Integration of stock markets using autoregressive distributed lag bounds test approach

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Abstract: Financial integration plays a decisive role to the institutional investors for diversification of their investment portfolio(s). This research investigates the integration of selected stock markets (India, Australia, China, Spain, UK, and the USA) from different continents that are highly affected by COVID-19, employing the autoregressive distributed lag approach using daily data from 2 January 2011 to 7 May 2020. The outcomes show evidence of long and short-run integration among the markets. The rest of the markets are co-integrated with the markets of India, China, and UK. India has a long-run equilibrium with the USA and Spain, whereas China has a long-run association with Spain, and the UK has a long-run association with the USA. In short-run, India is positively influenced by the returns of rest of the markets, whereas all the markets under the study except USA influence China. Further, the UK’s market is significantly inclined negatively by its own past innovations.

Keywords: COVID-19; stock market integration; cointegration; autoregressive distributed lag; ARDL; bounds testing; USA; UK; structural breaks.

JEL codes: C58, F15, F36, G15, I12.


Biographical notes: Nikunj Patel is currently a program Chair of the MBA. He has almost 18 years of standing in his academic career. His areas of teaching and research include accounting, financial management, investment and portfolio management, behavioural finance and high frequency trading. He has also acted as a resource person in several faculty development and management development programmes. He has also completed a research project sponsored by Nirma University and Government of Gujarat sponsored project on district human development report of one of the district.

Bhavesh Patel has 20 years of experience in teaching and research. His areas of teaching and research include financial management, investments, portfolio management, management accounting and international finance. He has been credited for research papers in the journals of national and international repute.
1 Introduction

Integration of stock markets plays a crucial role in foreign investor decision taking to diversify their portfolio post deregulation, liberalisation and globalisation in developing economies. There is a considerable rise in the participation in international capital market activity after the relaxation of foreign exchange restrictions in developed and nascent markets, technical advances in communications and trading systems. In addition, it has provided more opportunities for overseas investment led to the advent of innovative products, such as depository receipts and overseas funds (Phylaktis and Ravazzolo, 2005). By investing into the countries, the international investors are impelled to improve their risk-adjusted returns, which are less correlated thereby reduced country specific risk (Baele and Inghelbrecht, 2009; Johnson and Soenen, 2003; Narayan et al., 2014). The diversification gain is low if the markets are exceedingly correlated and share a similar stochastic pattern (Aggarwal and Kyaw, 2005; Barari et al., 2008; Jayasuriya, 2011). According to the studies, the financial integration between stock markets is rising (Chien et al., 2015; Morana and Beltratti, 2008; Park, 2013; Phylaktis and Ravazzolo, 2005; Yu et al., 2010). However, there is still evidence of diversification among the emerging and developed market to diversify the risk (Al Nasser and Hajilee, 2016; Chelley-Steeley, 2004; Guidi et al., 2016; Johnson and Soenen, 2003; Lehkonen and Heimonen, 2014; Modi et al., 2010; Mohti et al., 2019; Rizwanullah et al., 2020). Chen (2018) finds the integration at a global level as well as geographical group of stock markets.

It is one of the most researched fields of international finance in the last four decades following the introduction of the cointegration concept by Granger (1983), which states combination of non-stationary series become stationary. Further, Engle and Granger (1987), Johansen (1988), Johansen and Juselius (1990) and many more have extended the cointegration concept. The global financial markets are increasingly integrated, as international trades for goods, financial assets, and services are promptly expanding (Kearney and Lucey, 2004). Financial integration is a situation when the identical risky assets earn the same risk adjusted returns irrespective of their domicile, hence all assets tests for law of equilibrating price with the same risk (Phylaktis and Ravazzolo, 2002; Ragunathan, 1999). Financial integration has a significant role in shock transmission. For example, if two markets are cointegrated, the shock in one market will immediately transmit the shock to the other market, and this is called financial contagion (Forbes and Rigobon, 2002). Bae and Zhang (2015) find that more globally integrated stock markets experienced a greater fall in prices during periods of crisis. Hence, the international investors always look for the markets, which are not integrated; this will reduce the chances of incurring the losses in both the markets. Investigating the integration of stock markets is very important from the economic and financial context for efficiently allocating resources, minimising capital costs and reducing the possibility of asymmetric shocks (Claus and Lucey, 2012; Lean and Smyth, 2014; Narayan et al., 2011; Phylaktis and Ravazzolo, 2002; Umutlu et al., 2010). These benefits to the foreign investors to diversify their portfolio, as within an economy there is only one possibility of diversification based on the industry. However, when investing in different countries helps them to diversify not only through countries but also through industries. However, it is rather difficult to switch investments from one country to other country, if markets have presence of capital restriction (Wu, 2020).
Nonetheless, during the crisis period, the stock market integration is dynamic and time varying (Chakrabarti and Roll, 2002; Gupta and Guidi, 2012; Huyghebaert and Wang, 2010; Longin and Solnik, 1995; Morana and Beltratti, 2008; Narayan et al., 2014). This is due to the diversification and preference of foreign investors to the emerging economies after market liberalisation. In integrating the emerging markets, development of the financial markets and policies for financial liberalisation plays an important role (Carrieri et al., 2007). However, the presence of long-run market equilibrium and the short-run deviation away from the equilibrium are likely to reverse to the long-run equilibrium relationship, which primarily rejects the weak form of market efficiency (Granger, 1986; Davies, 2006). The cross market return dispersion, Kalman filter method, dynamic cointegration analysis, common component approach, synchronisation of financial market cycle approach and correlation using dynamic conditional correlation (DCC) model are various metrics that measures stock market integration (Yu et al., 2010).

