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Research article

Integration of Pakistan's stock market with the stock markets of top ten developed economies

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ABSTRACT

This study examines the integration of Pakistan's Stock Market with the stock markets of the top ten largest economies in the world—USA, China, Japan, Germany, the UK, India, France, Italy, Brazil, and Canada—from January 2015 to October 2020. To examine long- and short run integration, this study employed Johansen and Juselius co-integration and pair-wise Granger causality tests. In the long run, the results indicated that Pakistan's Stock Market is not integrated with these markets. This implies that the market is more attractive in portfolio diversification for international investors, and vice versa. In the short run, the results revealed that, except for China, Pakistan's stock market integrates with the remaining nine markets. However, Pakistan's stock market exhibits a bidirectional relationship with the USA, Japan, Germany, the UK, and France in the lead-lag relationship. However, its relationship with India, Italy, Brazil, and Canada is unidirectional, with Pakistan's stock market leading, while these markets are following. For Pakistani investors, China is the optimal market, and vice versa. Importantly, our findings help policymakers to comprehend Pakistan's dynamic relationship with its trading partners. To the best of our knowledge, no prior study has employed advanced techniques to address the time-varying correlation among the selected markets. By determining Pakistan's stock market integration with its trading partners, this study aimed to fill this empirical literature gap.

1. Introduction

Over the past three decades, the emerging market economies' economic crises—the Mexican crisis of 1994 and 1995, Asian crisis of 1997, Russian crisis of 1998, Brazilian crisis of 1999, and Turkey crisis of 2001—indicate more integration between real economies and financial markets. In contrast, the disorder in mortgage and sub-prime credit markets resulted in deregulation in the USA's banking sector. This, in turn, affected the control limits in derivative markets in 2007, causing the global economic crisis of 2008 to evolve [1]. The 2018 global financial crisis is one of the most intricate and severe crises because of its rapid spread. It is second only to the 1929 financial and economic crisis, which caused a financial imbalance and adversely affected economies globally. This proves that real economies and financial markets are integrated. Markowitz's [2] modern portfolio theory encourages financial planners to diversify their portfolio investments by optimizing mean-variance. The principle underlying portfolio diversification is the adage "do

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not put all eggs in one basket." It entails selecting various market securities. It is crucial to incorporate the co-movement of the selected securities into the selection process. The overall growth in economic conditions and globalization stimulates integration among emerging markets and enhances co-movement compared to the advanced stock markets. However, in this scenario, the financial dynamics of integration for emerging markets are distinct and heterogeneous [3].

Financial integration is influenced by internal and external factors, such as specific macroeconomic variables, international and financial policies, and economics. Since the mid-1990s, the investigation of stock market integration has attracted researchers' attention, with modern literature presenting evidence of enhanced integration. However, contemporary literature indicates that the degree of integration among equity markets has evolved throughout history [4]. One of the main factors driving increased integration in the developed world is the close interdependence between the economic and financial sectors of these economies. Relatedly, Abbasi et al. [5] propose an integrated location-allocation-routing model that encompasses all preliminaries required to make home healthcare supply chain corporation decisions amidst the COVID-19 pandemic. Conversely, the increasing growth in emerging markets is the driving force behind global economic growth. Further, this rapid growth has prompted financial and economic integration among various economies. Other factors contributing to the emergence of integration among international equity markets include technological advancement, the removal of statutory control, capital movements, foreign investments, and open world trade [6]. In addition, by unlocking new economic opportunities and facilitating tourism development in the region, economic corridors, contribute to the achievement of sustainable development goals. Green economic growth promotes environmental sustainability. Wang et al. [7] examine tourism and sustainable development pursuits under OBOR economic projects, which present opportunities for enhancing residents' quality of life. Their findings suggest essential and applicable policies to attain the desired sustainability level. Moreover, the findings contribute to tourism, well-being, and sustainability literature. Jiakui et l [8]. examine the impact of green finance, financial development, and green technology innovation on green total factor productivity across 28 Chinese provinces from 2011 to 2021. The findings indicate that green finance substantially increases green productivity. Other elements, such as financial development and technological innovation, contribute significantly to green production. Moreover, Rehman et al. [9] report that dependency on technology adoption and utilization in the tourism sector is contingent on the recruiters' willingness and innovativeness. They demonstrate that technology acceptance in the recruitment processes results in minimized cost, reduced time, and quality recruits.

