Research in International Business and Finance 67 (2024) 102098

Contents lists available at ScienceDirect

Research in International Business and Finance

journal homepage: www.elsevier.com/locate/ribaf

Potential diversification benefits: A comparative study of Islamic and conventional stock market indexes

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ARTICLE INFO

Keywords:
Islamic finance
Stock market integration
Diversification benefits
DCC-GARCH

ABSTRACT

The study aims to contribute to the better understanding of potential diversification benefits for US and its major trading partners, namely Canada, Japan, and the UK, across both Islamic and conventional indexes. We applied a Dynamic Conditional Correlations (DCC) model to examine the dynamic correlation and volatility of returns during 2001–2017. The findings put in evidence that, unlike Canadian peers, Japanese indexes exhibit a low dynamic correlation with US indexes, which ultimately suggests diversification opportunities for US-based investors. Understanding volatilities and correlations patterns through international markets would help investors, policymakers, and market participants to take informed decisions, mitigate risks, and anticipate potential spillover effects.

1. Introduction

The integration of international stock market indexes and the pursuit of diversification have gained significant attention from researchers and financial analysts, driven by the remarkable development of the international financial system through financial liberalization and economic globalization. This development, fueled by increased trade links and securitization, has played a crucial role in the growth of stock markets in major industrial countries; what enables investors to capitalize on geographical diversification benefits and seek higher returns in foreign markets. Additionally, the liberalization of financial markets in most developed countries has facilitated foreign investors' access to domestic stock markets. Although this integration has resulted in increased savings, improved efficiency, and economic growth, economic cycles and correlations between stock market inventories have become more synchronized over time and across countries. The interdependence among stock markets through diversified securities holdings has become a critical concern for investors who are struggling to mitigate risks in today's landscape (Henry, 2000; Watson, 1986; Khan, 2011; Bouteska et al., 2023; Yadav et al., 2023).

The groundbreaking work of Markowitz (1959) was instrumental in addressing the issue of portfolio diversification. Utilizing Modern Portfolio Theory, Markowitz (1959) developed a model to determine the optimal portfolio, achieving a desirable balance between risk and return. His arguments extended beyond risk reduction to emphasize the maximization of portfolio returns. Consequently, Markowitz (1959) advocated for portfolio diversification as a means to mitigate excessive risk exposure in stock markets, where correlations tend to increase during co-movements. It follows that investors can reap diversification benefits when stock

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https://doi.org/10.1016/j.ribaf.2023.102098
Received 19 January 2023; Received in revised form 29 August 2023; Accepted 8 September 2023
Available online 11 September 2023

markets exhibit low correlation, and vice versa (Abdul Kader, Leong, 2009). However, the strong interdependence among stock markets exposes investors to precarious situations and reduces potential benefits of cross-border diversification. Optimal diversification aims to moderate the overall portfolio risk. Building upon market efficiency hypothesis, Fama (1970) criticized Markowitz's (1959) arguments and suggested another model that allows market participants could swiftly intervene and react in perfectly efficient financial markets. The presence of information symmetry would attract more investors and enhance stock price credibility.

Numerous empirical studies have examined the issue of diversification in both developed and developing economies. However, the majority of these studies have predominantly investigated conventional markets, with a particular focus on the US and European sets. A few studies have explored the diversification potential of conventional and Islamic stock market indexes (Arshanapalli and Doukas, 1993; Karolyi and Stulz, 1996; Cheng and Glascock, 2006; Saiti et al., 2014; Rahim and Masih, 2016; Saâdaoui et al., 2017; Bugan et al., 2021). Furthermore, most existing literature has separately analyzed conventional and Islamic markets; with no comprehensive comparison between them and have produced mixed results. Further investigation is hence needed to address this gap and shed some light on this issue. The large bulk of research have examined linkages among conventional stock indexes but yield inconclusive empirical findings. Islamic stock markets has recently gained momentum, given the amazing growth and rapid spread of Islamic finance. The global Islamic finance market surpassed $2 trillion in assets in 2019 and is projected to reach approximately $3.69 trillion by 2024 (Islamic Finance Development Report). Islamic financial assets, particularly banking assets, have witnessed a 14% increase to $1.99 trillion in 2019. Moreover, Islamic markets are argued to offer higher diversification potential compared to other regions (Saiti et al., 2014). Islamic stock indexes are also believed to be better positioned and more resilient during financial crises when compared to their conventional counterparts (Sukmana and Kolid, 2012; Dharani et al., 2022; Shear and Ashraf, 2022). This resilience can be attributed not only to Islamic rules such as the exclusion of speculation, high leverage, complex structured financial products like derivatives and toxic assets but also to the implementation of ethical screening practices.

This study aims to contribute to the better understanding of potential diversification benefits for US and its major trading partners, namely Canada, Japan, and the UK, across both Islamic and conventional indexes. The sample includes four Dow Jones (DJ) Islamic Market indexes and four conventional DJ indexes during 2001–2017. Based on DCC-GARCH modelling, the paper offers three key contributions. Firstly, it conducts a comparative analysis between Islamic and conventional indexes, offering insights into their diversification potential. Secondly, it expands the scope of analysis across four distinct contexts, encompassing the US, the UK, Canada, and Japan. Finally, it employs the DCC model to estimate both return volatility and dynamic correlation, which goes beyond traditional diversification studies relying on constant correlation (You and Daigler, 2010). In summary, our findings reveal important

Table 1
Summary of empirical studies on diversification.

