence from 73 Countries", *South East European Journal of Economics and Business* 15/2 (01 Aralık 2020), 15-27.

Dilber (2022)[57] did not find a significant relationship between sukuk issuance and economic growth. Smaoui and Khawaja (2016)[58] along with Smaoui et al. (2017)[59] identified high interest rates as a variable negatively affecting sukuk issuance.

Development of the sukuk market may not always lead to positive outcomes. Smaoui and Ghouma (2020)[60] caution that the increasing sukuk issuances could potentially deteriorate banks' capital structures. According to the authors, the sukuk market development causes an increase in competition among banks and leads them to operate with lower equity. This situation negatively affects banks' capital adequacy ratios. Conversely, Alandejani (2022)[61] suggests that banks in the Gulf Cooperation Council countries issuing sukuk can enhance efficiency and contribute positively to financial leverage and liquidity. Ledhem (2022)[62], examined the relationship between sukuk market development and the financial stability of Islamic banks through Islamic financial institutions in Malaysia, Saudi Arabia, Türkiye, Indonesia, and Brunei. In conformity with their outcomes, the development of the sukuk market positively influences the financial stability of Islamic banks. This perspective is supported by Taoual (2016)[63], indicating that sukuk issuance complements rather than competes with Islamic banks. By contrast, this conclusion contradicts with Mimouni et al. (2019)[64] and Smaoui and Ghouma (2020)[65]. In line with their rigorous investigations, the sukuk market acts as a competitor to Islamic banks, resulting in decreased profits and market share for Islamic banks, thereby adversely affecting their financial stability. Nevertheless, this impact has been mitigated since the 2008 Global Financial Crisis, prompting Islamic banks to begin competing through sukuk issuances.

Another commonly addressed topic in the literature where sukuk issuance is considered a variable (Beck et al., 2013; Johnes et al., 2014; Mollah and Zaman, 2015; Bitar et al., 2017)[66] is the comparison between sukuk and conventional bonds. Mohamed et al. (2015)[67] conducted a comparison between sukuk and conventional bond issuances, concluding that companies opting for sukuk issuance have optimized costs. Similar findings were corroborated by Halim et al. (2016)[68] and Klein and Weill (2016)[69], who found that firms with high information asymmetry are more likely to issue sukuk. Nagano (2016)[70] listed three primary reasons that drive companies towards sukuk issuance, namely the openness and accessibility of the sukuk market, minimal financial constraints, and the perception that their equity prices are low. Similar findings were partly corroborated by Grassa and Miniaoui (2018)[71]. They examined 88 sukuk and 287 conventional bond issuances in the OIC region

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57 Caner Dilber, "Sukuk ve Ekonomik Büyüme İlişkisi: Türkiye Üzerine Bir Uygulama", *Çankırı Karatekin Üniversitesi Sosyal Bilimler Enstitüsü Dergisi* 13/2 (2022), 343-364.

58 Smaoui - Khawaja, "The Determinants of Sukuk Market Development".

59 Smaoui et.al., "Sukuk, Banking System, and Financial Markets".

60 Smaoui - Ghouma, "Sukuk market development and Islamic banks' capital ratios".

61 Alandejani, "Does issuing Islamic bonds through banks increase banking efficiency?"

62 Ledhem, *Sustainability and Islamic Finance*.

63 Safiyah Taoual, *Economics Discussion Papers*, "Sukuk: A Potential for Stability and Development in the GCC", *Economics Discussion Papers*, (08 April 2016).

64 Mimouni et.al., "The Impact of Sukuk on the Performance of Conventional and Islamic Banks".

65 Smaoui - Ghouma, "Sukuk market development and Islamic banks' capital ratios".

66 Beck et.al., "Islamic vs. conventional banking"; Johnes et.al., "A comparison of the performance of Islamic and conventional banks 2004 to 2009"; Mollah - Zaman, "Shari'ah supervision, corporate governance and performance"; Bitar et.al., "What makes Islamic banks different?"

67 Mohamed et.al., "Why Do Issuers issue Sukuk or Conventional Bond?"

68 Zairihan Abdul Halim et.al., *Islamic Banking and Finance III*, "Agency costs and corporate sukuk issuance", *Pacific-Basin Finance Journal* 42 (01 April 2017), 83-95.

69 Paul-Olivier Klein - Laurent Weill, "Why Do Companies Issue Sukuk?", *Review of Financial Economics* 31/November (01 May 2016), 26-33.

70 Mamoru Nagano, "Who Issues Sukuk and When? An Analysis of the Determinants of Islamic Bond Issuance", *Review of Financial Economics* 31/C (2016), 45-55.

71 Rihab Grassa - Hela Miniaoui, "Corporate Choice between Conventional Bond and Sukuk Issuance Evidence from GCC Countries", *Research in International Business and Finance* 45/C (2018), 454-466.

between 2000 and 2015, aiming to identify factors influencing companies' decisions to issue sukuk or conventional bonds. As discerned from their empirical study, the size of financing needs and the length of maturity tend to steer companies towards sukuk issuance. There exists a positive correlation between credit quality and conventional bond issuance, whereas a negative correlation is observed with sukuk issuance. Additionally, Shahida and Saharah (2013)[72], investigated the reasons for preferring sukuk over conventional bonds and pointed to sukuk issuance experience, business size, and tax incentives. Azmat et al. (2014)[73] found that sukuk are perceived as safer by investors, contributing to their preference for conventional bonds.

Eventually, a significant area of comparison in the literature alongside sukuk issuances is Sharia-compliant equities. Many studies (Godlewski et al., 2014; Aloui et al., 2015a; Aloui et al., 2015b; Naifar, 2016; Naifar et al., 2016; Aloui et al., 2018; Mensi et al., 2020; Nasreen et al., 2020)[74] aim to identify the dynamic relationship and volatility spillover between these two financial instruments. Aloui et al. (2015b)[75] and Balli et al. (2022)[76] examined the volatility spillovers between the Sharia-compliant equity index and sukuk returns. They identified time-varying negative correlation and volatility spillovers between these financial instruments. Umar et al. (2023)[77], seeking to measure the impact of oil shocks on sukuk, bonds, and green bonds through volatility transmission, found that bonds and green bonds act as net transmitters of volatility, whereas sukuk act as net receivers of volatility. Maghyereh and Awartani (2016)[78] detected that stock volatility affects sukuk returns, but the sukuk market does not influence the stock market. In contrast, Godlewski et al. (2014)[79] analysed 131 sukuk issuances from 8 different countries and determined that companies issuing sukuk are positively affected by stocks. Similarly, Aloui et al. (2015a)[80] examined the relationship between Sharia-compliant stocks and sukuk using daily data from 5 countries in the OIC region, finding a strong dependency between them. Ashraf et al. (2021)[81] examined the impact of corporate governance and ownership structure on Sukuk issuance and found a positive relationship between public ownership share and sukuk issuance volume. Additionally, companies with high corporate governance practices, particularly those with a high number of independent board members, tend to have higher sukuk issuance volumes.

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72 S. Shahida - S. Saharah, "[PDF] Why Do Firms Issue Sukuk Over Bonds? Malaysian Evidence | Semantic Scholar" (15th Malaysian Finance Association Conference, Malaysia, 2013).

73 Saad Azmat et.al., "Issuer's Choice of Islamic Bond Type", *Pacific-Basin Finance Journal* 28/C (2014), 122-135.

74 Godlewski et.al., "(PDF) Do the Type of Sukuk and Choice of Shari'a Scholar Matter?"; Aloui et.al., "Co-movement between sharia stocks and sukuk in the GCC markets"; Aloui et.al., "Global factors driving structural changes in the co-movement between sharia stocks and sukuk in the Gulf Cooperation Council countries"; Nader Naifar, "Modelling dependence structure between stock market volatility and sukuk yields: A nonlinear study in the case of Saudi Arabia", *Borsa Istanbul Review* 16/3 (01 September 2016), 157-166; Naifar et.al., "Dependence Structure between Sukuk (Islamic Bonds) and Stock Market Conditions"; Chaker Aloui et.al., "Multivariate Co-Movement Between Islamic Stock and Bond Markets Among the GCC: A Wavelet-Based View", *Computational Economics* 52/2 (2018), 603-626; Walid Mensi et.al., "Does Bitcoin Co-Move and Share Risk with Sukuk and World and Regional Islamic Stock Markets? Evidence Using a Time-Frequency Approach", *Research in International Business and Finance* 53/C (2020); Samia Nasreen et.al., "A Wavelet-Based Analysis of the Co-Movement between Sukuk Bonds and Shariah Stock Indices in the GCC Region: Implications for Risk Diversification", *Journal of Risk and Financial Management* 13/4 (April 2020), 63.

75 Aloui et.al., "Global factors driving structural changes in the co-movement between sharia stocks and sukuk in the Gulf Cooperation Council countries".

76 Faruk Balli et.al., "Spillovers between Sukuks and Shariah-Compliant Equity Markets", *Pacific-Basin Finance Journal* 72/C (2022).