Recently many researchers have studied the impact of the COVID-19 on returns as well as volatility of the markets (Ashraf, 2020; Albulescu, 2021; Baker et al., 2020; Corbet et al., 2021; Phan and Narayan, 2020; Sharif et al., 2020; Zaremba et al., 2020). Due to this pandemic, it has created a need to investigate the long run and short run relationship among the stock markets of highly affected countries due to the pandemic. The present study is unique in terms of the approach threefold. First, we used the autoregressive distributed lag (ARDL) bounce test approach Pesaran et al. (2001) to study the long run and short-run relationships. Secondly, the research attempts to investigate the short-run and long run cointegration association among highly affected countries due to COVID-19 outbreak from continents like Australia, Asia, Europe, and North America. Thirdly, we investigate the relationship among the markets using daily prices.

This study contributes to the current research by fourfold. First, we expand the literature laid down by Sharma and Seth (2012) to include more recent and relevant literature. Second, we relate the literature to integration of the geographical and global markets. Thirdly, we added studies that employed the ARDL approach for cointegration. Fourth, there are limited studies, which capture the cointegration of our sample markets.

The findings of the study show the evidence of long and short-run integration among the markets. The rest of the markets are co-integrated with the markets of India, China, and UK. The outcomes have eminent inferences intended for the institutional investors, researchers, and policymakers. To convalesce risk-adjusted returns, the institutional investors can locate their funds by diversifying into the less cointegrated markets. Policymakers can use this research to see the interconnection with the other markets to attract foreign investments. Finally, we suggest that the future studies can explore the pre and post-COVID-19 cointegration.

The essence of this paper is structured according to the following sections. Section 2 discusses related research. Section 3 describes the data and methodology. Process and econometric models are proposed in Section 4. Section 5 deals with the empirical results; Section 6 addresses the study’s conclusion, managerial implications, and limitations.
2 Literature review

This study contributes to the current research by fourfold. First, we expand the literature laid down by Sharma and Seth (2012) to include more recent and relevant literature. Second, we relate the literature to integration of the geographical and global markets. Thirdly, some studies employed the ARDL approach to perform cointegration analysis. Thus, we add those literatures in the research. Fourth, there are limited studies, which capture the cointegration of our sample markets. Out of total literature survey, only Chowdhury et al. (2019), Mukherjee and Mishra (2007) and Pukthuanthong and Roll (2009) have taken all six sample markets. However, none of these researchers has used ARDL approach of cointegration. There are various studies, which are conducted to investigate cointegration of stock markets around the world. Nonetheless, results are mixed and indicate no consensus about the integration of the market. Seemingly, this is because of time-varying relationship between the markets. Most studies agreed on two aspects, the time-varying relationship and increasing association between the markets post financial crisis. For example, Wu (2020) examines the interconnection among the selected five ASEAN countries and other four stock markets tend to vary over time, using the weekly prices during 1999–2019. The recent study of Chowdhury et al. (2019) establishes stronger direct links to international markets using 42 countries’ daily prices during the period 1995–2016. The studies of cointegration are extensively classified into three categories positioned on the statistical methods employed. The first category of study includes GARCH-based models such as, GARCH-M, GARCH-DCC, TGARCH, DCCFIAPARCH etc. The investigation of the relationship using models of cointegration analysis such as Engle-Granger representation theorem, Johansen cointegration test, Granger causality, vector autoregression (VAR) and ARDL, etc. categorises the second. In the third category tools like Geweke Statistics, principal component analysis, Flood and Rose methodology, Gregory and Hansen’s cointegration tests, minimum spanning tree, cluster analysis, transition of the networks etc. are used. In addition, most of the studies describe the potential for investigating the relationship between emerging markets, combining emerging and developed markets with union markets such as ASEAN, BRICS, gulf, geographically concentrated markets, etc.