Authors	Markets	Econometrical Tools
Karolyi and Stulz (1996),	US and BRIC markets	Multivariate GARCH
Arshanapalli and Doukas (1993)	US, France, Germany, UK, and Japan	Informationally efficient frontier
Meric and Meric (1997)	US, UK, Germany, France, and Japan	Granger causality tests
Majid et al. (2009)	Malaysia, Thailand, Indonesia, the Philippines and Singapore	GMM modelling
Shan et al. (2022)	MSCI World Index: 23 DMs, 9 DMs: US, Japan Hong Kong, UK, Germany, France, Canada, Italy, and Australia; 10 EMs: China, South Africa, South Korea, India, Indonesia, Brazil, Mexico, Russia, Turkey, and Argentina; and the global market	Dynamic conditional correlation
Bley and Chen (2006)	GCC stock markets Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates	Impulse Response Analysis; Granger Causalities; Generalized Forecast Error Variance Decomposition
Marashdeh (2005)	MENA region, US, the UK, and Germany	ARDL approach
Aloui and Hkiri (2014)	GCC markets (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates	Wavelet coherence approach
Le et al. (2022)	24 Islamic countries	GMM modelling
Majid and Kassim (2010)	Malaysia, Indonesia, Japan, the UK and the US	AutoRegressive Distributed Lag (ARDL) and the Vector Error Correction Model (VECM)
Rizvi and Arshad (2013)	DJ World Financial Services, DJ US Financial Services. DJ US, DJ World Emerging Markets, DJ Islamic UK, DJ Islamic World, DJ Islamic US, And DJ Islamic World Emerging Markets	Multivariate GARCH
Majdoub and Mansour (2014)	US, Turkey, Indonesia, Pakistan, Qatar, and Malaysia	Multivariate GARCH BEKK, CCC, and DCC
Abu Bakar and Masih (2014)	DJ Islamic index and the US, UK, European, Japanese, Chinese and Malaysian international securities markets	Multivariate GARCH
Saiti et al. (2014)	MSCI indices of Japan, GCC, Indonesia, Malaysia and Taiwan Korea, Hong Kong, China and Turkey.	Multivariate GARCH
Rahim and Kasim (2016)	US, Malaysia, China, Singapore, Japan, and Thailand	Multivariate GARCH; wavelet coherence approach
Bugan et al. (2022)	DJ Islamic Stock Market Index (DJIM) and 13 emerging conventional markets: Argentina, Brazil China, the Czech Republic, India, Indonesia, South Korea, Malaysia, Mexico, Poland, Russia, South Africa, and Turkey	causality-in-variance, dynamic conditional correlations, optimal hedge ratios, and causality-in-risk tests
Attig et al. (2023)	25 developed markets and 23 emerging markets	Dummy variable model of Heston and Rouwenhorst

insights into assets allocation and portfolio diversification. Unlike Canadian peers, Japanese indexes exhibit a low dynamic correlation with US indexes; which ultimately suggests diversification opportunities for US-based investors. This evidence is valid for both Islamic and conventional indexes. Islamic US index also shows a low correlation with Islamic UK index; and hence potential diversification benefits. Additionally, our statistics demonstrate that dynamic correlation between the US and Islamic indexes is relatively lower than that with conventional peers; what might encourage US investors to capitalize in Islamic indexes to accrue additional diversification benefits. Overall, the study highlights that Islamic indexes have almost a little bit higher unconditional volatilities but lower dynamic correlation among each other than conventional peers.

The reminder of this paper is organized as follows. Section 2 provides a concise literature review on portfolio diversification. Section 3 outlines the empirical framework and presents the sample, and econometrical modelling. The empirical findings are reported and discussed in Section 4. The paper concludes by discussing the theoretical implications, acknowledging the limitations, and proposing potential avenues for future research.

2. Literature review

A large body of literature has examined diversification through cross volatility and co-movements between markets. Most research investigated developed countries with a lesser interest to emerging countries. More recent studies involved Islamic markets. Table 1 provides an overview of these some empirical studies.

Empirical studies have primarily focused on developed countries and particularly the US context. Many researchers, namely Karolyi and Stulz (1996), among others investigated the integration of the US stock market with its main trading partners. They suggested that financial integration between BRIC markets and international markets is incomplete; and that policymakers are required to open more their domestic markets to earn financial integration benefits. Other researchers centered on the integration issue in European stock markets. For instance, Arshanapalli and Doukas (1993) examined the integration among five major international markets using conventional stock market indexes (US, French, German, UK, and Japanese markets) and found a strong co-movement among them. Meric and Meric (1997) observed co-movements of sector indexes in the US, UK, German, French, and Japanese stock markets in bull and bear markets. Unlike bear market, in bull market, benefits will be sizeable with global diversification than with domestic diversification in the same sector; as opposed to investing in different sectors within the same country. There is also a substantial research on Asian context. Majid et al. (2009) explored market integration among five selected Association of Southeast Asian Nations (ASEAN) emerging markets (Malaysia, Thailand, Indonesia, the Philippines and Singapore) during the pre- and post-1997 financial crisis periods. They revealed that the long-run diversification benefits that are earned in the post-crisis period tend to decline unlike the pre-crisis period. As for China, Shan et al. (2022) put in evidence a low correlation between China stock market and the global market. They found also that the Chinese market was less vulnerable to international financial contagion and provided valuable diversification benefits. Mainland China stocks, particularly policy-sensitive ones, offered significant diversification advantages for international investors. However, a few studies have been conducted in Islamic countries. Bley and Chen (2006) found evidence of increasing market integration and highlighted that GCC stock markets offered potential diversification benefits. Aloui and Hkiri (2014) examined the short term and long term dependencies between GCC markets (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates). They noted an increasing strength of dependence among them during the last financial crisis; which implies enhanced portfolio benefits for investors. Using a sample of 24 Islamic countries, Le et al. (2022) demonstrated the positive impact of sectoral and income diversification on the performance of Islamic banking systems. They also found that Sukuk investment was the essential channel for diversification; and that diversification has potentially mitigated the negative effects of COVID-19.

A recent strand of research has analyzed the impact of diversification through developed and developing countries, including Islamic markets. No consensus has not yet been reached, and studies have yielded mixed results. Marashdeh (2005) tested financial integration among four emerging stock markets in the MENA region. The study revealed the existence of integration among these markets, but not between them and developed markets, namely US, the UK, and Germany. Besides, unlike domestic investors, international peers could earn long-run gains through portfolio diversification in the MENA region. Majid and Kassim (2010) assessed the degree of integration among five major Islamic stock markets, namely Malaysia, Indonesia, Japan, the UK and the US. They pointed out that diversification would be more profitable by diversifying in the Islamic markets across economic grouping; for instance in developed and developing markets. Benefits would be limited if diversification would be within the same economic category. Rizvi and Arshad (2013) demonstrated a low correlation between Islamic indices with the conventional global equity indices and a significant downward trend during the crisis era. The data was derived from Dow Jones indices, including four DJ conventional indices and four DJ Islamic indices. Similarly, Majdoub and Mansour (2014) found a low correlation between the US market and five emerging Islamic markets (Turkey, Indonesia, Pakistan, Qatar, and Malaysia). The authors did not find any spillover effect from the US market towards the Islamic market. However, Abu Bakar and Masih (2014) provided evidence of a stronger link between the Western markets and the Islamic index as compared to the Asian markets. Their sample included the DJ Islamic index and the US, UK, European, Japanese, Chinese and Malaysian international securities markets. Saiti et al. (2014) suggested that Islamic countries offer better diversification benefits compared to the Far East countries. Indeed, both the conventional and Islamic MSCI indices of Japan, GCC ex-Saudi, Indonesia, Malaysia and Taiwan exhibit better diversification benefits compared to Korea, Hong Kong, China and Turkey. Rahim and Kasim (2016) studied the diversification benefits that Malaysian Islamic investors can earn from their major trading partners (China, Singapore, Japan, United States and Thailand). Findings revealed that they can reap sizeable benefits with US Islamic index, moderate benefits with Thailand and Japan but not great ones with China and Singapore. Bugan et al. (2022) explored the relationship between the Dow Jones Islamic Stock Market Index (DJIM) and 13 major emerging conventional markets, namely: Argentina, Brazil China, the Czech Republic, India, Indonesia, South Korea, Malaysia, Mexico, Poland, Russia, South Africa, and Turkey. They reported

limited diversification benefits and also limited safe havens afforded by Islamic stock markets. Based on a large sample of stocks from 25 developed markets and 23 emerging markets, Attig et al. (2023) argued that over the past 27 years, international diversification provided a much more effective risk-reduction tool than industrial diversification, with gains attributed to mitigating market, political, and inflation risks.