77 Zaghum Umar et.al., "The connectedness of oil shocks, green bonds, sukuks and conventional bonds", *Energy Economics* 119 (01 March 2023), 106562.

78 Maghyereh - Awartani, "Dynamic Transmissions between Sukuk and Bond Markets".

79 Godlewski et.al., "(PDF) Do the Type of Sukuk and Choice of Shari'a Scholar Matter?"

80 Aloui et.al., "Co-movement between sharia stocks and sukuk in the GCC markets".

81 Ashraf et.al., "Not one but three decisions in sukuk issuance".

Even while this study is not the first to examine sukuk issuances in Türkiye, it is unique in that it deviates from previous studies in a few ways. Only panel data analysis is employed in the studies of Öner (2022a, 2022b)[82] to investigate the factors influencing participation banks' sukuk issuances. Once more, Öner (2022c)[83] examined the impact of the COVID-19 pandemic on sukuk issuances of public and participation banks using similar macroeconomic variables through panel data analysis. Despite this, since all three of these studies are conducted through panel data analysis, it is not conducted the long-term and short-term relationships as well as causality analyses between the variables. As evidenced by the literature review, no studies have identified the factors influencing sukuk returns and issuance sizes from the perspective of causality and detecting their relationship among each other. To this end, the contributions of this study are as follows: First, this is the inaugural study to investigate the factors influencing sukuk return and issuance in Türkiye both in the short run and long run. Secondly, to the best of our knowledge, the deposit interest rate is examined for its impact on sukuk returns and sukuk issuance for the first time. Finally, our findings provide valuable insights for regulators, policymakers, and sukuk issuers to determine appropriate pricing strategies.

2. Data Set and Methodology

2.1. Data Set

This study aims to identify the factors influencing the sukuk returns and the size of the sukuk issuance. To this end, the variables employed in the analysis and their anticipated effects are shown in Table 1. In that instance, the data set source is also mentioned concurrently. The monthly data set covers a period from 2013M11 to 2024M4. More importantly, the data set is restricted to the sukuk data as the Participation Banks Association of Türkiye (TKBB) provided. Monthly data sets serve as the basis for the data set frequency for both dependent and independent variables. Due to the Sukuk issuance size being million/billion TL, the natural logarithm of the series was taken and included in the analysis. The Sukuk returns and Sukuk issuance size figures are derived from TKBB[84] statistics. The monthly sukuk return is computed as a weighted average of all issuance, and the sukuk issuance size is determined by adding together all of the issuance for each month. Monthly statistics on deposit interest, inflation, and the dollar exchange rate were also acquired from the Central Bank of Türkiye (TCMB)[85] database.

Table 1. Variables and Expected Signs

	Explanation	Source	Expected Sign
Sukuk Return	Weighted average return of Sukuk issuance in the relevant month	TKBB	Dependent Variable
Sukuk Issuance Size	Natural logarithm of the total Sukuk issuance in the relevant month	TKBB	+
Deposit Interest Rate	Average interest rate applied by conventional banks to monthly deposits	TCMB	+
Inflation	A monthly rise in the overall price level	TCMB	+
USD/TRY	Turkish Lira equivalent of US Dollar in the relevant month	TCMB	+

By constructing Equation 1 below, analyses were conducted to ascertain the elements influencing the sukuk return.

82 Muhammed Hadin Öner, "Sukuk İhraçlarının Belirleyicileri: Katılım Bankaları Üzerine Bir Uygulama", Gaziantep Üniversitesi Sosyal Bilimler Dergisi 21/4 (ts.), 2223-2238; Muhammed Hadin Öner, "Makroekonomik Değişkenlerin Sukuk (Kira Sertifikaları) Üzerindeki Etkileri: Panel Veri Analizi", İslam İktisadı ve Finansı Teorik ve Ampriik Çalışmalar (Ankara: Orion Akademei, 2022), 243-262.

83 Muhammed Hadin Öner, "COVID-19 Pandemisinin Kamu ve Katılım Bankalarının Sukuk (Kira Sertifikaları) İhraçları Üzerindeki Etkisi", Sosyal Bilimler Metinleri 2 (2022), 109-118.

84 TKBB, "Veri Peteği" (Access: 01 June 2024).

85 TCMB, "EVDS | Anasayfa" (Access: 01 June 2024).

$$Sukuk\ Return_t = \alpha_1 + \beta_2 Sukuk\ Issuance_t + \beta_3 Deposit\ Rate_t + \beta_4 Inflation_t \beta_3 + USD/TRY_t + \varepsilon_t \quad (1)$$

After constructing Equation 1, Table 2 reports the descriptive statistics of the series. The extreme values between the sukuk issuance data were brought closer together by taking the natural logarithm of the series, as the descriptive statistics demonstrate. The remaining variables are expressed as percentages; thus, their standard deviations are modest and their mean and median values are quite near. Moreover, the data set of 118 monthly observations did not exhibit a normal distribution based on Jarque-Bera results.

Table 2. Descriptive Statistics

	Sukuk Return	Sukuk Issuance (Ln)	Deposit Interest Rate	Inflation	USD/TRY
Mean	0.164084	21.23851	0.178746	0.246228	8.926996
Median	0.132500	21.73842	0.139400	0.124950	5.743826
Maximum	0.532800	23.21000	0.671400	0.855100	32.40000
Minimum	0.078500	16.86003	0.081600	0.065700	2.030000
Std. Dev.	0.083136	1.515072	0.105303	0.231015	8.048678
Skewness	2.057484	-0.577745	2.351940	1.360412	1.511233
Kurtosis	7.994710	2.158147	9.190177	3.356623	4.217844
Jarque-Bera	205.9104	10.04904	297.1868	37.02283	52.20734
Probability	0.000000	0.006575	0.000000	0.000000	0.000000
Observations	118	118	118	118	118

Table 2 illustrates how volatile all variables with very little variation between maximum and lowest values. The series' erratic structure is an insightful representation of the economic overview of Türkiye. This unstable structure can be attributed to the Gezi Park Protest, the Coup Attempt, the COVID-19 Pandemic effects, and the shifts in economic policies from 2013 to 2024. Sukuk issuance data fluctuated over the relevant era, but they always followed an upward route. In contrast, deposit interest, inflation, and the dollar exchange rate all showed a constant upward tendency during that time. The variables will conform to a normal distribution if the skewness value is 0 (zero) and the kurtosis value is 3 (three). The examined variables have skewness values ranging from -0.57 to 2.35. Because of this, the values of all variables are positive and skewed to the right, whereas the distribution of the sukuk issuance size is negative and slanted to the left. Kurtosis values of the variables vary between 2.15 and 9.19. Consequently, at varying periods, all of the variables have steeper distributions than the regular ones. During this period, the lowest dollar exchange rate was determined as 2.03 TL, the deposit interest was defined as the lowest 8%, the inflation was the lowest 6.5%, and the sukuk return was chosen as the minimum 7.85%. In the same time frame, inflation reached 85%, deposit interest rose to 67%, and the dollar exchange rate increased to a maximum of 32.4 TL. The dollar rate was found to be 8.92 TL on average over the analysis period, while inflation was 24%, deposit interest was 17%, and the sukuk return was 16%.

2.2. Methodology

2.2.1. Autoregressive Distributed Lag

The Autoregressive Distributed Lag (ARDL) method aids in understanding the existence and nature of potential long-term equilibrium relationships between variables with varying integration levels by allowing the dependent variable to be explained using both the independent variable's historical data and its lagged values within the same model. Whether the independent variables are I(0) or I(1) is irrelevant (Shahbaz et al., 2013:12)[86].

[86] Shahbaz et.al., "Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia".