Modern literature indicates that only a few studies have focused on Pakistan's stock market integration with developed markets [6, 10,11] or analyzed co-movement among developed markets. Recent studies document the relationship between the Pakistan Stock Exchange and the world's leading stock exchanges [12,13]. They suggest a loose connection among markets over the period investigated. Hence, international investors who aim to reduce risk can invest in these markets to diversify their portfolio risk. Ullah et al. [14] present empirical evidence regarding the interconnectedness of international markets post-COVID-19. Khan [15] demonstrates that stock market volatility is spilling over from the Indian stock market to the stock markets of other BRICS nations, persisting in both the short- and long-term. In addition, Shah et al. [16] developed and evaluated the conceptual framework that examines the impact of GSL on PEB and the mediating role of environmental passion (EP) and climate for green creativity (CFGC) among SMEs' employees. Data were collected from 460 middle-line managers, and a structural equation modeling (SEM) technique was applied to test hypotheses. Their findings revealed that the PEB impacts GSL, whereas EP and CFGC mediated these relations. The study findings demonstrated that a GSL with strong practices and values towards the environment can significantly impact employees' PEB. Relatedly, Wang et al. [7] explore the role of social well-being (HDI), tourism development, FDI, renewable energy, information and communication technology (ICT), and urbanization on CO2 emissions in Belt and Road (BRI) developed economies. The estimated results exhibited that ICT and renewable energy significantly contributes to sustainability. However, to the best of our knowledge, no study has investigated Pakistan's stock market integration with the top ten major developed markets worldwide since the demutualization (August 27th, 2012) and merging of the stock markets of Karachi, Lahore, and Islamabad into Pakistan's Stock Market (January 11th, 2016).

This study contributes to the literature by investigating the interdependence, integration, and co-movement of the ten most technologically developed markets in Pakistan's stock market. First, the study is significant because developing markets' financial turbulence is linked with developed markets, and vice versa. From a policymaking perspective, this is an essential question for financial policymakers because it provides insights into the necessity of monitoring other countries' economic and financial positions. Second, investigating the lead-lag relationship among stock markets would enable policymakers to forecast boom and recession in one market, which would subsequently impact other markets and facilitate timely corrective measures. Third, this study's novelty lay in the fact that it was conducted across a wide range of economies. This study will explore the integration of developed, developing, and emerging markets. Through the knowledge of diverse mix economies, investors can benefit from portfolio diversification. Finally, policymakers must comprehend Pakistan's dynamic relationship with its trading partners. As far as we know, no prior study has utilized advanced techniques to consider the time-varying correlation among the selected markets. By determining Pakistan's stock market integration with its trading partners, this study aimed to fill this empirical literature gap.

This paper's remaining sections are structured as follows:

Section 2 comprises a literature review of the area of the study in the global scenario and Pakistan. Section 3 comprises data and methodology, whereas Section 4 presents the results and discussion. Section 5 concludes the paper, and provides policy implications and future research recommendations.

2. Literature review

Numerous studies on various facets of this topic have demonstrated the significance of stock market integration. Initial studies focused on integrating stock markets in developed economies, particularly the US. Grubel [17] examined the US stock market, building on the extension of modern portfolio theory [2], and further highlighted the global benefits of diversifying portfolios. In the same manner, the stock markets of the global developing economies have also demonstrated increased returns for investors [18]. Their study which included stock markets from both developing and developed economies, utilized a large sample size. According to Solnik [19], Japan, the US, and nine other European markets from 1966 to 1971 reinforced the arguments of prior studies that investors benefit from diversifying their investment portfolios across international markets.

Additional studies examining the integration of developed stock markets have demonstrated that the expansion of the international nexus has occurred at varying times, resulting in reduced diversification benefits for investors in these markets. Taylor and Tonk [20] analyzed the stock markets of the US, Germany, the UK, Japan, and the Netherlands. They discovered increased integration among these markets, which suggests that investors' portfolio diversification in these markets is lower due to continuous efforts for financial liberation. Furthermore, Blackman et al. [21] and Coleman et al. [22] inferred that the level of integration among international markets has increased. Investors have experienced reduced returns and diminished diversification benefits and lowered returns for investors in these developed markets.

Previous studies have demonstrated a significant interconnection between developed stock markets and substantial growth in developing economies. Consequently, scholarly attention during the 1990s was redirected to investigating the integration of stock markets integration in developing economies. Studies conducted by Barus [23], Palac-McMiken [24], and Ibrahim [25] exhibited that the Asian region stock markets are segmented and provide investors with diversification benefits. However, empirical studies post-2000 revealed that Central Asia and South Asia (Taiwan, Korea, India, and China) as well as Southeast Asia (Malaysia, Philippines, and Indonesia), exhibited both segmentation and integration [26]. In contrast, developed stock markets (the US, the UK, and Japan) concluded that the Japanese market is already integrated with those in South and Central Asia. Nevertheless, the other two developed markets were segmented. Micah et al. [27] document that, in 2019, at the onset of the COVID-19 pandemic, US$9·2 trillion (95% uncertainty interval [UI] 9·1–9·3) was spent on health worldwide. They discover significant disparities in the amount of resources devoted to health, with high-income countries spending $7·3 trillion (95% UI 7·2–7·4) in 2019, which is 293·7 times the $24·8 billion (95% UI 24·3–25·3) spent by low-income countries in 2019. Balsalobre-Lorente et al. [28] identify that product market competitiveness positively contributed to determining the firm performance. Besides, in the study, digital financial innovation is the mediator, which partially positively determines firm performance. They demonstrate that firm financial innovation fails to account for firm performance fully.