All of these studies applied various techniques including the dummy variable model of Heston and Rouwenhorst (1994) (Attig et al., 2023), constant correlation for typical diversification (You and Daigler, 2010), GMM modelling (Majid et al., 2009), AutoRegressive Distributed Lag (ARDL) (Marashdeh, 2005; Majid and Kassim, 2010); and the Vector Error Correction Model (VECM) (Majid and Kassim, 2010) while few studies apply the DCC modelling to estimate returns volatility and dynamic correlation (Majdoub and Mansour, 2014; Bugan et al., 2022). More recent studies apply more sophisticated econometric tools, namely the GARCH models particularly the multivariate GARCH (Karolyi and Stulz, 1996; Rizvi and Arshad, 2013; Abu Bakar and Masih, 2014; Majdoub and Mansour, 2014; Saiti et al., 2014; Rahim and Masih, 2016), the causality-in-variance technique (Bugan et al., 2022) and the wavelet coherence analysis approach (Aloui and Hkiri, 2014; Rahim and Masih, 2016).

3. Research methodology

3.1. Data

The sample is made up of 8 indexes, 4 Islamic indexes and 4 conventional indexes, from December 03, 2001 to March 22, 2017. Related time series on closing prices are extracted from the Thomson-Reuters Data Stream database. We used four Dow Jones (DJ) Islamic Market (DJIM) indexes and four conventional DJ (DJ) indexes to measure stock market index returns. Both DJIM indexes and DJ indexes include 4 stock markets, namely Canada, Japan, the UK, and the US. Table 2 presents the financial indexes that are explored in the study.

Following several articles in this context, we measure returns of stock market indexes through the differences in the logarithmic daily closing prices as follows:

$$r_t = \ln(p_t) - \ln(p_{t-1}) \tag{1}$$

where p stands for the index value, while t represents the time dimension.

3.2. Multivariate GARCH dynamic conditional correlations

The DCC model, which is a GARCH model, allows accurately determining both the nature and moment of potential changes in the co-movement of time series. Besides, the DCC model provides a predictive estimation for the correlation between the series of subsequent periods (Lebo and Box-Steffensmeier, 2008). The DCC-GARCH model offers several advantages over alternative models. Firstly, the DCC-GARCH model allows for the estimation of time-varying correlations, capturing the dynamic nature of relationships between financial assets as market conditions change. This flexibility is crucial for accurately representing the evolving interdependencies in financial markets. Secondly, the DCC-GARCH model separates the estimation of conditional volatilities (via the GARCH component) from the estimation of conditional correlations (via the DCC component), enabling a more precise depiction of the relationships between assets. This separation allows correlations to change independently of volatilities, enhancing the model's ability to capture complex market dynamics. Additionally, the DCC-GARCH model is computationally efficient, making it suitable for large-scale applications and the analysis of multiple assets simultaneously. Furthermore, the empirical validation and extensive use of the DCC-GARCH model in various financial contexts provide confidence in its effectiveness and reliability. While alternative models may have their own strengths and specific applications, the DCC-GARCH model remains a popular and widely adopted choice due to its flexibility, separation of volatility and correlation, computational efficiency, and empirical support.

According to Engle and Sheppard (2001), there are two steps to estimate of the DCC model. This two-steps methodology aims to simplify the estimation of a time-varying correlation matrix. Engle (2002) and Tse and Tsui (2002) suggest the following DCC model to reveal the dynamics of time-varying conditional correlation:

$$y_t = Cx_t + \varepsilon_t$$

$$\varepsilon_t = H_t^{1/2} v_t$$

$$H_t = D_t^{1/2} R_t D_t^{1/2}$$

Table 2
Summary of Dow Jones indices used in the study.

Conventional Indices	Islamic Indices		
DJCA	Dow Jones Canada	DJCAI	Dow Jones Islamic Canada
DJUS	Dow Jones US	DJUSI	Dow Jones Islamic US
DJUK	Dow Jones UK	DJUKI	Dow Jones Islamic UK
DJJA	Dow Jones Japan	DJJAI	Dow Jones Islamic Japan

$$R_t = diag\Gamma_t^{-1/2}\Gamma_t diag\Gamma_t^{-1/2}$$

$$\Gamma_t = (1-\theta_1-\theta_2)\Gamma + \theta_1\eta_{t-1}\eta'_{t-1} + \theta_1\Gamma_{t-1} \quad (2)$$

where y_t is a vector of dependent variables, C is the matrix of parameters, x_t is the vector of independent variables, which may contain lags of y_t. The variable υ_t vector of normal, independent, and identically distributed innovations. The scalar parameters θ_1 and θ_2 allow capturing the effects of past shocks and past dynamic conditional correlations on current DCC.

The DCC model has become a popular estimation procedure for at least two main reasons: first of all the flexibility of modeling individual volatilities; and secondly the ability to apply it to a wide range of portfolios (Pesaran and Pesaran, 2007). The fat nature of the return index distribution makes the t-multivariate distribution based - DCC model most suitable, especially for risk analysis that focused on the tail properties of turn distributions. Engle (2002) suggest a two-step procedure to maximize the log-likelihood function of the DCC model. However, such a procedure can not comply with the *t*-DCC specification. Perhaps, it would be worth applying a simultaneous approach to estimate the model parameters, including the degree-of-freedom parameter of the multivariate *t*-distribution (Pesaran and Pesaran, 2007).

4. Findings and discussions

4.1. Descriptive analysis

Table 3 reports the descriptive statistics for the indexes utilized in our study. The descriptive statistics highlight that the conventional DJ UK index exhibits the highest volatility of returns, whereas the Islamic DJ US returns demonstrate the lowest volatility. The standard deviation provides a measure of absolute volatility of returns, irrespective of the time period.

The skewness and kurtosis parameters deviate significantly from those of a Gaussian distribution, indicating that the standard distribution is not the most suitable assumption for a fitting model. Moreover, these statistics align with the results of the Jarque-Bera test, which strongly rejects the normality of the residuals across all indices. By comparing these statistics between conventional markets and Islamic markets, we can infer that the latter exhibit greater similarity to the standard distribution, implying that conventional markets may exhibit more pronounced signs of extreme risks. Consequently, employing fat-tailed distributions such as Student's distribution could be more appropriate in our DCC-GARCH models to capture the characteristics of the data accurately.