Nonetheless, it may be argued that one significant restriction is that none of the model's variables should be I(2) (Göksu, 2023:228; Akçay, 2022: 41; Balkı, 2013; 151)[87]. If not, the consistency of the model will be compromised. To detect the effects of independent variables on the dependent variable, the ARDL model is developed in Equation 2.

$$\Delta Sukuk\ Return_t = \varphi_0 + \varphi_1 dummy + \sum_{i=1}^{p=4} \varphi_{2i}\, \Delta Sukuk\ Return_{t-i} + \sum_{j=0}^{r=0} \varphi_{3j}\, \Delta Sukuk\ Issuance\ Size_{t-j} + \sum_{k=0}^{s=3} \varphi_{4k}\, \Delta Deposit\ Rate_{t-k} + \sum_{l=0}^{t=4} \varphi_{5l}\, \Delta Inflation_{t-l} + \sum_{l=0}^{y=4} \varphi_{6m}\, \Delta USD/TRY_{t-m} + \beta_1 Sukuk\ Return_{t-1} + \beta_2 Sukuk\ Issuance\ Size_{t-1} + \beta_3 Deposit\ Rate_{t-1} + \beta_4 Inflation_{t-1} + \beta_5 USD/TRY_{t-1} + \varepsilon_t \quad (2)$$

In equation 2, "Δ" shows the difference operator, "ε_t" error term, "*p, r, s, t, y*" lag lengths, "φ_0" constant term, "$\varphi_2, \varphi_3, \varphi_4, \varphi_5, \varphi_6$" short-term coefficients and "$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$" indicates long-term coefficients. F_{PSS} ve t_{BDM} bounds tests will be used to ascertain the cointegration relationship between the variables. The null and alternative hypotheses of the F_{PSS} bounds test for the model are as follow: $H_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$ and $H_A = \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$. The null and alternative hypotheses of the t_{BDM} bound test models are also as follow: $H_0 = \beta_1 = 0$ ve $H_A = \beta_1 \neq 0$. Pesaran et al. (2001)[88] provided the bound test statistics for each of these tests, which were then compared, for a restricted sample, with the lower and upper limit critical values determined by Narayan (2005)[89]. Equation 3 below illustrates the error correction models that will be used to determine the short-term and ECT coefficients of model.

$$\Delta\ Sukuk\ Return_t = \varphi_0 + \varphi_1 dummy + \sum_{i=1}^{p=4} \delta_{2i}\, \Delta Sukuk\ Return_{t-i} + \sum_{j=0}^{r=0} \delta_{3j}\, \Delta Sukuk\ Issuance\ Size_{t-j} + \sum_{k=0}^{s=3} \delta_{4k}\, \Delta Deposit\ Rate_{t-k} + \sum_{l=0}^{t=4} \delta_{5l}\, \Delta Inflation_{t-l} + \sum_{l=0}^{y=4} \delta_{6m}\, \Delta USD/TRY_{t-m} + \varphi_2 ECT_{t-1} + \tau_t \quad (3)$$

In equation 3, "Δ" shows the first difference, "τ" error term, "*p, r, s, t, y*" lag length, "φ_0" constant coefficient, "δ" short-term coefficients and ECT_{t-1} represents the error correction term. It is expected that the φ_2 coefficient/value is negative and the probability value is less than 0.05.

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87 Serkan Göksu, "Türkiye'de Katılım Bankalarınca Sağlanan Finansman Türlerinin Ekonomik Büyüme Üzerine EtkisiThe Effect of Financing Types Provided by Participation Banks in Türkiye on Economic Growth", *Kocatepe İslami İlimler Dergisi* 6 (09 October 2023), 217-237; Selçuk Akçay, "Remittances and Income Inequality in the Philippines", *Asian-Pacific Economic Literature* 36/1 (2022), 30-47; Ali Balkı, "Katılım Bankacılığı ve Geleneksel Bankacılık ile Ekonomik Büyüme İlişkisinin Karşılaştırmalı Analizi: Türkiye Örneği / Comparative Analysis of the Relationship between Economic Growth and Participation Banking, and Traditional Banking: Türkiye Example", *Kocatepe İslami İlimler Dergisi* 6 (09 October 2023), 141-160.

88 M. Hashem Pesaran et.al., "Bounds Testing Approaches to the Analysis of Level Relationships", *Journal of Applied Econometrics* 16/3 (2001), 289-326.

89 Paresh Narayan, "The Saving and Investment Nexus for China: Evidence from Cointegration Tests", *Applied Economics* 37 (01 February 2005), 1979-1990.

Finally, obtaining the best lag length is the first step of implementing Toda and Yamamoto's (1995)[90] Granger causality analysis approach, which will be used to ascertain the causal relationship between variables. After that, the maximum degree of integration is added to this lag length to estimate the VAR model. The following is an expression for the VAR model employed in this study:

$$Sukuk\ Return_t = \gamma_0 + \sum_{i=1}^{k+d_{max}} \gamma_{1i}\, Sukuk\ Return_{t-i} + \sum_{i=1}^{k+d_{max}} \vartheta_{1i}\, Sukuk\ Issuance\ Size_{t-i} + \sum_{i=1}^{k+d_{max}} \alpha_{1i}\, Deposit\ Rate_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{1i}\, Inflation_{t-i} + \sum_{i=1}^{k+d_{max}} \omega_{1i}\, USD/TRY_{t-i} + \mu_{1t} \quad (4)$$

Tables and figures will be used to describe the ensuing relationship between variables when this created model is tested once more, with each variable acting as a dependent variable.

2.2.2. Toda-Yamamoto Causality Test

The Toda-Yamamoto causality test was introduced to the literature in 1995 as an advanced version of the causality test developed by Granger in 1969. This method utilizes vector autoregressive (VAR) models, constructed with the lagged values of variables that allow for the investigation of dynamic relationships between variables. The series must be stationary since studies using non-stationary data may result in spurious causality. Information is lost when non-stationary series become stationary by taking their first or second differences. The Granger causality test can likewise be implemented to examine the cointegration between distinct series that are not stationary at the level. It is evident that if there is a cointegration between any of the variables, the F-statistic, that is employed in the Granger causality test, loses its validity because it fails to correspond to the normal distribution. Toda-Yamamoto causality test in response to the aforementioned issues. This analysis is based on the VAR model and enables the causality relationship between variables to be estimated using lagged values and the Wald test, without considering the stationarity level and the cointegration relationship between the series. (Toda and Yamamoto, 1995:227; Gazel, 2017:291)[91]. To this end, the Toda-Yamamoto model is a variant of the Granger causality test that could be deployed irrespective of whether a series is I(0), I(1), or I(2), cointegrated or not to any level, (Jain and Ghosh, 2013:90)[92].

A regular Toda-Yamamoto Causality test includes Y and X variables that could be established for the estimation of VAR (k+d_{max}) model below:

$$Y_t = \varphi + \sum_{i=1}^{k} \alpha_{1i} x_{t-i} + \sum_{i=1}^{k} \beta_{1i} y_{t-i} + \sum_{j=k+1}^{d_{max}} \sigma_{1i}\, x_{t-i} + \sum_{j=k+1}^{d_{max}} \vartheta_{1i}\, y_{t-i} + \varepsilon_{1t} \quad (5)$$

$$X_t = \omega + \sum_{i=1}^{k} \alpha_{2i} x_{t-i} + \sum_{i=1}^{k} \beta_{2i} y_{t-i} + \sum_{j=k+1}^{d_{max}} \sigma_{2i}\, x_{t-i} + \sum_{j=k+1}^{d_{max}} \vartheta_{2i}\, y_{t-i} + \varepsilon_{2t} \quad (6)$$

3. Empirical Findings

[90] Hiro Y. Toda - Taku Yamamoto, "Statistical inference in vector autoregressions with possibly integrated processes", *Journal of Econometrics* 66/1 (01 March 1995), 225-250.

[91] Hiro Y. Toda - Taku Yamamoto, "Statistical inference in vector autoregressions with possibly integrated processes", Journal of Econometrics 66/1 (01 Mart 1995), 225-250; Sümeyra Gazel, "BİST Sınai Endeksi ile Çeşitli Metaller Arasındaki İlişki: Toda-Yamamoto Nedensellik Testi", Akademik Sosyal Araştırmalar Dergisi 5/52 (2017), 287-299.

[92] Anshul Jain - Sajal Ghosh, "Dynamics of global oil prices, exchange rate and precious metal prices in India", Resources Policy 38/1 (2013), 88-93.

Spurious regression can arise from non-stationary time series with stochastic-variable-random trend effects. Consequently, analysis conducted in the absence of this random trend would provide inaccurate findings. Additionally, unit root testing is also essential in choosing the appropriate analysis technique. The classic unit root test, the Phillips-Perron (PP) is carried out in the present study. Furthermore, the Lee-Strazicich (LS) unit root test is also used, to identify potential structural breaks in the series.

PP unit root test results are presented in Table 3. Inference from these findings, all models with constant, constant and trend, and no constant- no trend exhibit that the dependent variable, the Sukuk Return, is non-stationary at the level. When the first difference of this variable is taken, it becomes stationary for all models. The sukuk issuance size variable is stationary in the model with constant and trend, but not stationary at the level for the rest models 1% significance level. It is evident that almost all of the independent variables are I(1). To get inconsistent findings concerning the variables and account for structural breakdowns in the unit root test, the LS unit root test was also utilised.

Tablo 3. Phillips-Perron Unit Root Test Results

PP	**Constant**		**Constant and Trend**		**No Constant and Trend**	
Level	t-Statistic	Prob.	t-Statistic	Prob.	t-Statistic	Prob.
Sukuk Return	2.5647	1.0000	1.0397	0.9999	2.7946	0.9987
Sukuk Issuance	-2.2654	0.1850	**-6.7315*** **	0.0000	1.6772	0.9770
Deposit Interest Rate	4.7612	1.000	3.3388	1.0000	3.5191	0.9999
Inflation	-0.7895	0.8181	-2.1478	0.5137	0.1734	0.7348
USD/TRY	4.8771	1.0000	1.5776	1.0000	6.8797	1.0000
First Difference						
Δ(Sukuk Return)	-10.5071***	0.0000	-10.7806***	0.0001	-10.3219***	0.0000
Δ(Sukuk Issuance)	-49.9653***	0.0000	-77.7735***	0.0000	-20.9267***	0.0000
Δ(Deposit Interest Rate)	-4.2690***	0.0008	-4.9492***	0.0005	-3.8828***	0.0001
Δ(Inflation)	--5.6241***	0.0000	-5.6524***	0.0000	-5.5630***	0.0000
Δ(USD/TRY)	-6.2693***	0.0000	-6.7829***	0.0000	-5.5104***	0.0000

Note: "***", shows %1 significance level.