3. Integration status of Pakistan's stock market (PSX) with other markets

The literature revealed contradictory results; the Pakistani stock market depicted varied integration with other markets over time [29]. The selection of different time spans, techniques, and the frequency of observations, i.e., daily, weekly, and monthly closing stock indices, accounts for mixed results. According to Ali et al. [6], Alvi et al. , Alvi and Chughtai [11], Shah et al. [30], and Zafar et al. [31], no evidence of market integration was found between Pakistan and these nine states, which are, the Netherlands, India, China, Indonesia, Singapore, Malaysia, Taiwan, Italy, and Russia during the periods 1998–2008, 2007–2014, 2004–2019, and 2000–2014. Numerous researchers have investigated the interdependence of stock markets. However, the interrelationships among stock markets have not yielded consistent results. Thus, unlike the studies above, it was proven that, from 1994 to 2016 and 2005 to 2018, the PSX was integrated with the stock markets of the USA, Japan, Australia, China, Indonesia, Malaysia, and the UK [32,33]. Additionally, equity market integration significantly affects a portfolio's risk minimization; therefore, it is imperative to conduct risk assessment. Khan et al. [34] and Aamir and Shah [35] indicated that the Pakistani stock market is co-integrated with the stock markets of India, China, the USA, Brazil, Chile, Egypt, Indonesia, Korea, Malaysia, Morocco, Poland, Thailand, Turkey, and Israel. However, the studies reveal that from 2007 to 2014 and 2001 to 2014, PSX was not integrated with the stock markets of Malaysia, Hong Kong, Japan, the UK, Germany, Australia, and France. Further, it was determined that PSX has a bidirectional causal relationship with the equity markets of Malaysia and Japan, but a unidirectional causal relationship with the equity markets of the USA and Australia. Furthermore, Khan et al. [34] studied integration from 2000 to 2015. It was determined that PSX and the economies of Egypt, China, India, Sri Lanka, Bangladesh, Indonesia, Thailand, Malaysia, Korea, the Philippines, and Singapore exhibited a unidirectional causal relationship. Younis et al. [37] examined co-integration from 1993 to 2019, while Rehman and Shahzad [36] examined integration from 2000 to 2016. However, these studies found no evidence of PSX's integration with Turkey, Mexico, South Korea, USA, and Japan markets. Conversely, PSX has been integrated with the equity markets of Turkey, China, and India between 2015 and 2019; however, it has not been integrated with those of Bangladesh and Singapore [38]. Contrary to the previous studies, PSX has not integrated with the Chinese and Japanese markets. However, from 2007 to 2013, PSX indicated integration with India, Malaysia, Singapore, and Indonesia [39]. Other studies [29,35,40–42] conducted in the area demonstrate that PSX has not integrated with Malaysia, China, Japan, Taiwan, India, Indonesia, Korea, Thailand, Brazil, Russia, Bangladesh, Nepal, and Sri Lanka from 2001 to 2013, 2001 to 2013, 2001 to 2015, 2006 to 2016, and 2003 to 2018.

4. Methodology and data

This study's analysis is based on the monthly stock indices for the sample period from January 2015 to October 2020. It comprises 70 observations collected from the official websites of Yahoo Finance and B3.

Subsequently, the selected markets' monthly closing indices were analyzed using descriptive statistics. This analysis aimed to investigate whether there were any stochastic/temporal properties in the data. After that, all series were transformed to logarithmic form. Monthly data is preferred over quarterly, bi-annually, and annual data to avoid the problem of false correlation. This is because monthly data allows for more flexibility in selecting an appropriate lag structure, which is crucial for accurate analysis [43]. However, the daily data are subject to the day-of-week effect and contain excessive noise [44]. Relatedly, Iorember et al. [45] utilize the second-generation econometrics methods—system GMM, panel quantile regression via moments, and the Dumitrescu-Hurlin causality test. These methods are applied to panel data covering 2008–2017. The empirical results establish a trade-off between the ecological factors and health outcomes. Jawad et al. [46] assess the role of product market competitiveness on firm performance using the mediating role of digital financial innovation. The annual data of 90 companies from 2014 to 2020 is collected from the Pakistan Stock Exchange market. The empirical results are estimated using the SEM regression approach paths. They identify that product market competitiveness positively contributes to determining the firm's performance. Furthermore, Shah et al. [47] employ estimation techniques to investigate the desired study objectives in 15 waste-recycled economies from 2000 to 2020. Consequently, they discover that the significant contribution to REG is by population, waste management, and environmental policy. In contrast, the quality of life and natural resource utilization (NRU) do not significantly contribute to renewable electricity generation.