Table 4 displays the outcomes of the unit root analysis performed using the augmented Dickey-Fuller test and the Philips-Peron test. The results from both tests reveal that all variables examined in the study exhibit stationarity at the level.

The trends of returns for both Islamic and conventional DJ indexes are depicted in Figs. 1 and 2. Graphical representation of daily returns of the conventional and Islamic indexes provide a deeper perspective than do previous descriptive statistics. Figs. 1 and 2 illustrate that the returns of the conventional and Islamic indexes exhibit a stationary behavior around a constant, with fluctuations in both positive and negative directions. But above all, Figs. 1 and 2 put in evidence a high volatility of respectively conventional and Islamic indexes during the period that spans from 2001 to 2017, with a peak around the global financial crisis of 2008.

Amazingly, the volatility of returns seem to spike up at the same instance for both conventional and Islamic indexes. Such a result is in line with the findings of Rizvi and Arshad (2013). However, the distribution of return volatility in Islamic indices exhibits greater stationarity compared to conventional indices, reflecting a more stable and predictable pattern of variability over time. In contrast, conventional markets display a higher frequency of extreme values, indicating heightened volatility and unpredictability. This divergence in market behavior positions Islamic markets as a more consistent and secure investment environment, fostering investor confidence. Conversely, conventional markets pose elevated risks due to their susceptibility to significant market fluctuations. Thus, Islamic markets present an appealing option for those seeking reliable and predictable investment opportunities, while conventional markets entail a higher degree of risk associated with extreme market movements.

4.2. Estimation of volatilities and unconditional correlations: DCC-MGARCH model

We run DCC model under both Gaussian and *t* distributions to identify the more suitable model for our data. We investigate the

Table 3
Descriptive statistics and goodness-of-fit tests of all financial indexes.

	Conventional DJ				**Islamic DJ**			
	DJUS	DJJA	DJUK	DJCA	DJUSI	DJJAI	DJUKI	DJCAI
Mean	0.000128	1.02E-05	6.49E-06	0.000198	0.000120	0.000107	-2.01E-05	-3.73E-05
Median	0.000424	0.000195	0.000301	0.000800	0.000328	0.000121	0.000136	0.000559
Maximum	0.107740	0.126605	1.721268	0.523630	0.120499	0.106586	0.116768	0.118689
Minimum	-0.096348	-0.120659	-1.690728	-0.123630	-0.121037	-0.095483	-0.100300	-0.172147
Std. Dev.	0.012396	0.014286	0.038796	0.016896	0.012140	0.014036	0.014416	0.017850
Skewness	-0.243809	-0.184699	1.023351	6.478374	0.086741	0.029965	-0.064955	-0.787358
Kurtosis	10.91771	8.551352	1702.053	216.2461	14.60878	7.141744	10.45426	13.69803
Jarque-Bera	11531.53	5672.314	5.29E+ 08	8363856	24700.97	3144.137	10185.55	21426.99
JB p-values	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Table 4
Results of unit root stationarity statistics (p-values between parentheses).

Indexes	ADF		Phillips-Peron	
	Level	Difference	Level	Difference
Conventional indexes				
DJUS	-70.755 (0.000)	-22.632 (0.000)	-60.138 (0.000)	-104.350 (0.000)
DJJA	-51.818 (0.000)	-23.399 (0.000)	-65.903 (0.000)	-113.025 (0.000)
DJUK	-37.898 (0.000)	-23.007 (0.000)	-139.144 (0.000)	-175.767 (0.000)
DJCA	-61.489 (0.000)	-23.652 (0.000)	-54.355 (0.000)	-97.770 (0.000)
Islamic indexes				
DJUSI	-53.200 (0.000)	-22.470 (0.000)	-67.480 (0.000)	-109.214 (0.000)
DJJAI	-54.005 (0.000)	-24.339 (0.000)	-66.137 (0.000)	-105.545 (0.000)
DJUKI	-33.612 (0.000)	-23.523 (0.000)	-57.797 (0.000)	-95.277 (0.000)
DJCAI	-30.468 (0.000)	-23.280 (0.000)	-53.439 (0.000)	-91.140 (0.000)

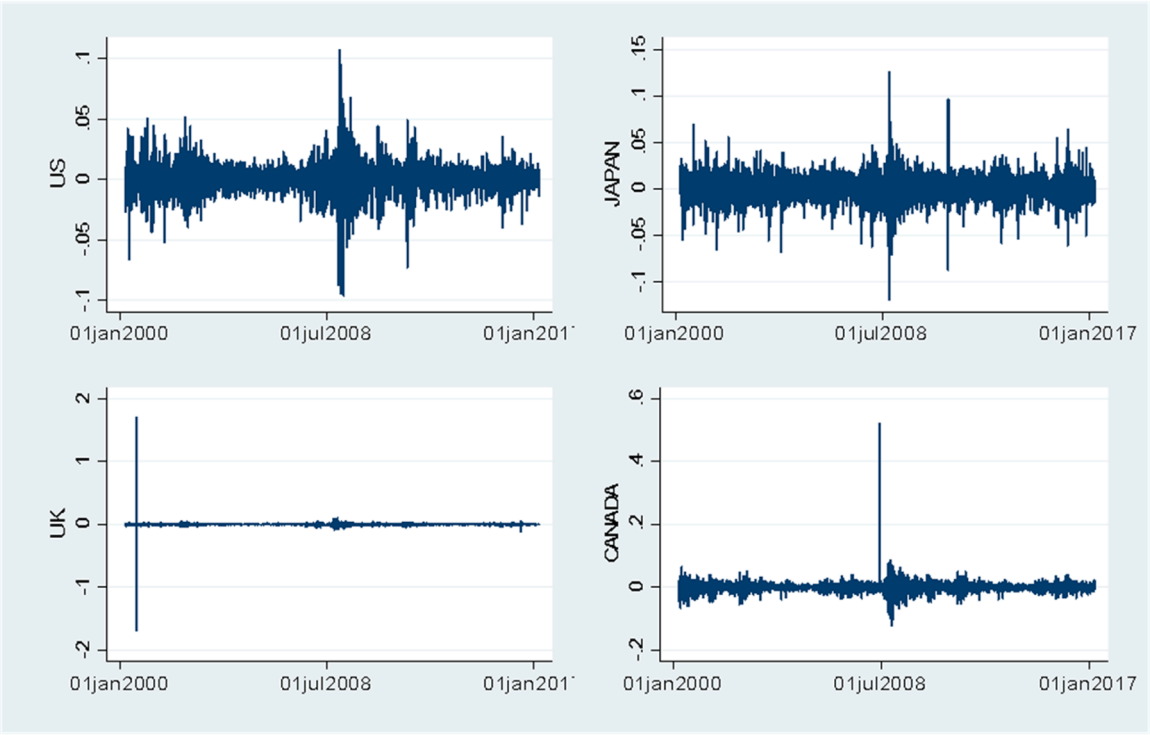

Fig. 1. Conventional DJ index returns during the period 2001–2017.