The variables sukuk return, deposit interest rate, and USD/TRY are stationary at first difference. In contrast, the Sukuk issuance size and inflation are stationary at the level, in alignment with the findings of the LS unit root test shown in Table 4 below. Beyond that, Table 4 reports the structural break periods that are present in the series.

Table 4. Lee-Strazicich Unit Root Test Results

Variables	**At Level**			**First Difference**			**Decision**
	Lag	**Break Point**	**t-statistic**	**Lag**	**Break Point**	**t-statistic**	
Sukuk Return	3	2023M02-2023M04	-1.635613	2	2019M05-2022M08	-3.809784**	I(1)
Sukuk Issuance	1	2017M07-2019M02	-5.609659***		-	-	I(0)
Deposit Interest Rate	3	2022M12-2023M2	-1.263057	4	2018M09-2020M11	-2.55004***	I(1)
Inflation	4	2021M11-2022M03	-3.749200**	-	-	-	I(0)
USD/TRY	3	2021M12-2022M02	-1.836195	2	2021M10-2022M02	-5.051459***	I(1)

Note: "***", shows significant at %1; "**", is significant at %5.

The two unit root tests provide the same decision, resulting in the variables being stationary at various levels and no stationary variable in second differences "I(2)". Thus, the ARDL approach is employed as a technique since the variables are stationary at different levels. Finding the maximum lag length is a prerequisite to using this method. Due to the fact the data set is monthly, the maximum lag length is determined as 8. The best-fitted model, as identified by the Akaike Information Criterion (AIC), is (4, 0, 3, 4, 4). F_{PSS} and t_{BDM} tests were performed to examine potential cointegration relationships between the variables after selecting the best-suited lag lengths. The findings are shown in Table 5. At the 1% significance level, there is a cointegration between the variables in the model used to discover the variables impacting the sukuk return. These findings suggest that the variables will eventually move in tandem and that their linear combinations will converge at equilibrium.

Table 5. ARDL Bound Test Results

Model			
$f\,(sukuk\ retun \mid Sukuk\ Issuance\ (\ln), deposit\ interest\ rate, inflation, USD/TRY\ )$			
ARDL (4, 0, 3, 4, 4) k:4 m:4			
F_{PSS} : 10.3941***		Co-integrated	
t_{BDM}: -6.770207***			
F Critical Values n=1.000		F Critical Values n=80	
I(0)	**I(1)**	**I(0)**	**I(1)**
2.45	3.53	2.548	3.644
2.86	4.01	3.01	4.216
3.74	5.06	4.096	5.512

Notes: The models were estimated based on case #III. k: number of independent variables; m: lag value; n: number of observations; "***" shows %1; "**" shows %5 significance level.

Upon analysis of Table 6, which represents the long-term coefficient estimates for the models, it can be observed that all coefficients in the model developed to ascertain the factors influencing the sukuk return exhibit significance at 1%. The Dollar exchange rate is the sole variable that deviates from the expected sign values shown in Table 1. The coefficient of USD/TRY is around -0.003, meaning that a 1% increase in the USD/TRY exchange rate results in a 0.0031% decrease in the Sukuk returns. This implies that a rise in the dollar exchange rate harms the return of Sukuk. Alternatively, the sukuk return might benefit from the decline in the value of the USD/TRY currency. In ARDL estimation based on long-term coefficients, deposit interest is the most important variable affecting the sukuk return. The sukuk return will grow by 0.83% for every 1% increase in deposit interest. As a result, sukuk return might decline in the days ahead if deposit interest rates decrease.

Tablo 6. Long Run Form Coefficient

Variable	**Coefficient**	**t-statistic**	**Probability**
Sukuk Issuance (Ln)	0.005552***	5.898515	0.0000
Deposit Interest Rate	0.834277***	31.00772	0.0000
Inflation	0.070606***	5.720455	0.0000
USD/TRY	-0.003153***	-4.952626	0.0000

Not: "***", shows significance at %1.

Table 7 shows the short-term forecast results obtained from the models. The error correction term of the model is negative and statistically significant. A negative coefficient

means that 75% of a shock will occur in the short term and will disappear in the long term. The coefficient sign of the dummy variable included in the model is not as negative as expected and is not statistically significant. Not only the lagged values of the dependent variable up to three periods but also the coefficient values of independent variables are statistically significant and distinguished as positive and negative in the model.

Tablo 7. Short Run Form Coefficient (Error Correction Regression)

Model	Coefficient	t-statistic	Probability
C	-0.068817***	-7.268008	0.0000
Δ(Sukuk Return) $_{t-1}$	0.017679	0.166853	0.8678
Δ(Sukuk Return) $_{t-2}$	0.518231***	5.123433	0.0000
Δ(Sukuk Return) $_{t-3}$	0.203902***	4.337160	0.0000
Δ(Deposit Interest Rate)	0.677653***	11.52543	0.0000
Δ(Deposit Interest Rate) $_{t-1}$	0.441711***	3.906135	0.0002
Δ(Deposit Interest Rate) $_{t-2}$	-0.726062***	-5.267545	0.0000
Δ(lnflation)	0.058707*	1.866829	0.0651
Δ(lnflation) $_{t-1}$	0.018075	0.519379	0.6047
Δ(Inflation) $_{t-2}$	0.143592***	4.123621	0.0001
Δ(lnflation) $_{t-3}$	-0.081298***	-2.857594	0.0053
Δ(USD/TRY)	-0.001393	-0.870223	0.3864
Δ(USD/TRY) $_{t-1}$	0.001246	0.594072	0.5539
Δ(USD/TRY) $_{t-2}$	-0.006487***	-2.983975	0.0036
Δ(USD/TRY) $_{t-3}$	-0.003009	-1.550059	0.1245
Dummy	0.005264	0.602400	0.5484
ECT $_{t-1}$	-0.750507***	-7.362213	0.0000

Note: "***" shows %1; "**" shows %5 and "*" shows %10 significance level.

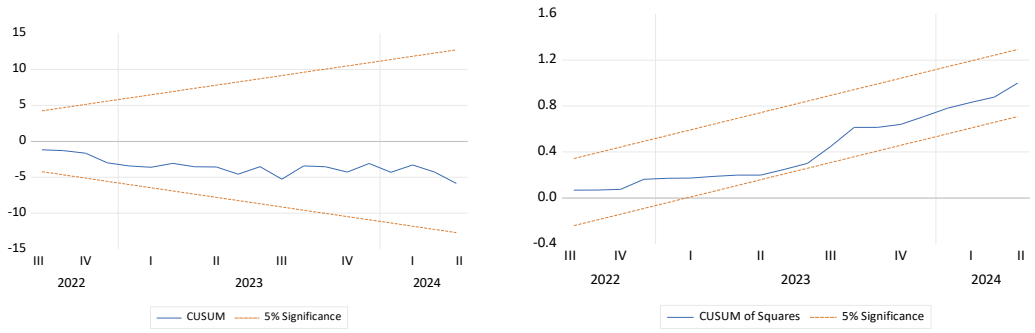
The diagnostic test results are listed in Table 8. These findings show no autocorrelation and heteroscedasticity problems in the model. The functional form structure of the model is properly developed, and the series is suitable for a normal distribution.

Tablo 8. Diagnostic Test Results

Diagnostic Test	Statistics	
	Test Value	Prob.
X^2_{SC}	0.515798	0.7727
X^2_{FF}	6.793719	0.1628
$X^2_{NORM\ (J\text{-}B)}$	0.509313	0.5093
$X^2_{HET(ARCH)}$	1.686271	0.1014
$X^2_{HET(BPG)}$	31.16546	0.0530

The model's parameters are stable, as seen in Figure 1, since the CUSUM and CUSUMSQ values stay within the 95% confidence interval. These findings demonstrate the validity of the short- and long-term coefficient estimates produced for the established models.

Figure 1. CUSUM and CUSUMSQ Graphs



The ARDL bounds test outcomes demonstrate a long-term correlation between the size of the sukuk issuance, inflation, deposit interest, USD/TRY and the sukuk return. However, this result does not give an idea about the direction of the relationship. To figure out the causality relationship between sukuk issuance and sukuk return with macroeconomic variables, the causality test is also examined. The primary objective of causality analysis is to enhance the understanding of the interactions between variables and detect the direction of their relationships. The Toda-Yamamoto causality test is preferred to determine the direction of the relationship because the variables in the model are not stationary at the same level. The first step for this test is to determine the optimal lag length structure. The most appropriate lag length for the series was determined as 4. The highest degree of integration of the series is dmax = 1; thereby, given the findings of the unit root test, it emerged that the $k+d_{max}$ level required for the causality test should be 5. Table 8 below illustrates the findings obtained after adjusting for these factors.