To account for various stock market holidays, the study adopted Occam's razor technique. This is because missing observations are relatively more important in investigating global stock market integration by simply filling in the price of previous closed days [48,49]. This was necessary because the stock market does not generate any information, especially on holidays; thus, the previous day's closing is carried forward to the next day.

5. Unit root test

Macroeconomic variables in the time series data are non-stationary; thus, analysis based on non-stationary series results in spurious regression [50]. Therefore, data stationarity is a prerequisite for co-integration. Hence, the Philips-Perron and Augmented Dickey and Fuller (ADF) tests were employed to determine whether series are stationary or non-stationary [51]. The study used the ADF test because ADF is considered the finest and most reliable for time series data with autoregressive structure while also ensuring white noise residuals in regression [43]. Furthermore, to determine a more suitable number of lags, the study utilized the Schwarz Information Criterion (SIC), a standard tool for selecting lag structure [52]. The unit root test will be accepted under the null hypothesis if the series are non-stationary at all levels (1%, 5%, and 10%). Trace statistic values are less positive or negative than critical values.

$$Yt = a + bt + byt - 1 \ldots\ldots \tag{1}$$

Suppose there are non-stationary series at the level followed by the series conversion into the first difference. In that case, the data would be required to be made stationary using the equation below:

$$\Delta yt = a + bt + cyt - 1 + d\Delta yt - 1 + ut \tag{2}$$

6. Multivariate Johansen co-integration

Because the study's econometric model comprises more than two explanatory variables, the study utilizes Johansen and Juselius's [53] multivariate co-integration. According to Gujarati [54], Econometrics by Example 2nd Edition, if series are integrated in the same order, either equation (1) or (2), then co-integration will be used; otherwise, autoregressive distributed lag (ARDL) will be used. Johansen and Juselius believed that two likelihood ratios were used to identify the number of co-integration associations. The maximum eigenvalue ratio is applied to test the null hypothesis of the existence of "r" co-integration vectors compared with the alternative "r + t" co-integration vectors. Statistically, the maximum eigenvalue is such that

$$\lambda\ max = -T\ln\left(1 - \lambda r + 1\right) \tag{3}$$

where $\lambda r+1$, $\lambda r+2$ …. λn shows the n-r least squared canonical correlations, whereas T indicates the number of observations in equation (3). Further, the trace statistics ratio tests the null hypothesis of vectors' "r" co-integration comparatively to the alternative of "r+1" co-integration vectors. The statement is as follows in equation (4):

$$\lambda trace = -T\Sigma\ln(1 - \lambda i) \tag{4}$$

7. Granger causality

A lead-lag relationship is possible if a long run relationship exists among series. Granger causality can be examined using three variations: pair-wise Granger causality using the vector error correction model (VECM) approach, standard Granger causality, and Hsiao's version of the Granger causality. The last two Granger causality approaches are applicable only when there is no equilibrium relationship among variables, whereas the first one is suited for co-integration. Granger causality can be tested in the vector autoregessive (VAR) framework as follows in equations (5) and (6):

$$yt = x1 + \sum_{j=1}^{m} B1jYt - j + \sum_{j=1}^{m} \delta 1jxt - j + \varepsilon 1t \tag{5}$$

$$xt = x2 + \sum_{j=1}^{m} B2jxt - j + \sum_{j=1}^{m} \delta 2jyt - j + \varepsilon 2t \tag{6}$$

8. Preliminary analysis

The study uses graphs and statistics to examine the temporal and stochastic characteristics of the data. As shown in Fig. 1, all stock markets demonstrated a downward movement throughout 2016, However, in 2020, with the exception of the SSC180, all stock markets indicated an abrupt sharp downward movement. Furthermore, the stock markets exhibited a non-universal shock; specifically, only a few of the selected markets—SP500, Nikkei225, GSPTSE, FTSE100, SSE180, FTSEMIB30, FCHI40, and DAX30—indicated relatively lower shocks in 2018, than in 2016 and 2020. For the reference, the description of indices is provided in Table 1.