plotted conditional correlations and estimated volatilities. This analysis helps us gain insights into the dynamic relationships and volatility patterns within our dataset. We estimate the DCC models on the daily returns of the conventional and Sharia-compliant DJ indexes. Empirical results do not detect any case of non-convergence. The results of the DCC model with Gaussian and student innovations are presented in Tables 5 and 6, respectively. The estimates indicate that all measures of return volatility are statistically significant and the sum of each couple of parameters is close to unity, and hence a gradual variation in volatility under the DCC model with Gaussian and t innovations. The estimated value of the degree of freedom for the t-student distribution is approximately 4, suggesting that the t-distribution based model is more suitable for capturing the characteristics of stock returns distribution.

Table 5 reports the maximum likelihood estimates of the Gaussian models on the daily returns of four conventional and Islamic stock indexes as well the volatility parameters: λ_{1i} and λ_{2i} $(i = 1,2,3,4)$. These parameters are significant, and the estimates of $\lambda_{1i}$are close to unity, which implies that volatility is progressively decreasing. The ML estimates of the DCC model with Gaussian innovations serve as an initial step in selecting the appropriate model.

In Table 6, we consider the significance of Lambda1_j and Lambda2_j parameters, which respectively represent the sensitivity and persistence of index j following its own volatility shock. We observe notable differences between conventional and Islamic indices, except for DJUS. The first type of parameters reveals that conventional indices generally exhibit relatively higher values compared to Islamic indices, indicating greater sensitivity to their own volatility shocks. Conversely, Islamic markets display a contrasting pattern, with shocks being relatively more persistent compared to conventional markets. Interestingly, the DCC Theta parameters demonstrate

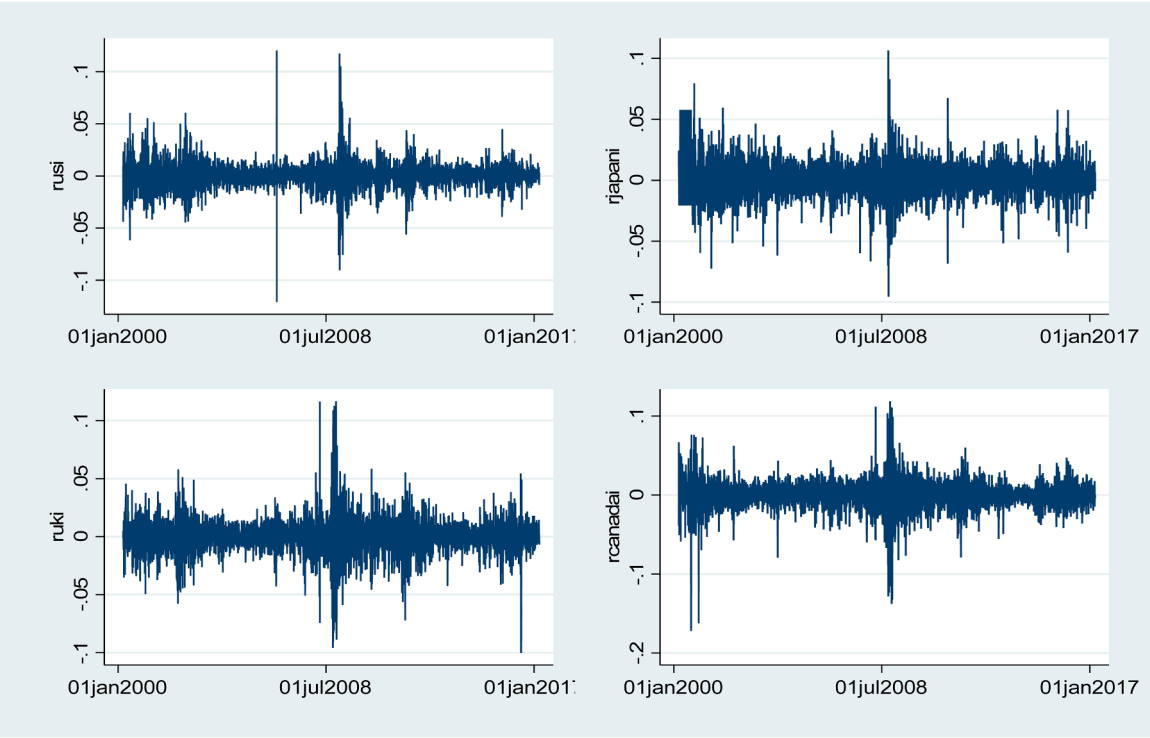

Fig. 2. Islamic DJ index returns during the period 2001–2017.

Table 5
Maximum likelihood estimates of the DCC model (Gaussian innovations).

	Conventional stock indexes				Islamic stock indexes			
Parameters	Coef.	St. Err.	t-statistic	Pr	Coef.	St. Err.	t-statistic	Pr
Lambda1_DJUS	0.231	0.022	10.32	[.000]	0.232	0.022	10.58	[.000]
Lambda1_DJJA	0.199	0.025	8.11	[.000]	0.192	0.022	8.65	[.000]
Lambda1_DJUK	0.352	0.029	12.09	[.000]	0.273	0.024	11.24	[.000]
Lambda1_DJCA	0.334	0.023	14.42	[.000]	0.196	0.019	10.37	[.000]
Lambda2_DJUS	0.951	0.057	16.73	[.000]	0.878	0.059	15.00	[.000]
Lambda2_DJJA	0.737	0.078	9.40	[.000]	0.819	0.083	9.89	[.000]
Lambda2_DJUK	0.702	0.054	12.99	[.000]	0.686	0.057	11.98	[.000]
Lambda2_DJCA	0.629	0.035	17.78	[.000]	0.840	0.065	12.96	[.000]
Theta 1	0.006	0.001	7.48	[.000]	0.010	0.001	8.03	[.000]
Theta 2	0.994	0.001	1288.6	[.000]	0.982	0.002	513.16	[.000]
Maximum likelihood	47,867.02				47,400.99			

Table 6
Maximum likelihood estimates of the DCC model (***t* innovations**).