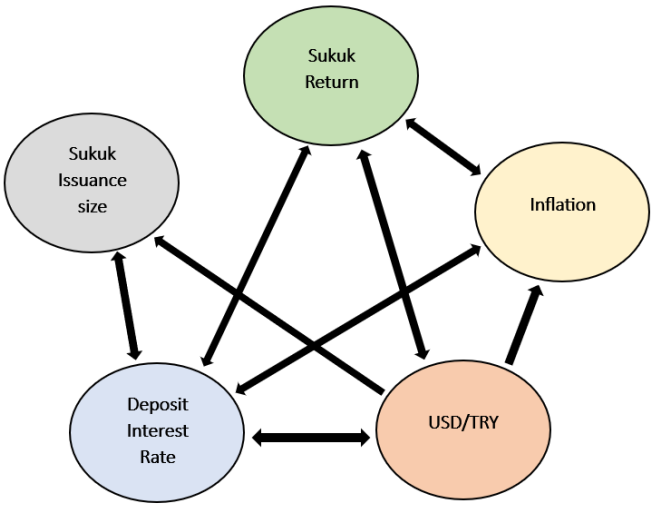
Tablo 8. Toda-Yamamoto Causality Test Results

Null Hypothesis	$k+d_{max}$	Wald Statistic	p Value	Decision	Direction of Causality
Sukuk Issuance Size ⇏Sukuk Return	4+1=5	1.240722	0.8713	H_0: Not Rejected	Sukuk Issuance Size⇏Sukuk Return
Sukuk Return ⇏ Sukuk Issuance Size	4+1=5	7.541134	0.1099	H_0: Not Rejected	Sukuk Return ⇏ Sukuk Issuance Size
Deposit Interest Rate⇏Sukuk Return	4+1=5	248.9855***	0,0000	H_0 Reject	Deposit Interest Rate⇔ Sukuk Return
Sukuk Return⇏ Deposit Interest Rate	4+1=5	28.09010***	0.0000	H_0 Reject	
Inflation ⇏ Sukuk Return	4+1=5	26.34542***	0,0000	H_0 Reject	Inflation ⇔ Sukuk Return
Sukuk Return ⇏ Inflation	4+1=5	22.83654***	0.0002	H_0 Reject	
USD/TRY ⇏ Sukuk Return	4+1=5	10.48192**	0.0330	H_0 Reject	USD/TRY ⇔ Sukuk Return
Sukuk Return ⇏ USD/TRY	4+1=5	17.09254***	0.0019	H_0 Reject	
Deposit Interest Rate ⇏ Sukuk Issuance Size	4+1=5	8.936477*	0.0627	H_0 Reject	Sukuk Issuance Size ⇔ Deposit Interest Rate
Sukuk Issuance Size ⇏ Deposit Interest Rate	4+1=5	10.48192**	0.0330	H_0 Reject	
Inflation ⇏ Sukuk Issuance Size	4+1=5	4.411684	0.3531	H_0: Not Rejected	Inflation ⇏ Sukuk Issuance Size
Sukuk Issuance Size ⇏ Inflation	4+1=5	6.138930	0.1890	H_0: Not Rejected	Sukuk Issuance Size ⇏Inflation
USD/TRY ⇏ Sukuk Issuance Size	4+1=5	8.461106*	0.0761	H_0 Reject	USD/TRY ⇒ Sukuk Issuance Size
Sukuk Issuance Size ⇏ USD/TRY	4+1=5	3.917310	0.4173	H_0: Not Rejected	Sukuk Issuance Size ⇏ USD/TRY
Inflation ⇏ Deposit Interest Rate	4+1=5	13.77118***	0.0081	H_0 Reject	Inflation ⇔ Deposit Interest Rate
Deposit Interest Rate ⇏ Inflation	4+1=5	20.46746***	0,0004	H_0 Reject	

USD/TRY ⇏ Deposit Interest Rate	4+1=5	17.18842***	0.0018	H_0 Reject	USD/TRY ⇔ Deposit Interest Rate
Deposit Interest Rate ⇏ USD/TRY	4+1=5	10.84405**	0.0284	H_0 Reject	
USD/TRY ⇏ Inflation	4+1=5	71.72438***	0.0000	H_0 Reject	USD/TRY ⇒ Inflation
Inflation ⇏ USD/TRY	4+1=5	4.245144	0.3738	H_0: Not Rejected	Inflation ⇏ USD/TRY

The outcomes of the Toda-Yamamoto Causality test reveal that there is no causality between the sukuk issuance size and the sukuk return. Hence, rejecting the null hypothesis for these two variables was impossible. The two variables do not have a bidirectional connection between them. This means that the sukuk return is unaffected by the sukuk issuance size. Likewise, the sukuk return does not affect the sukuk issuance size. Despite this, the sukuk return is impacted by inflation, deposit interest, and the USD/TRY exchange rate. These factors and the sukuk return are causally related in both directions. The relationship between sukuk and inflation can be analysed through the lens of deposit interest rates. As deposit interest rates are typically adjusted in response to inflationary pressures, increases in these rates also exert upward pressure on sukuk returns. This is because investors seek to preserve their purchasing power by demanding returns that at least match the rate of inflation. Consequently, this dynamic leads to a rise in the expected returns on sukuk, as issuers must offer more competitive yields to attract investment in an inflationary environment. The linear relationship between the dollar and inflation also provides sufficient evidence to explain the findings. This correlation suggests that fluctuations in the value of the dollar can directly influence inflationary trends, offering a robust framework for interpreting the results obtained in the study. In this context, the unidirectional causality from the dollar to inflation highlights that increases in the value of the dollar lead to rising costs, which ultimately result in higher inflation. The relationship between the dollar exchange rate and inflation, both of which are key determinants of sukuk return, is closely monitored by sukuk investors. This dynamic also impacts the size of sukuk issuances, as changes in these variables can influence investor demand and the cost of issuance in the market.

Figure 1. Direction of Causality



Source: Designed by author

The USD/TRY exchange rate influences sukuk issuance size, but the exchange rate is unaffected by issuance size. Increases in the dollar exchange rate also raise the price of the

underlying assets supporting sukuk issuances, thereby facilitating an increase in sukuk issuance volumes. As the value of these underlying assets rises, issuers may find it more favourable to raise funds through sukuk, leading to higher issuance amounts in response to the asset price appreciation driven by currency fluctuations. As can be detected from Figure 1, there is a bidirectional causality between deposit interest and Sukuk issuance. A similar situation arises with increases in deposit interest rates, which play a significant role in determining investors' expected returns from alternative investment instruments. As deposit rates rise, they create a benchmark for investors, influencing their return expectations across various asset classes and prompting a reassessment of the attractiveness of different investment opportunities. Apart from this, no factor affects the size of Sukuk issuance. These findings conflict with the findings of Smaoui and Khawaja, (2016)[93] and Smaoui et al., (2017)[94], Öner (2022a, 2022b)[95] nonetheless it is consistent with the findings of Echchabi et al. (2016)[96], Billah et. al. (2023)[97], Suriani et. al. (2021)[98], Öner (2022c)[99] and Naifar and Mseddi (2013)[100]. To this end, examining the impact of macroeconomic variables like Dollar currency, inflation, deposit interest rate on sukuk return and sukuk issuance is imperative for the government. Numerous potential outcomes will emerge when attention is directed toward the findings. Sukuk can help alleviate inflationary pressures by providing an alternative investment tool in terms of returns. Also, Sukuk is offered in the form of payment against traditional deposit interest amounts, the demand for goods and services might be balanced or found, hence inflation was present. Through the issuance of sukuk, the savings of those with Islamic sensitivities will also be integrated into the economy, thereby enhancing the diversity of resources within the financial ecosystem. A reduction in the cost of financing for individuals and companies in need of funds will result from this improved resource diversity, encourage more investment and support economic growth.