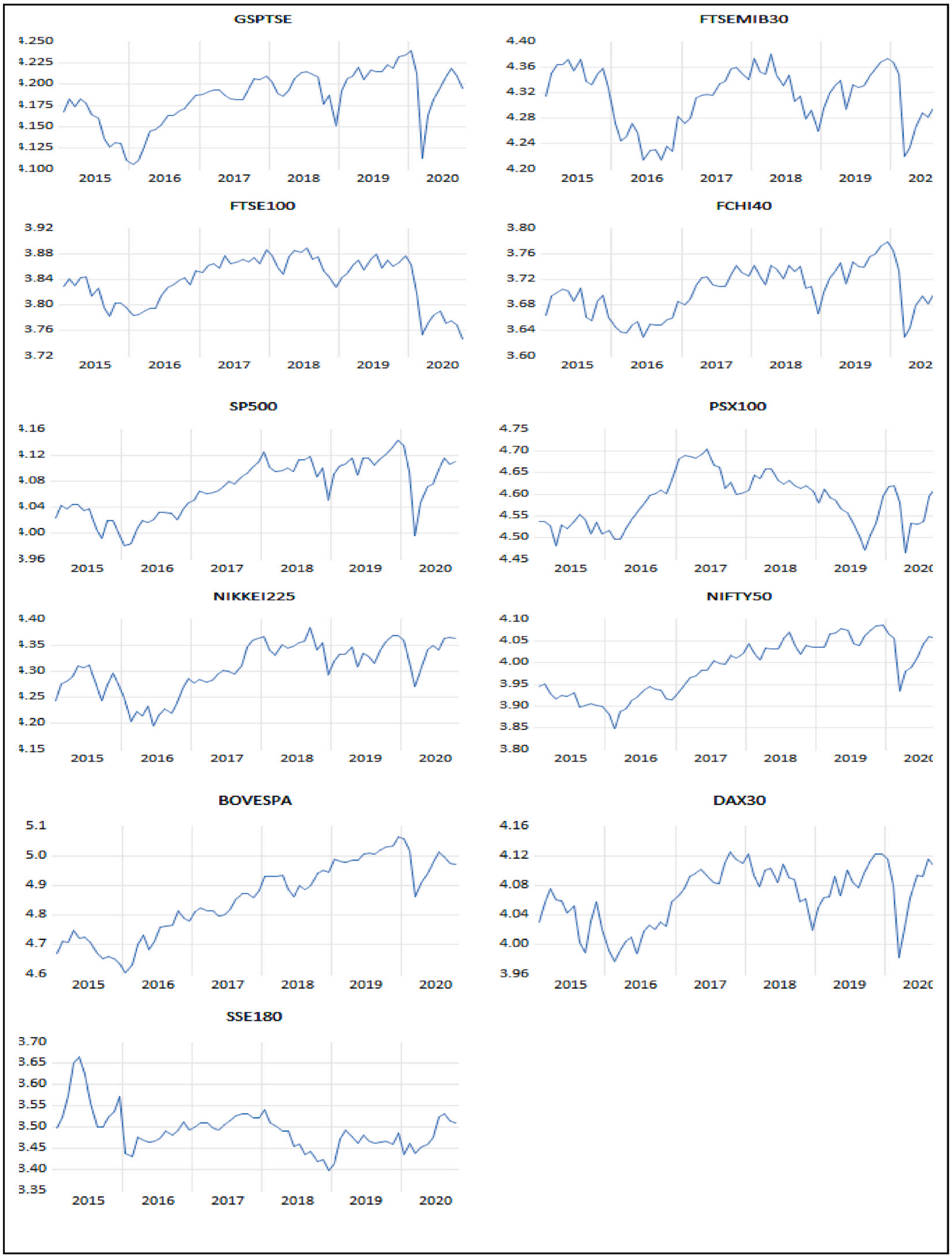

Fig. 1. Graphical representation of the series * X- and Y-axis denote year and volatility, respectively.

Table 2 shows the descriptive statistics results. During the sampling period, BOVESPA and PSX100 have the highest mean values, whereas SSE180 and FCHI40 have the lowest. Moreover, BOVESPA and NIFTY50 had the highest volatility, as indicated by the standard deviation coefficient, whereas GSPTSE and FTSE100 had the lowest during the same period. The skewness results demonstrated positive skewness for PSX100 and SSE180, which indicating that upward movement is more frequent than downward movement. In contrast, the other markets demonstrated negative skewness coefficients, implying that downward movements are more frequent than upward movements. During the period, all kurtosis coefficients featured a platykurtic distribution, except for SSE180. In addition, the JarqueBera test rejected the null hypothesis of normal distribution, indicating a non-normal data distribution.

Fig. 1 depicts a graphical representation of descriptive statistics and pair-wise correlations among series. Thus, it is evident that the data do not follow a normal distribution. Additionally, the correlation matrix in Table 3 confirms the results of Fig. 1, with the highest correlation of 0.944 observed between NIFTY50 and SP500.