	Conventional stock indexes				Islamic stock indexes			
Parameters	Coef.	St. Err.	t-statistic	Pr	Coef.	St. Err.	t-statistic	Pr
Lambda1_DJUS	0.199	0.026	7.68	[.000]	0.230	0.029	7.99	[.000]
Lambda1_DJJA	0.177	0.032	5.49	[.000]	0.157	0.028	5.51	[.000]
Lambda1_DJUK	0.213	0.030	6.97	[.000]	0.186	0.025	7.38	[.000]
Lambda1_DJCA	0.258	0.027	9.60	[.000]	0.139	0.022	6.39	[.000]
Lambda2_DJUS	0.995	0.088	11.26	[.000]	0.892	0.083	10.74	[.000]
Lambda2_DJJA	0.863	0.135	6.38	[.000]	0.944	0.133	7.10	[.000]
Lambda2_DJUK	0.987	0.101	9.74	[.000]	0.846	0.102	8.31	[.000]
Lambda2_DJCA	0.713	0.059	12.13	[.000]	0.935	0.117	7.97	[.000]
Theta 1	0.005	0.001	5.22	[.000]	0.014	0.001	9.30	[.000]
Theta 2	0.994	0.001	1305.0	[.000]	0.979	0.002	433.23	[.000]
Degrees of freedom	4.466	0.180	24.86	[.000]	4.690	0.198	23.74	[.000]
Maximum likelihood	48825.35				48269.15			

similar values for both conventional and Islamic indices.

Table 7 displays the results related to the estimated unconditional volatilities and correlations. The diagonal entries of Table 7 report the unconditional volatilities of conventional indexes. Related results are presented in Table 8. The off-diagonal elements of Table 7 assess the unconditional correlations for both conventional and Islamic indexes. The most substantial correlation identified within the conventional DJ indexes is approximately 0.932, linking the Canadian and UK indexes. Notably, the conventional US index displays the highest correlation at approximately 0.153, notably with the Canadian counterpart among the conventional indexes. This robust correlation can be attributed to the geographical proximity and substantial volume of trade exchange between the two nations. Conversely, Table 7 illustrates the lowest correlation, which is negative at around (−0.057). This correlation pertains to the conventional US and Japanese DJ Indexes. As a result, the inclusion of conventional Japanese indexes alongside conventional US indexes in portfolios could potentially offer U.S. investors diversification advantages. Table 7 further displays the unconditional correlations among Islamic DJ indexes. Analogous to their conventional counterparts, the Islamic DJ indexes exhibit a peak correlation of around 0.266, observed between the Islamic Canadian and UK indexes. Interestingly, the Islamic US index showcases a distinct negative correlation of approximately (−0.032) with the Islamic Japanese index, mirroring the conventional pattern. Additionally, the Islamic US index demonstrates a modest correlation with the Islamic UK index, while achieving its highest correlation with the Islamic Canadian index. Consequently, a strategic combination of Islamic US indexes with either Islamic Japanese or Islamic UK indexes could yield potential diversification gains. Overall, Table 7 emphasizes lower correlation among Islamic stock indexes than conventional peers. Such findings might suggest meaningful guidelines while making informed decisions regarding portfolio diversification and risk management; and eventually recommend investing in Islamic indexes to accrue diversification benefits. Indeed, the lower the correlation, the better the diversification (Markowitz, 1959). To minimize the portfolio risk, investors are required to construct a well-diversified portfolio, with either negatively correlated or uncorrelated assets. Incorporating conventional and Islamic Japanese indexes or UK Islamic indices into a US-index portfolio has the potential to reduce the overall risk and improve diversification.

The diagonal entries of Table 7 are reported in Table 8 and capture the unconditional volatilities of conventional indexes. The returns volatility are also classified in Table 8. The unconditional volatilities of conventional indexes are relatively low and vary between 0.059 and 0.135. The Canadian DJ index is relatively the least volatile whereas the Japanese one is the most volatile among other conventional indexes. Perhaps, Canada represents a developing hub for capital markets and can eventually promote some stability during the global financial crisis of 2008. As for Islamic indexes, they have almost a little bit higher volatilities than conventional peers and range from 0.083 to 0.133. These findings would suggest that the application of Shariah principles in constructing Islamic indexes does not impose extensive constraints on investment allocation. Investors can achieve similar levels of volatility in conventional and Islamic markets, as supported by previous research (Guyot, 2011; Saiti, 2014). Similarly, Islamic Japanese index has the highest unconditional volatility among other Islamic peers, like conventional Japanese index. However, Islamic US index exhibits the lowest unconditional volatility among other Islamic indexes.

But above all, our empirical results claim the relative low volatility of DJ conventional Canadian indexes and Islamic US peers across other countries. Such findings would have considerable effects on asset allocation and would encourage investors looking for stability and lower risk to invest in conventional Canadian index and Islamic US one.

4.3. Graphical analysis

Graphical representation of conditional volatilities of the returns would allow us to assess the dynamic nature of conditional correlations and capture the time-varying nature of volatilities and correlations. Fig. 3 displays the conditional volatilities of the DJ indexes returns during 2001–2017. The volatility charts of conventional and Islamic indexes are juxtaposed for comprehension and comparative purposes.

Fig. 3 reveals that there is a convergence of conditional volatilities in the conventional DJ index returns over time. The chart exhibits a similar trend among the four indexes, with the exception of a distinctive peak identified for Canada after 2009. Fig. 3 similarly shows that Canadian Islamic DJ index exhibits relatively higher levels of volatility, while the Islamic US, UK and Japanese DJ indexes display comparatively lower volatility. The DJ conditional volatility graph also show two high volatility eras, starting from 2009. The peak of 2009 is primarily attributed to the Lehman Brothers' bankruptcy event and the occurrence of the global financial crisis 2007–2008. This period exhibits an overall higher volatility in the market.

For both conventional and Islamic indexes, we observe a notable increase in volatility in the returns of the stock market indexes after 2009. Therefore, we focus on graphical representation of conditional volatilities of the returns for the period that spans from 2008 to 2017 through Fig. 4. Fig. 4 corrobates our earlier findings. Fig. 4 reveals the convergence of conditional volatilities in the conventional DJ index returns, with notable singularities in the Canadian index, for both conventional and Islamic markets. However,

Table 7
Correlations and unconditional volatilities.

Conventional stock indexes					**Islamic stock indexes**				
	DJUS	DJJA	DJUK	DJCA		DJUSI	DJJA	DJUKI	DJCAI
DJUS	**0.088**	-0.057	0.097	0.153	DJUSI	**0.083**	-0.032	0.013	0.043
DJJA	-0.057	**0.135**	0.238	0.172	DJJAI	-0.032	**0.133**	0.128	0.121
DJUK	0.097	0.238	**0.101**	0.932	DJUKI	0.013	0.128	**0.102**	0.266
DJCA	0.153	0.172	0.932	**0.059**	DJCAI	0.043	0.121	0.266	**0.117**

Table 8
Unconditional volatility ranks.