Conclusion

This study aimed to determine the factors that are likely to affect sukuk returns and sukuk issuance sizes. In this instance, a monthly data set from 2013 to 2024 is utilised for the analyses. The different levels of stationarity for variables indicated the use of the ARDL model, as demonstrated by the PP unit root test results. Furthermore, the Lee-Strazicich unit root test was applied to detect potential structural breaks within the sequence. Certain variables became stationary at level; some became stationary after getting the first difference due to these tests. The ARDL model has proper conditions since none of the variables became stationary at I(2). The ARDL model indicates a significant relationship and cointegration between all the variables, also the series are cointegrated. Based on the bounds test, the constructed model is significant at the 1% significance level. On top of that, a significant positive relationship between Sukuk returns and deposit interest, inflation, sukuk issuance size might be stated by assessing the long-term coefficients. Only the USD/TRY exchange rate negatively affects sukuk returns according to long-term coefficients. Moreover, the coefficient of error correction model is negative and significant which is developed to get the short-term

93 Smaoui - Khawaja, "The Determinants of Sukuk Market Development".

94 Smaoui et.al., "Sukuk, Banking System, and Financial Markets".

95 Muhammed Hadin Öner, "Sukuk İhraçlarının Belirleyicileri: Katılım Bankaları Üzerine Bir Uygulama"; Muhammed Hadin Öner, "Makroekonomik Değişkenlerin Sukuk (Kira Sertifikaları) Üzerindeki Etkileri: Panel Veri Analizi"

96 Echchabi et.al., "Does Sukuk Financing Promote Economic Growth an Emphasis on The Major Issuing Countries".

97 Billah Syed Mabruk et.al., "Sukuk and Bond Dynamics in Relation to Exchange Rate", International Journal of Islamic and Middle Eastern Finance and Management 16/3 (2023), 621-646.

98 Suriani Suriani et.al., "Sukuk and Monetary Policy Transmission in Indonesia: The Role of Asset Price and Exchange Rate Channels", Journal of Islamic Accounting and Business Research 12/7 (03 Eylül 2021), 1015-1035.

99 Muhammed Hadin Öner, "COVID-19 Pandemisinin Kamu ve Katılım Bankalarının Sukuk (Kira Sertifikaları) İhraçları Üzerindeki Etkisi".

100 Nader Naifar - Slim Mseddi, "Sukuk spreads determinants and pricing model methodology", *Afro-Asian Journal of Finance and Accounting* 3/3 (2013), 241-257.

coefficients. ECM model indicated that 75% of a shock occurred in the short term and these shocks will disappear in the long term.

Ultimately, once determining the factors affecting sukuk returns, the Toda-Yamamoto causality test was applied to detect the direction of each variable. As a result of the causality tests examining the relationship between all variables, no statistical causality relationship could be detected between Sukuk returns and Sukuk issuance size. It may be concluded from this finding that sukuk issuance size does not cause sukuk returns, but neither do sukuk returns cause sukuk issuance size. Conversely, there is a bidirectional causality relationship between the sukuk returns and dollar exchange rate, inflation, and deposit interest rates. Besides that, the deposit interest rate and the USD/TRY exchange rate are the factors that influence the size of the Sukuk issuance. Hence, the size of Sukuk issuance is determined by changes in deposit interest and currency rates. This biased outcome suggests that the dollar exchange rate and the deposit interest structure have a greater influence on the size of sukuk issuances than the sukuk return.

The findings are important for both policymakers and investors. It is evident that governments and companies must have to follow deposit interest rates, which is the primary criterion for Sukuk issuance. The most significant finding of the study is that sukuk returns could potentially be forecast by monitoring the deposit interest rate that is determined by the policy rate. Additionally, following the finding that the size of the Sukuk issuance has no discernible impact on sukuk returns, it is advised that sukuk investors track changes in the dollar exchange rate. Sukuk investors might benefit from declines in the currency rate brought on by the healthy development of Türkiye's reserves. More importantly, sukuk issuers can increase their profits by constantly monitoring inflation when determining sukuk returns. The main limitation of this study is the number of observations due to the monthly data set. In future studies, researchers are recommended to compare the issuance size and returns of sukuk issued by the state and private sector sukuk. It is also feasible to inquire about how the maturity structures of sukuk impact its issuance size and yield.

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References

AAOIFI. "Accounting and Auditing Organization for Islamic Financial Institutions". Access 01 June 2024. https://aaoifi.com/ss-17-investment-sukuk/?lang=en

Abdullah, A.M. et.al. "The Impact of Crude Oil Price on Islamic Stock Indices of South East Asian Countries: Evidence from MGARCH-DCC and Wavelet Approaches". *Borsa Istanbul Review* 16/4 (01 December 2016), 219-232. https://doi.org/10.1016/j.bir.2015.12.002

Ahmad, Nursilah et.al. "Economic Forces and the Sukuk Market". *Procedia - Social and Behavioural Sciences* 65 (01 December 2012), 127-133. https://doi.org/10.1016/j.sbspro.2012.11.101

Ahmad, Nursilah - Muda, Muhamad. "Exchange Rate Pass-through Estimates for Sukuk Issuing Countries". *Procedia Economics and Finance* 7 (2013), 134-139. https://doi.org/10.1016/S2212-5671(13)00227-X

Ahmad, Wahida - Radzi, Rafisah. "Sustainability of Sukuk and Conventional Bond during Financial Crisis: Malaysia's Capital Market". *Glob. Econ. Financ. J.* 4 (2011), 1-14.

Ahmed, Habib - Khan, Tariqullah. "Risk Management in Islamic Banking". *Chapters*. https://ideas.repec.org//h/elg/eechap/3621_10.html

Akçay, Selçuk. "Remittances and Income Inequality in the Philippines". *Asian-Pacific Economic Literature* 36/1 (2022), 30-47. https://doi.org/10.1111/apel.12346

Akhtar, Shumi M. et.al. *Intensity of Volatility Linkages in Islamic and Conventional Markets* (SSRN Scholarly Paper, 29 December 2016). Social Science Research Network. Access 30 June 2024. https://doi.org/10.2139/ssrn.2906546

Alandejani, Maha. "Does issuing Islamic bonds through banks increase banking efficiency?" *Heliyon* 8/8 (01 August 2022), e10041. https://doi.org/10.1016/j.heliyon.2022.e10041

Alnaggar, Ahmed et.al. "The Challenges of Developing the Saudi Sukuk Market in Line with Objectives of Vision 2030". 987-1010, 2021. https://doi.org/10.1007/978-3-030-69221-6_76

Aloui, Chaker et.al. "Co-movement between sharia stocks and sukuk in the GCC markets: A time-frequency analysis". *Journal of International Financial Markets, Institutions and Money* 34/C (2015a), 69-79.

Aloui, Chaker et.al. "Global factors driving structural changes in the co-movement between sharia stocks and sukuk in the Gulf Cooperation Council countries". *The North American Journal of Economics and Finance* 31/C (2015b), 311-329.

Aloui, Chaker et.al. "Multivariate Co-Movement Between Islamic Stock and Bond Markets Among the GCC: A Wavelet-Based View". *Computational Economics* 52/2 (2018), 603-626.

Al-Raeai, Arafat et.al. "The Influence of Macroeconomics Factors and Political Risk on the Sukuk Market Development in Selected GCC Countries: A Panel Data Analysis (Pengaruh Faktor Makroekonomi dan Risiko Politik ke atas Pembangunan Pasaran Sukuk di Negara GCC Terpilih: Analisis Data Panel)". *Jurnal Ekonomi Malaysia* 53/2 (23 October 2019). https://doi.org/10.17576/JEM-2019-5302-15

Aman, Ameenullah et.al. "Factors affecting sukuk market development: empirical evidence from sukuk issuing economies". *International Journal of Islamic and Middle Eastern Finance and Management* ahead-of-print (16 December 2021). https://doi.org/10.1108/IMEFM-03-2020-0105

Ariff, Mohamed et.al. "Significant Difference in the Yields of Sukuk Bonds versus Conventional Bonds". *Journal of Emerging Market Finance* 16 (01 August 2017), 115-135. https://doi.org/10.1177/0972652717712352

Ashraf, Dawood et.al. "Not one but three decisions in sukuk issuance: Understanding the role of ownership and governance". *Pacific-Basin Finance Journal* 69 (01 August 2020), 101423. https://doi.org/10.1016/j.pacfin.2020.101423

Azmat, Saad et.al. "Issuer's Choice of Islamic Bond Type". *Pacific-Basin Finance Journal* 28/C (2014), 122-135.

Bacha, Obiyathulla - Mirakhor, Abbas. "Funding development infrastructure without leverage: A risk-sharing alternative using innovative sukuk structures". *The World Economy* 41/3 (20 June 2017), 752-762. https://doi.org/10.1111/twec.12512

Bakang, Marlyse Linda Ngo. "Effects Of Financial Deepening on Economic Growth In". *International Journal of Business and Commerce* 4/7 (ts.), 1-50.

Balkı, Ali. "Katılım Bankacılığı ve Geleneksel Bankacılık ile Ekonomik Büyüme İlişkisinin Karşılaştırmalı Analizi: Türkiye Örneği / Comparative Analysis of the Relationship between Economic Growth and Participation Banking, and Traditional Banking: Türkiye Example". *Kocatepe İslami İlimler Dergisi* 6 (09 October 2023), 141-160. https://doi.org/10.52637/kiid.1353457

Balli, Faruk et.al. "Spillovers between Sukuks and Shariah-Compliant Equity Markets". *Pacific-Basin Finance Journal* 72/C (2022). https://ideas.repec.org//a/eee/pacfin/v72y2022ics0927538x22000208.html

Basyariah, Nuhbatul et.al. "Determinants of Sukuk Market Development: Macroeconomic Stability and Institutional Approach". *The Journal of Asian Finance, Economics and Business* 8/2 (28 February 2021), 201-211. https://doi.org/10.13106/JAFEB.2021.VOL8.NO2.0201

Beck, Thorsten et.al. "Islamic vs. conventional banking: Business model, efficiency and stability". *Journal of Banking & Finance* 37/2 (01 February 2013), 433-447. https://doi.org/10.1016/j.jbankfin.2012.09.016

Bhuiyan, Rubaiyat Ahsan et.al. "Financial Integration between Sukuk and Bond Indices of Emerging Markets: Insights from Wavelet Coherence and Multivariate-GARCH Analysis". *Borsa Istanbul Review* 18/3 (2018), 218-230.