Another prospect is that economic fundamentals, global factors, regional factors, and financial factors are intricately linked to the level of global financial markets integration (see Aladesanmi et al., 2019; Chen, 2018; Lee and Cho, 2017; Narayan et al., 2014). Many studies point out the time-varying relationship between the world’s markets (see Barari et al., 2008; Chowdhury et al., 2019; Narayan et al., 2014; Wu, 2020). Numerous studies divulge a strong correlation between US market and other markets. For example, Neaime (2012) finds strong correlation of Dubai, Egypt, Jordan, and Kuwait with USA during 2007–2010. Marashdeh (2005) observes all the MENA countries are cointegrated but not with developed market. The recent study of Bakry and Almohamad (2018) find all MENA countries are cointegrated with each other as well as with the USA. Gil-Alana et al. (2018) explore the connections among the emerging equity markets in Africa and global markets during 2000 and 2018, and find the evidence of co-integration between Egypt and Kenya opposing the Europe Zone and UK. Abraham and Madani (2012) who observe segmented GCC stock markets using weekly data for the period July 2004 to December 2010. Kapar et al. (2019) conducted the study on the existence of a long-run equilibrium relationship among the three financial indices of UAE stock markets. Hatemi-J (2012) also indicates UAE and USA markets cointegrated during
2005–2011; however, this cointegration becomes stronger during a falling market than a rising market. This implies that in the bearish situation, the markets are becoming more cointegrated (Maghyereh et al., 2005; Chowdhury et al., 2019). These results are more evident with the study of Burdekin and Siklos (2012) who researched Chinese, USA and Asia-Pacific markets during 1995–2010. They identified the level of crises for affecting the persistence of equity returns in the Asia Pacific region and support the consequences of contagion. However, post-Asian era of financial crisis revealed long-run ties between China, New Zealand, and the US market. This supports the view of Narayan and Smyth (2005) who note cointegration between New Zealand and US market. Modi et al. (2010) manifest a strong opportunity for portfolio diversification for US investors on the Hong Kong, Russian and Indian markets during 1997–2008. However, Huyghebaert and Wang (2010) argue that the returns in East Asia and Mainland China are heavily affected by the US, although the reverse does not hold true. Karim et al. (2009) observe the Indonesian stock market cointegration with US, Japan, Singapore and China stock markets in between 1988–2007. Wang (2014) identified the strengthened connections between East Asian six major stock markets after universal crisis of 2008. The author examined the decreasing influences of Hong Kong, Singapore and US stock markets and the rising importance of the post-crisis stock markets in South Korea and Japan. Negi et al. (2012) also observe an increase in the linkages between emerging markets and USA market. Majid et al. (2008) evaluated the interdependence of five ASEAN stock markets with the US and Japan, they find that ASEAN stock markets are progressing towards greater integration either with each other or with the US and Japan, especially in the financial turmoil that followed the year 1997. Karim and Karim (2012) state similar results in five ASEAN countries, which implies lesser opportunities for international investors to expand their portfolio in ASEAN markets. Barari et al. (2008) reassess the co-movements among G7 equity markets. Since 2001, there is a rising conditional correlations and significant time-varying long-run relationships between the US and most other G7 markets. There is also significant evidence that the regional market cointegration increases a number of events like relaxation in the trade restrictions, emergence of euro etc. (Bekaert et al., 2009; Phylaktis and Ravazzolo, 2005). Exploring integration in the NAFTA zone, for example, after NAFTA’s passage, Aggarwal and Kyaw (2005) observe increased financial integration and co-movement in NAFTA equity markets. Therefore, since the passage of NAFTA, US stock prices became more integrated with the Canadian and Mexican stock prices. Carriero et al. (2007) conclude Mexico as the most integrated market and India as the most segmented. Johnson and Soenen (2003) examine eight America’s equity markets during 1988–1999 using Geweke contemporaneous feedback measures and pooled regression analysis. They statistically confirm a high percentage of ongoing connections including the American markets. The impact on stock market integration is partly attributed to the large share of trade with the USA. Phylaktis and Ravazzolo (2002) find strong integration between Thailand with the US. Chelley-Steeley (2004) also observes Thailand has been expeditious into global integration, Korea and Singapore are less segmented. The price change in the US market can be used to forecast Hong Kong and Taiwan’s move next day (Huang et al., 2000). These empirical evidences show the role of USA markets integration to the world markets. Mukherjee and Bose (2008) argue that American and other Asian markets dominated Indian stock returns. Their findings further emphasise that the Indian market also affects stock returns in other Asian markets significantly. Many studies note that the US market often plays a significant role in leading the other stock markets. For example Aityan et al. (2010)
indicate that Asian stock markets appear to follow some of the leading Western
developed markets. However, Climent and Meneu (2003) assert the US market's lead
position. Bessler and Yang (2003) discuss the structure of interdependence in
international stock markets during 1997–1999 using daily data. Their findings show that
the US market is strongly influenced by its own historical innovations but is also
influenced by UK, Switzerland, Hong Kong, France, and Germany market innovations.