	Conventional stock indexes		Islamic stock indexes	
No.	Indexes	Unconditional volatility	Indexes	Unconditional volatility
1.	DJCA	0.059	DJUSI	0.083
2.	DJUS	0.088	DJUKI	0.102
3.	DJUK	0.101	DJCAI	0.117
4.	DJJA	0.135	DJJAI	0.133

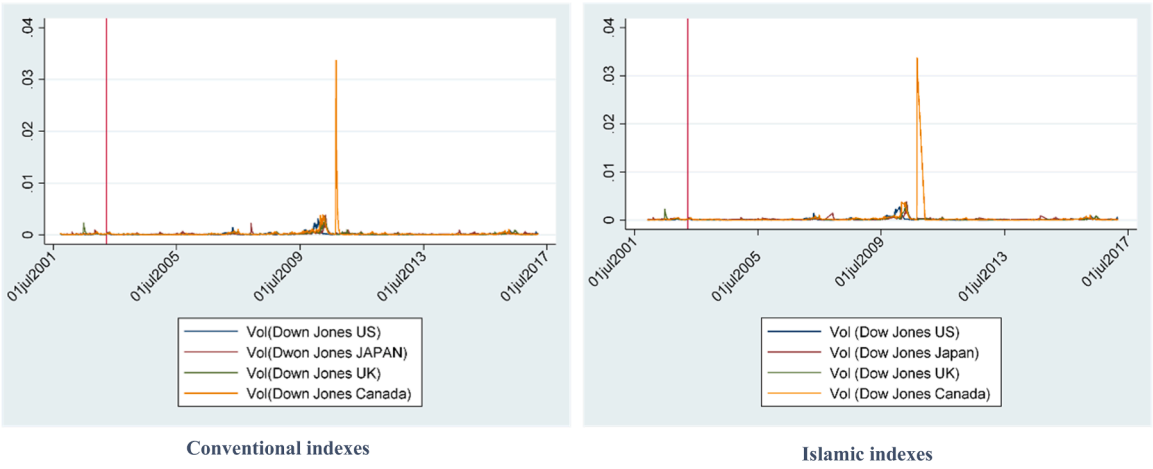

Fig. 3. Volatility of conditional and Islamic indexes over the period 2001–2017.

Fig. 4 puts in evidence a second peak for Islamic Japanese index in the second trimester of 2012. Furthermore, Fig. 4 reveals that conditional volatilities of conventional indexes exhibit relatively higher volatility than Islamic peers. Such an observation is in line with the common assumption that Islamic banks are less risky and more resilient than their counter parts. Indeed, Islamic investments are argued to be better positioned and more resilient during financial crises when compared to their conventional counterparts (Sukmana and Kolid, 2012); due to their several restrictive rules and ethical screening practices.

Fig. 5 graphically represents the conditional correlations of the returns for both the conventional and Islamic DJ stock indexes of the four indexes. Fig. 5 provides insights into the correlation patterns of the conventional DJ indexes. It indicates that the U.S. DJ index exhibits the highest correlation with its Canadian counterpart, whatever is the kind of market Islamic or conventional. Such a result suggests a close relationship between both stock markets; and would reflect tied economic and financial relationships between the US and Canada. Fig. 5 also highlights relatively low dynamic correlation between US and Japanese indexes, and also between US and UK indexes, for both conventional and Islamic indexes. Perhaps, these markets may operate with more distinct dynamics and respond to different factors.

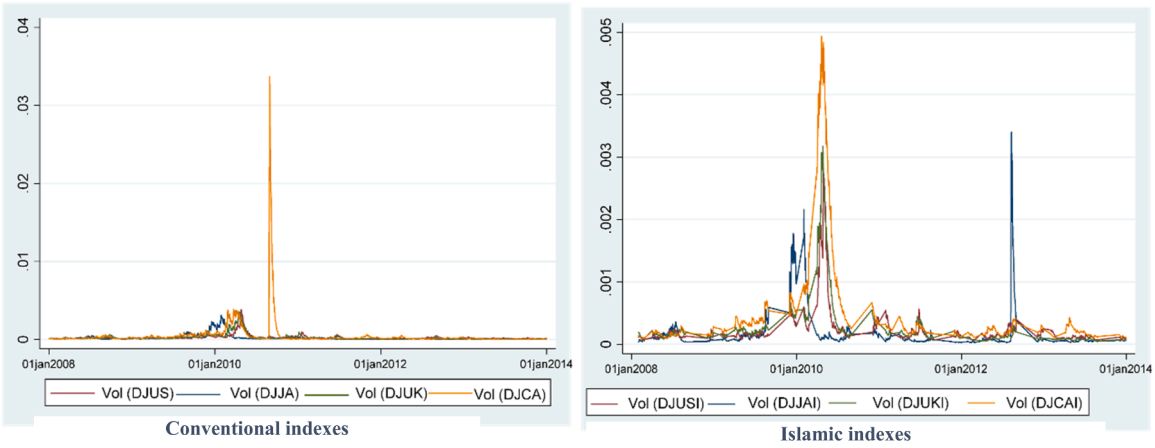

Fig. 4. Volatility of conditional and Islamic indexes over the period 2008–2014.

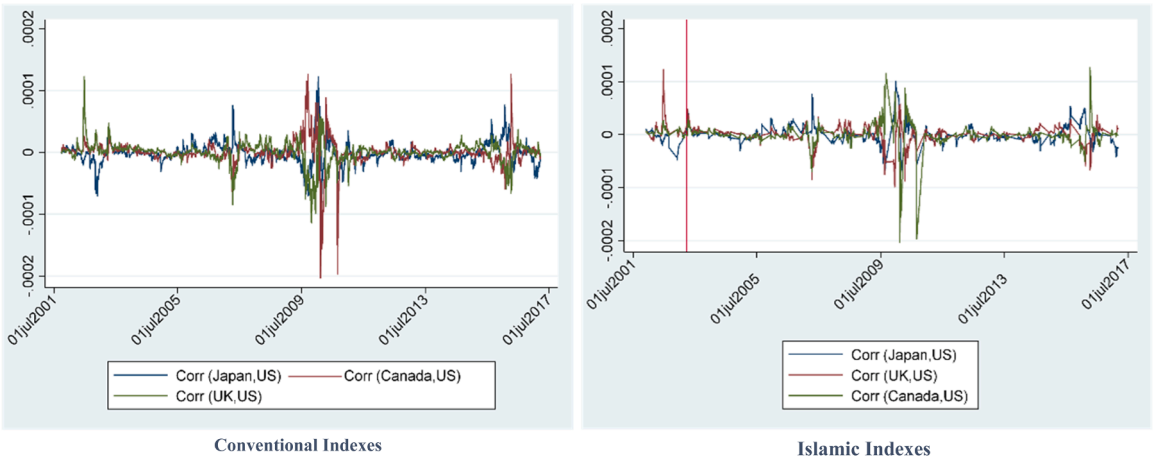

Fig. 5. Conditional correlations of conventional and Islamic indexes over the period 2001–2017.