Additionally, the ADF test tested the data behaviors for unit root and order of integration. First, all series, both at the log level and first difference, were tested with and without trend and intercept. Thus, as shown in Table 4, all series were non-stationary at the log level; however, the results further indicate significant ADF statistics for the first difference at the 5% significance level. Both models demonstrated insensitive results with intercept, intercept, and trend. Furthermore, the series order of integration is I (1).

As shown in Table 4, all series are initially stationary and integrated in the same order; therefore, the co-integration statistics are examined. Thus, before co-integration analysis, the research examined lag criteria and determined that SIC was the best-suited choice for the model. The study further tested for appropriate lag length criteria through VAR Lag Order Selection Criteria. as According to Table 5, the appropriate lag length for the study model is “2.” Further, Table 4 indicates the appropriate lag length for the LR test statistic, Final prediction error (FPE), Akaike information criterion (AIC), and Hannan-Quinn information criterion (HQ), which is determined to be “5.”

After determining the study model’s lag length criteria, the next step entails performing a co-integration analysis. The Johansen and Juselius co-integration techniques are based on five assumptions. Therefore, to avoid spurious results, we tested all the five models separately to determine the appropriate model. Table 6 presents the results, indicating that the study has the freedom to choose from the first three models. Consequently, model three of co-integration analysis, which offers more flexibility than the first two co-integration models, was chosen.

9. Empirical results and discussion

As discussed in Section 3, this study aims to evaluate Pakistan’s stock market integration with the top ten developed economies. Based on the trace statistics and maximum eigenvalue, present the Johansen and Juselius co-integration results are presented in Tables 7 and 8. The results indicate a lack of integration between PSX100 and SP500, SSE180, NIKKEI125, DAX30, FTSE100, NIFTY50, FCHI40, FTSEMIB30, BOVESPA, and GSPTSE at the 5% significance level.

Table 8 displays the results of the maximum eigenvalue statistics, which provide additional support for the trace statistics’ findings.

This study’s findings are consistent with those of Husain and Saidi [55]. It indicates that the PSX100 may provide investors in the US., China, Japan, Germany, the UK, India, France, Italy, Brazil, and Canada with the opportunity to diversify their portfolios. Further, it indicates that Pakistani investors can minimize risk by diversifying their portfolios internationally in these countries’ stock markets.

Table 9 shows that the demutualized market RPSX100 has co-movement with the demutualized markets RSP500, RNIKKEI225, RDAX30, RFTSE100, RNIFTY50, RFCHI40, RFTSEMIB30, RBOVESPA, and RGSPTSE. However, the RPSX100 has no co-movement with the demutualized market RSSE180. Furthermore, the results reveal a bidirectional short run causal relationship between RPSX100 and RSP500, RNIKKEI225, RDAX30, RFTSE100, and RFCHI40. In contrast, a unidirectional causal relationship exists between RPSX100 and NIFTY50, RFTSEMIB30, RBOVESPA, and RGSPTSE, wherein RPSX100 is leading. Moreover, RSSE180 and RPSX100 do not exhibit a lead-lag relationship. Additionally, these markets demonstrate the following modality:

10. Conclusions

Using monthly data from January 2015 to October 2020, this study analyzes the long and short run integration of PSX across major

Table 1
Description of indices.

Country	Stock Market	Index
Pakistan	Pakistan Stock Exchange	PSX – 100 Index
USA	New York Stock Exchange	S&P – 500 Index
China	Shanghai Stock Exchange	SSE – 180 Index
Japan	Tokyo Stock Exchange	Nikkei – 225 Index
Germany	German Stock Exchange	DAX – 30 Index
UK	London Stock Exchange	FTSE – 100 Index
India	National Stock Exchange	Nifty – 50 Index
France	French Stock Exchange	FCHI – 40 Index
Italy	Italian National Stock Exchange	FTSEMIB–30 Index
Brazil	Brazil Stock Exchange	BOVESPA Index
Canada	Toronto Stock Exchange	GSPTSE Index

Table 2
Descriptive statistics.

Description	PSX100	SP500	SSE180	NIKKEI225	DAX30	FTSE100	NIFTY50	FCHI40	FTSEMIB30	BOVESPA	GSPTSE
Mean	4.583	4.069	3.493	4.306	4.065	3.837	3.988	3.700	4.311	4.854	4.183
Maximum	4.703	4.143	3.665	4.383	4.125	3.889	4.086	3.779	4.380	5.063	4.239
Minimum	4.465	3.981	3.397	4.195	3.976	3.746	3.847	3.629	4.213	4.606	4.106
Std. Dev.	0.059	0.042	0.049	0.047	0.040	0.037	0.064	0.037	0.046	0.126	0.031
Skewness	0.045	−0.307	1.150	−0.522	−0.518	−0.659	−0.216	−0.102	−0.523	−0.206	−0.714
Kurtosis	2.146	1.956	5.456	2.322	2.247	2.303	1.740	2.084	2.143	1.843	2.860
Jarque-Bera	2.151	4.278	33.032	4.522	4.791	6.495	5.174	2.567	5.334	4.402	6.008
Observation	70	70	70	70	70	70	70	70	70	70	70

Table 3
Correlation matrix.