Billah, Syed Mabruk et. al. "Sukuk and Bond Dynamics in Relation to Exchange Rate", *International Journal of Islamic and Middle Eastern Finance and Management* 16/3 (2023), 621-646.

Bitar, Mohammad et.al. "What makes Islamic banks different? A multivariate approach". *Economic Systems* 41/2 (01 June 2017), 215-235. https://doi.org/10.1016/j.ecosys.2016.06.003

Boukhatem, Jamel. "How does financial risk affect sukuk market development? Empirical evidence from ARDL approach". *Heliyon* 8/5 (01 May 2022), e09453. https://doi.org/10.1016/j.heliyon.2022.e09453

Bourkhis, Khawla - Nabi, Mahmoud. "Islamic and conventional banks' soundness during the 2007–2008 financial crisis". *Review of Financial Economics* 22/2 (2013), 68-77.

Chapra, Muhamed. "The Global Financial Crisis: Can Islamic Finance Help Minimize the Severity and Frequency of Such a Crisis in the Future?" *Islam and Civilisational Renewal (ICR)* 1 (01 January 2008). https://doi.org/10.52282/icr.v1i2.745

Chazi, Abdelaziz - Syed, Lateef A.M. "Risk exposure during the global financial crisis: the case of Islamic banks". *International Journal of Islamic and Middle Eastern Finance and Management* 3/4 (01 January 2010), 321-333. https://doi.org/10.1108/17538391011093261

Chowdhury, Tasruma Sharmeen - Salema, S.M. Kalbin. "Factors influencing the individual investors of Bangladesh to opt for investment in sukuk". *Islamic Economic Studies* 31/1/2 (01 January 2023), 88-107. https://doi.org/10.1108/IES-01-2023-0002

Cihak, Marchin - Hesse, Heiko. "Islamic Banks and Financial Stability: An Empirical Analysis". *IMF Working Papers* 38 (01 December 2010), 95-113. https://doi.org/10.1007/s10693-010-0089-0

Dilber, Caner. "Sukuk ve Ekonomik Büyüme İlişkisi: Türkiye Üzerine Bir Uygulama". *Çankırı Karatekin Üniversitesi Sosyal Bilimler Enstitüsü Dergisi* 13/2 (2022), 343-364. https://doi.org/10.54558/jiss.1137116

Duqi, Andi - Al-Tamimi, Hussein. "Factors affecting investors' decision regarding investment in Islamic Sukuk". *Qualitative Research in Financial Markets* 11/1 (09 May 2019), 60-72. https://doi.org/10.1108/QRFM-01-2018-0009

Echchabi, Abdelghani et.al. "Does Sukuk Financing Promote Economic Growth an Emphasis on The Major Issuing Countries". *Turkish Journal of Islamic Economics* 3 (22 August 2016), 63-63. https://doi.org/10.15238/tujise.2016.3.2.63-73

Gazel, Sümeyra. "BİST Sınai Endeksi ile Çeşitli Metaller Arasındaki İlişki: Toda-Yamamoto Nedensellik Testi", *Akademik Sosyal Araştırmalar Dergisi* 5/52 (2017), 287-299.

Ghassan, Hassan Belkacem - Guendouz, Abdelkrim Ahmed. "Panel modelling of z-score: evidence from Islamic and conventional Saudi banks". *International Journal of Islamic and Middle Eastern Finance and Management* 12/3 (01 January 2019), 448-468. https://doi.org/10.1108/IMEFM-04-2018-0122

Ghildiyal, Vipin et.al. "Impact of Financial Deepening on Economic Growth in Indian Perspective: ARDL Bound Testing Approach to Cointegration". *Asian Development Policy Review* 3/3 (2015), 49-60.

Godlewski, Christophe et.al. "(PDF) Do the Type of Sukuk and Choice of Shari'a Scholar Matter?" *International Monetary Fund, Middle East Center for Economics and Finance (WP/14/147)*. https://www.researchgate.net/publication/279212473_Do_the_Type_of_Sukuk_and_Choice_of_Shari'a_Scholar_Matter

Göksu, Serkan. "Türkiye'de Katılım Bankalarınca Sağlanan Finansman Türlerinin Ekonomik Büyüme Üzerine EtkisiThe Effect of Financing Types Provided by Participation Banks in Türkiye on Economic Growth". *Kocatepe İslami İlimler Dergisi* 6 (09 October 2023), 217-237. https://doi.org/10.52637/kiid.1352885

Grassa, Rihab - Miniaoui, Hela. "Corporate Choice between Conventional Bond and Sukuk Issuance Evidence from GCC Countries". *Research in International Business and Finance* 45/C (2018), 454-466.

Halim, Zairihan Abdul et.al. *Islamic Banking and Finance III*. "Agency costs and corporate sukuk issuance". *Pacific-Basin Finance Journal* 42 (01 April 2017), 83-95. https://doi.org/10.1016/j.pacfin.2016.05.014

Hasan, Maher Mohamad - Dridi, Jemma. *The Effects of the Global Crisis on Islamic and Conventional Banks: A Comparative Study* (SSRN Scholarly Paper, 01 September 2010). Social Science Research Network. Access 01 June 2024. https://papers.ssrn.com/abstract=1750689

Hassan, M. Kabir et.al. "The Determinants of Co-Movement Dynamics between Sukuk and Conventional Bonds". *The Quarterly Review of Economics and Finance* 68/C (2018), 73-84.

Hossain, Mohammed Sawkat et.al. "Sukuk and Bond Puzzle: An Analysis with Characteristics Matched Portfolios". *Emerging Markets Finance and Trade* 57/13 (2021), 3792-3817.

IFSB. "Islamic Financial Services Board Financial Stability Report". *Islamic Financial Services Board* (blog). Access 01 June 2024. https://www.ifsb.org/publication/

IIFM. "International Islamic Financial Market Sukuk Report of 2022". Access 02 June 2024. https://www.iifm.net/

Jain Anshul - Ghosh, Sajal. "Dynamics of global oil prices, exchange rate and precious metal prices in India", *Resources Policy* 38/1 (2013), 88-93.

Johnes, Jill et.al. "A comparison of the performance of Islamic and conventional banks 2004 to 2009". *Journal of Economic Behaviour and Organization* 103/Supplement (June 2014), S93-S107. https://doi.org/10.1016/j.jebo.2013.07.016

Kassim, Salina. "Evidence of Global Financial Shocks Transmission: Changing Nature of Stock Markets Integration during the 2007/2008 Financial Crisis". *Journal of Economic Cooperation and Development* 33 (01 January 2012), 117-138.

Kenourgios, Dimitris et.al. "Islamic financial markets and global crises: Contagion or decoupling?" *Economic Modelling* 57 (30 April 2016), 36-46. https://doi.org/10.1016/j.econmod.2016.04.014

Klein, Paul-Olivier - Weill, Laurent. "Why Do Companies Issue Sukuk?" *Review of Financial Economics* 31/November (01 May 2016), 26-33. https://doi.org/10.1016/j.rfe.2016.05.003

Kusuma, K. - Silva, A. "Sukuk Markets: A Proposed Approach for Development". Text/HTML. *World Bank*. Access 01 June 2024. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/637041468320946094/Sukuk-markets-a-proposed-approach-for-development

Ledhem, Mohammed Ayoub. *Sustainability and Islamic Finance*. "The financial stability of Islamic banks and sukuk market development: Is the effect complementary or competitive?" *Borsa Istanbul Review* 22 (01 December 2022), S79-S91. https://doi.org/10.1016/j.bir.2022.09.009

Maghyereh, A. - Awartani, B. "Dynamic Transmissions between Sukuk and Bond Markets". *Research in International Business and Finance* 38 (30 April 2016), 246-261. https://doi.org/10.1016/j.ribaf.2016.04.016

Mensi, Walid et.al. "Does Bitcoin Co-Move and Share Risk with Sukuk and World and Regional Islamic Stock Markets? Evidence Using a Time-Frequency Approach". *Research in International Business and Finance* 53/C (2020). https://ideas.repec.org//a/eee/riibaf/v53y2020ics0275531919307822.html

Mimouni, Karim et.al. "The Impact of Sukuk on the Performance of Conventional and Islamic Banks". *Pacific-Basin Finance Journal* 54/C (2019), 42-54.