Beyond empirical results, our analysis reveals that the period following the subprime crisis presented significant challenges for diversification, particularly within conventional markets. Notably, the indices of these markets exhibited a pronounced inter-correlation, and hence a strong co-movement during this period. These findings are consistent with prior studies conducted by Saâdaoui et al. (2017) and Arif et al. (2022), which extensively explored diversification strategies during both crisis and non-crisis periods. Interestingly, our observations extend beyond the subprime crisis and are applicable to other crises, such as the recent COVID-19 pandemic, as highlighted by Shahzad and Naifar (2022).

Moreover, our research converges from comparative studies, including the work by Ben Rejeb and Arfaoui (2019). We demonstrate that Islamic markets exhibit higher overall volatility compared to conventional markets. This provides compelling evidence that Islamic finance does not truly offer a potentially less risky investment avenue. Islamic finance does not truly differ from conventional finance even though they rely on divergent principles (Chong and Liu, 2009). Indeed, most financing of Islamic banks is dominated by debt-like financing instruments based on deferred payment sales and leasing versus a negligible portion strictly based on risk sharing (Kader and Leong, 2009; Abdul Rahman et al., 2014). Their risk management techniques are merely replicas from their conventional peers (Abdul Rahman et al., 2014). However, *Shariah* compliance might influence the liquidity and solvency of the Islamic banks and may have serious implications in terms of systemic risk and financial stability (Grira and Labidi, 2021).

On the other hand, Islamic indexes show lower dynamic correlation among each other than conventional peers. Therefore, Islamic finance might offer more potential benefits of diversification; and eventually greater resilience to crises. Particularly, our findings put in evidence that the American and Japanese indices exhibit the least correlation within the conventional system, but more significantly within the Islamic system. This aligns with the conclusions drawn by Tabash et al. (2023), who revealed that the Japanese Shariah-based market presents superior portfolio opportunities for U.S. traders. Our study confirms the impact of the subprime crisis and turbulent periods on hindering diversification in conventional markets. These findings greatly enhance the current literature and provide valuable insights for investors and researchers. Further investment in advanced econometric techniques, like multiresolution data mining (Rabbouch et al., 2018, 2022) and machine learning (Moula et al., 2017; Abedin et al., 2021; Sahoo et al., 2023), is now necessary to refine these results. This could be the focus of future research, which could also explore additional control variables such as geopolitical risks (Saâdaoui et al., 2022, 2023).

5. Conclusion

This study aimed to analyze the portfolio diversification advantages of Islamic and conventional stock indexes for the US and its major trading partners (Canada, Japan, and the UK) during the period from 2001 to 2017. The empirical findings of this study shed some light on the variations in volatility levels and correlation patterns across conventional and Islamic indexes, and provide insights into assets allocation and portfolio diversification.

At first glance, we note that Islamic indexes have almost a little bit higher unconditional volatilities than conventional peers. The Canadian index is relatively the least volatile whereas the Japanese index is the most volatile among other conventional counterparts. On the other hand, Islamic Japanese index has the highest unconditional volatility while the US index exhibits the lowest one among Islamic peers. Such findings would attract investors looking for stability and lower risk to invest in conventional Canadian index and Islamic US one.

While focusing on mutual correlations, the highest correlation observed among indexes exists between the Canadian and UK indexes, whether the indexes are conventional or Islamic. Furthermore, conventional (Islamic) US indexes exhibit a negatively low correlation with conventional (Islamic) Japanese peers versus a high correlation with conventional (Islamic) Canadian indexes. Islamic US index also shows a low correlation with Islamic UK index. These findings suggest that conventional and Islamic Japanese indexes and eventually Islamic UK indexes are likely to offer better diversification benefits to US investors compared to other indexes. This can

be attributed to the fact that these nations serve as developing hubs for capital markets, which may provide some stability during times of financial turmoil. Moreover, considering their status as significant trading partners of the US further emphasizes the appeal to include their stocks for diversification purposes. By diversifying across conventional and Islamic Japanese indexes and also Islamic UK indexes, US investors can potentially benefit from reduced portfolio risk and enhanced returns.

Overall, empirical findings suggest that there is a lower correlation among Islamic stock indexes than conventional peers. Our statistics also demonstrate that dynamic correlation between the US and Islamic indexes is relatively lower than that with conventional peers; what might encourage US investors to capitalize in Islamic indexes to accrue additional diversification benefits. On the other hand, our results show a high dynamic correlation between UK and Canadian indexes, for both conventional and Islamic markets; and hence less diversification returns. Conversely, there is a relatively low dynamic correlation between Japanese and Canadian indexes, whatever is the kind of market; which might offer potential profits of diversification.

The findings of this study have important implications for portfolio diversification strategies and future research in the field. The observed correlation patterns have important economic and financial implications, as they highlight the interdependencies and relationships between these markets. Understanding these correlations would help investors, policymakers, and market participants to take informed decisions, mitigate risks, and anticipate potential spillover effects between markets. While acknowledging the limitations of the study, such as restricted time frame and focus on specific countries and selected indexes, it is crucial to recognize the need for broader investigation across different time periods and countries to validate and generalize these findings. In addition to correlations and diversification benefits, further research and analysis are warranted to explore additional factors and expand the scope of diversification strategies for US investors. Future research should incorporate a more comprehensive analysis that considers various factors that might influence portfolio performance, including market dynamics, economic conditions, and specific industry sectors. By examining these factors, a more holistic understanding of portfolio diversification strategies can be achieved, leading to more informed investment decisions.

Furthermore, an exciting avenue for future work lies in exploring the application of machine learning approaches, particularly within the multiresolution category. Leveraging advanced analytical techniques can uncover hidden correlations and patterns at finer scales of variations in the data, enhancing the accuracy and precision of portfolio diversification strategies. By incorporating machine learning techniques, researchers can gain deeper insights into the relationships between stock indexes and uncover new opportunities for optimizing portfolio allocation. By addressing the limitations and incorporating advanced analytical techniques, future studies have the potential to advance our understanding of portfolio diversification, provide more robust recommendations for stock investors, and contribute to the development of more effective investment strategies in an evolving financial landscape.

Funding statement

The authors received no financial support for the research, authorship, and/or publication of this article.

Ethics approval statement

This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of interest disclosure

The authors declared no potential conflicts of interest.

Data availability

Data will be made available on request.

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