	PSX100	SP500	SSE180	NIKKEI225	DAX30	FTSE100	NIFTY50	FCHI40	FTSEMIB30	BOVESPA	GSPTSE
PSX100	1										
SP500	0.334	1									
SSE180	−0.107	−0.159	1								
NIKKEI225	0.225	0.878	−0.019	1							
DAX30	0.425	0.873	0.139	0.824	1						
FTSE100	0.483	0.568	−0.015	0.377	0.621	1					
NIFTY50	0.281	0.944	−0.307	0.831	0.758	0.446	1				
FCHI40	0.274	0.851	0.007	0.785	0.880	0.755	0.755	1			
FTSEMIB30	0.037	0.457	0.423	0.560	0.632	0.516	0.337	0.771	1		
BOVESPA	0.209	0.886	−0.359	0.760	0.664	0.319	0.927	0.652	0.186	1	
GSPTSE	0.343	0.933	−0.062	0.756	0.869	0.615	0.858	0.820	0.417	0.816	1

Table 4
ADF statistics.

	Level		First Difference	
	with constant	with constant & trend	with constant	with constant & trend
PSX100	−2.076	−2.057	−8.100	−8.041
SP500	−2.101	−3.125	−8.833	−8.765
SSE180	−2.603	−2.929	−7.462	−7.416
NIKKEI225	−2.006	−2.728	−8.569	−8.507
DAX30	−2.713	−2.979	−7.919	−7.858
FTSE100	−1.007	−0.886	−7.934	−8.026
NIFTY50	−1.292	−2.883	−8.706	−8.658
FCHI40	−2.526	−2.466	−8.416	−8.375
FTSEMIB30–2.361	−2.349	−8.660	−8.596	
BOVESPA	−1.343	−2.496	−6.650	−6.608
GSPTSE	−2.440	−3.184	−8.654	−8.591

Note: The critical value for the level at 5% with an intercept is −2.904, with an intercept and trend is −3.476, and the critical value for the first difference at 5% with an intercept is −2.904, with an intercept and trend is −3.477, thereby indicating data stationarity at the 5% significance level.

Table 5
VAR lag order selection criteria.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1727.134	NA	7.21e-37	−52.004	−51.639	−51.859
1	2226.346	816.892	7.94e-42	−63.465	−59.085*	−61.734
2	2325.173	128.775	2.08e-41	−62.793	−54.399	−59.476
3	2482.735	152.787	1.63e-41	−63.901	−51.493	−58.998
4	2770.291	182.990*	8.68e-43*	−68.948*	−52.525	−62.458*

Note: * denotes the appropriate lag length.

Table 6
Co-integration model selection criteria.

R	M-1	M-2	M-3	M-4	M-5
0	L	L	L	L	L
1	S	S	S	L	L
2	S	S	S	S	S
3	S	S	S	S	S
4	S	S	S	S	S
5	S	S	S	S	S

Note: Model selection criteria, critical values are the comparison of Trace statistics with 5% critical value; if Trace statistics exceed 5% critical values, the study assigns “L”; otherwise, it assigns “S.”

Table 7
Co-integration test trace statistics.

Hypothesis	Eigenvalue	Trace Statistics	0.05% Critical Value	Prob.**
None*	0.682	302.694	285.142	0.007
At most 1	0.548	224.595	239.235	0.187
At most 2	0.526	170.505	197.370	0.469
At most 3	0.395	119.648	159.529	0.857
At most 4	0.342	85.375	125.615	0.937
At most 5	0.267	56.863	95.753	0.977
At most 6	0.187	35.701	69.818	0.987
At most 7	0.121	21.620	47.856	0.978
At most 8	0.101	12.846	29.797	0.898
At most 9	0.069	5.563	15.494	0.746
At most 10	0.009	0.661	3.841	0.416

Note: Trace Statistics indicate 1 co-integrating equation at the 5% significance level.
* Denotes rejection of the null hypothesis at the 5% significance level.
** McKinnon-Haug-Michelis (1999) *P*-values.

Table 8
Co-integration test maximum eigenvalue statistics.

Hypothesis	Eigenvalue	Trace Statistics	0.05% Critical Value	Prob.**
None*	0.682	78.099	70.535	0.008
At most 1	0.548	54.089	64.504	0.338
At most 2	0.526	50.856	58.433	0.228
At most 3	0.395	34.273	52.362	0.830
At most 4	0.342	28.511	46.231	0.856
At most 5	0.267	21.161	40.077	0.943
At most 6	0.187	14.081	33.876	0.988
At most 7	0.121	8.774	27.584	0.996
At most 8	0.101	7.282	21.131	0.942
At most 9	0.069	4.902	14.264 0.751	
At most 10	0.009	0.661	3.841	0.416

Note: Maximum eigenvalue test indicates 1 co-integrating equation at 5% significance level.
* Denotes rejection of the null hypothesis at the 5% significance level.
** MccKinnon-Haug-Michelis (1999) *P*-values.