Mohamed, Hanifa et.al. "Why Do Issuers issue Sukuk or Conventional Bond? Evidence from Malaysian Listed Firms Using Partial Adjustment Models". *Pacific-Basin Finance Journal* 34 (01 February 2015), 233-252. https://doi.org/10.1016/j.pacfin.2015.02.004

Mollah, Sabur - Zaman, Mahbub. "Shari'ah supervision, corporate governance and performance: Conventional vs. Islamic banks". *Journal of Banking & Finance* 58/C (2015), 418-435.

Nagano, Mamoru. "Who Issues Sukuk and When? An Analysis of the Determinants of Islamic Bond Issuance". *Review of Financial Economics* 31/C (2016), 45-55.

Naifar, Nader et.al. "Dependence Structure between Sukuk (Islamic Bonds) and Stock Market Conditions: An Empirical Analysis with Archimedean Copulas". *Journal of International Financial Markets, Institutions and Money* 44/C (2016), 148-165.

Naifar, Nader. "Modelling dependence structure between stock market volatility and sukuk yields: A nonlinear study in the case of Saudi Arabia". *Borsa Istanbul Review* 16/3 (01 September 2016), 157-166. https://doi.org/10.1016/j.bir.2016.01.005

Naifar, Nader - Hammoudeh, Shawkat. "Do Global Financial Distress and Uncertainties Impact GCC and Global Sukuk Return Dynamics?" *Pacific-Basin Finance Journal* 39/C (2016), 57-69.

Naifar, Nader - Mseddi, Slim. "Sukuk spreads determinants and pricing model methodology". *Afro-Asian Journal of Finance and Accounting* 3/3 (2013), 241-257.

Narayan, Paresh. "The Saving and Investment Nexus for China: Evidence from Cointegration Tests". *Applied Economics* 37 (01 February 2005), 1979-1990. https://doi.org/10.1080/00036840500278103

Nasreen, Samia et.al. "A Wavelet-Based Analysis of the Co-Movement between Sukuk Bonds and Shariah Stock Indices in the GCC Region: Implications for Risk Diversification". *Journal of Risk and Financial Management* 13/4 (April 2020), 63. https://doi.org/10.3390/jrfm13040063

Oseni, Umar - Hassan, M. Kabir. "Regulating the governing law clauses in Sukuk transactions". *Journal of Banking Regulation* 16/3 (16 April 2014), 220-249. https://doi.org/10.1057/jbr.2014.3

Öner, Muhammed Hadin. "Sukuk İhraçlarının Katılım Bankalarının Finansal Performansı Üzerindeki Etkisi". *Kocatepe İslami İlimler Dergisi* 6/Özel Sayı (15 October 2023), 161-180. https://doi.org/10.52637/kiid.1352281

Öner, Muhammed Hadin. "Sukuk İhraçlarının Belirleyicileri: Katılım Bankaları Üzerine Bir Uygulama", *Gaziantep Üniversitesi Sosyal Bilimler Dergisi* 21/4 (2022a.), 2223-2238;

Öner, Muhammed Hadin. "Makroekonomik Değişkenlerin Sukuk (Kira Sertifikaları) Üzerindeki Etkileri: Panel Veri Analizi", *İslam İktisadı ve Finansı Teorik ve Ampriik Çalışmalar* (Ankara: Orion Akademei, 2022b), 243-262.

Öner, Muhammed Hadin. "COVID-19 Pandemisinin Kamu ve Katılım Bankalarının Sukuk (Kira Sertifikaları) İhraçları Üzerindeki Etkisi", *Sosyal Bilimler Metinleri* 2 (2022c), 109-118.

Pesaran, M. Hashem et.al. "Bounds Testing Approaches to the Analysis of Level Relationships". *Journal of Applied Econometrics* 16/3 (2001), 289-326.

Cakir, Selim- Raei, Faezeh "Sukuk vs. Eurobonds: Is There a Difference in Value-at-Risk?" 7/237 (01 October 2007). https://www.elibrary.imf.org/view/journals/001/2007/237/article-A001-en.xml

Razak, Siti Sarah et.al. *Islamic Financial Instruments and Institutions*. "The contracts, structures and pricing mechanisms of *sukuk*: A critical assessment". *Borsa Istanbul Review* 19/1 (01 August 2019), 521-533. https://doi.org/10.1016/j.bir.2018.10.001

Refinitiv Report. "Refinitiv Releases Findings of 2021 Islamic Finance Development Indicator". Access 01 June 2024. https://en.katilimfinans.com.tr/global-economy/refinitiv-releases-findings-of-2021-islamic-finance-development-indicator-h324.html

Saeed, Momna et.al. "Yield spread determinants of *sukuk* and conventional bonds". *Economic Modelling* 105 (01 December 2021), 105664. https://doi.org/10.1016/j.econmod.2021.105664

Said, A. - Grassa, R. "The Determinants of Sukuk Market Development: Does Macroeconomic Factors Influence the Construction of Certain Structure of Sukuk?" *Journal of Applied Finance & Banking* 3/5. Access 01 June 2024. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2318233

Sclip, Alex et.al. "Dynamic Correlations and Volatility Linkages between Stocks and Sukuk: Evidence from International Markets". *Review of Financial Economics* 31/C (2016), 34-44.

Shahbaz, Muhammad et.al. "Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia". *Renewable and Sustainable Energy Reviews* 25 (01 September 2013), 109-121. https://doi.org/10.1016/j.rser.2013.04.009

Shahida, S. - Saharah, S. "[PDF] Why Do Firms Issue Sukuk Over Bonds? Malaysian Evidence | Semantic Scholar". Malaysia, 2013. https://www.semanticscholar.org/paper/Why-Do-Firms-Issue-Sukuk-Over-Bonds-Malaysian-Shahida-Sapiyi/688c639e8adc22479974e9c91a699c7175548f63

Siddiqui, Anjum. "Financial contracts, risk and performance of Islamic banking". ed. M. Mansoor Khan - M. Ishaq Bhatti. *Managerial Finance* 34/10 (01 January 2008), 680-694. https://doi.org/10.1108/03074350810891001

Smaoui, Houcem et.al. "Sukuk, Banking System, and Financial Markets: Rivals or Complements?" *Economics Letters* 161/C (2017), 62-65.

Smaoui, Houcem - Ghouma, Hatem. "Sukuk market development and Islamic banks' capital ratios". *Research in International Business and Finance* 51 (01 January 2020), 101064. https://doi.org/10.1016/j.ribaf.2019.101064

Smaoui, Houcem - Khawaja, Mohsin. "The Determinants of Sukuk Market Development". *Emerging Markets Finance and Trade* 53/7 (2017), 1501-1518.

Smaoui, Houcem - Nechi, Salem. "Does Sukuk Market Development Spur Economic Growth?" *Research in International Business and Finance* 41/C (2017), 136-147.

Sugiyanto, Catur - Yolanda, Zefania. "The Effect of Financial Deepening on Economic Growth, Inequality, and Poverty: Evidence from 73 Countries". *South East European Journal of Economics and Business* 15/2 (01 December 2020), 15-27. https://doi.org/10.2478/jeb-2020-0012

Suriani, Suriani et.al., "Sukuk and Monetary Policy Transmission in Indonesia: The Role of Asset Price and Exchange Rate Channels", *Journal of Islamic Accounting and Business Research* 12/7 (2021), 1015-1035.

Taoual, Safiyah. *Economics Discussion Papers*. "Sukuk: A Potential for Stability and Development in the GCC". *Economics Discussion Papers*. https://ideas.repec.org//p/ris/kngedp/2016_007.html

Tariq, Ali - Dar, Humayon. "Risks of Sukuk structures: Implications for resource mobilization". *Thunderbird International Business Review* 49 (01 March 2007), 203-223. https://doi.org/10.1002/tie.20140

TCMB. "EVDS | Anasayfa". Access 01 June 2024. https://evds2.tcmb.gov.tr/

TKBB. "Veri Peteği". Access 01 June 2024. 2024. https://veripetegi.tkbb.org.tr/

Toda, Hiro Y. - Yamamoto, Taku. "Statistical inference in vector autoregressions with possibly integrated processes". *Journal of Econometrics* 66/1 (01 March 1995), 225-250. https://doi.org/10.1016/0304-4076(94)01616-8

Umar, Zaghum et.al. "The connectedness of oil shocks, green bonds, sukuks and conventional bonds". *Energy Economics* 119 (01 March 2023), 106562. https://doi.org/10.1016/j.eneco.2023.106562

Usmani, Muhammad Taqi. "Sukuk and Their Contemporary Applications". https://d1wqtxts1xzle7.cloudfront.net/19945996/sukuk-and-their-contemporary-applications.

Wang, Aidong. "An empirical study on the relationship between China's financial development and economic growth based on sensor technology". *EURASIP Journal on Wireless Communications and Networking* 2019/1 (20 February 2019), 42. https://doi.org/10.1186/s13638-018-1322-z