Table 9
Pair-wise Granger causality test.

Null Hypothesis	F-Statistics	Prob.
RSP500 does not Granger Cause RPSX100	44.883	0.000**
RPSX100 does not Granger Cause RSP500	4.037	0.048**
RSSE180 does not Granger Cause RPSX100	2.069	0.155
RPSX100 does not Granger Cause RSSE180	0.234	0.630
RNIKKEI225 does not Granger Cause RPSX100	9.273	0.003**
RPSX100 does not Granger Cause RNIKKEI225	8.413	0.005**
RDAX30 does not Granger Cause RPSX100	17.309	0.000**
RPSX100 does not Granger Cause RDAX30	6.499	0.013**
RFTSE100 does not Granger Cause RPSX100	17.398	0.000**
RPSX100 does not Granger Cause RFTSE100	3.800	0.055**
RNIFTY50 does not Granger Cause RPSX100	29.925	0.000**
RPSX100 does not Granger Cause RNIFTY50	0.467	0.496
RFCHI40 does not Granger Cause RPSX100	17.119	0.000**
RPSX100 does not Granger Cause RFCHI40	6.082	0.016**
RFTSEMIB30 does not Granger Cause RPSX100	15.561	0.000**
RPSX100 does not Granger Cause RFTSEMIB30	3.040	0.085
RBOVESPA does not Granger Cause RPSX100	27.756	0.000**
RPSX100 does not Granger Cause RBOVESPA	1.747	0.190
RGSPTSE does not Granger Cause RPSX100	37.297	0.000**
RPSX100 does not Granger Cause RGSPTSE	2.658	0.107

Note: ** Shows significance at 5%.

markets in the top ten economies, namely the USA, China, Japan, Germany, the UK, India, France, Italy, Brazil, and Canada. Johansen and Juselius co-integration was employed to examine market integration in the long run, whereas pair-wise Granger causality was used to examine market integration in the short run. In the long run, the results demonstrated that PSX is not integrated with the markets of the concerned economies. In these countries, the results inferred that PSX is more attractive to investors in these countries who are seeking to diversify their portfolios and vice versa. In the short run, the study concluded that PSX is integrated with the stock markets of the top ten economies, except for China. This reveals that, compared with other stock markets examined, the Chinese stock market is more suitable and attractive for Pakistani investors regarding portfolio diversification and vice versa. Furthermore, PSX exhibits a bidirectional nexus with the USA, Japan, Germany, the UK, and France stock markets, which implies that any boom or recession in these markets would affect PSX and vice versa. In addition, PSX exhibits a unidirectional lead-lag relationship with the stock markets of India, Italy, Brazil, and Canada, where it is leading. In contrast, these stock markets demonstrate the following modality, which implies that any boom and recession in PSX will affect the movement in these markets.

11. Limitations and future recommendations

The study submits that stock market integration would produce diverse outcomes depending on the frequency of observations, that is, daily, weekly, and monthly. Thus, for future research, we recommend using high-frequency data (i.e., daily and weekly data) to test integration. Additionally, studying the stock market contagion effect/spillover via the volatility model may present a potential avenue for future research. To check the co-integration, we conducted this study within a limited timeframe. A review of previous research on co-integration in Asian markets, particularly within my chosen sample, reveals a scarcity of studies investigating these markets collectively. Therefore, it is worth exploring the potential of investigating co-integration and volatility in these markets as an emerging area of study. Using various econometric methods, an examination of causality and contagion may also yield intriguing results regarding the degree of integration among the equity markets of Southeast Asia. Additional studies may disclose further economic variables that may cause financial and economic integration, such as interest rate differentials, foreign direct investment, GDP, portfolio investment, inflation rate, stock market capitalization ratio, and money supply.

12. Policy implications

Policymakers and managers should investigate and identify the potential contributors to financial and economic integration among the two stock markets. This issue requires a detailed study. Particularly, money managers in the Asian market must understand the market co-movement in emerging markets and consider the implementation of a hedging strategy involving a wide range of global portfolios. A firm would have its hedging strategy when adjacent markets fluctuate because such fluctuations and/or adjacent economies' downturns may spill over its economy and firms.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Seunghyup Lee: Writing – review & editing. **Chune Young Chung:** Writing – original draft. **Farid Ullah:** Writing – review & editing.

Declaration of competing interest

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