Pukthuanthong and Roll (2009) address the stock market cointegration in all available
eighty-two countries in DataStream up to the year 2008. A rise in market integration has
been experienced besides Bangladesh, Nigeria, Pakistan, Sri Lanka, and Zimbabwe. This
is consistent with Morana and Beltratti (2008) showing a rise in US, UK, Germany, and
Japan co-integration. Chowdhury et al. (2019) confirms the rise in integration among
42 markets, but few are relocated over being primarily associated to global markets
through key bridge market similar to Hong Kong. Donadelli (2013) explores monthly
data to study 35 stock markets in 1988–2011, financial integration has been shown to be
accompanied by economic integration and the correlation dynamics are weak
measurements of financial integration. Al Nasser and Hajilee (2016) use the ARDL
approach and find the presence of short-run integration in emerging and developed
markets. However, in all emerging markets, the long-run coefficients for stock market
returns indicate a substantial relationship with the returns of Germany. This is consistent
with the results of Guidi and Ugur (2014) who recognised that the South-Eastern
European markets are cointegrated with Germany and UK over the period 2000–2013.

Several studies examined the co-integration of regional markets, such as Asian,
ASEAN, MENA, European, etc. Over the time, they found a rise in integration between
these markets. A greater extent of stock market links for economic growth and integration
is shown in countries around neighbouring geographical areas, which indicates the
foreign investors have to inflate their investments into several regional markets. During
the period 1990–2005, Mukherjee and Mishra (2007) examined the integration of stock
markets and the economic factors of 23 countries. They experience an increasing degree
of market integration. India performed a prominent role in the Asian region for nations,
but five other European countries and the US strongly lead the Indian market. These
results are consistent with Yang et al. (2003) who observed similar results in the Asian
relatively greater segmented Asian frontier stock market, that is consistent with Gupta
and Guidi (2012) who observe short-run relationships between India, Hong Kong, Japan
and Singapore. Conversely, Gulzar et al. (2019) confirms the US market and emerging
(2009) recognise China’s increased stock-market links with the Hong Kong market, but it
is feeble with the US market. Lehkonen and Heimonen (2014) observe poor correlation
among US and Asian markets such as Japan, Australia and China. Lean and Smyth
(2014) analyse the cointegration among six ASEAN markets with Chinese market during
2001–2012 using daily data. They found long-run cointegration in the ASEAN-6 and
Shanghai stock markets that shocks one market quickly and is adjusted in the short run.
Further, during 1994–2002 Chien et al. (2015) employ weekly data to study the dynamic
cointegration among the five ASEAN along with Chinese markets. They also find an
increase in integration. Recent study by Hussian and Saeed (2017) investigated the
co-movements of Asian stock markets using ARDL approach during 1995–2014 using
daily prices. They find Pakistan market reacts to the price innovation from the developed
and emerging markets but no other way. The insignificant integration of Sri Lanka with
the US and Asian markets are reported by Elyasiani et al. (1998). Nurrachmi (2019) examines the movements of Islamic stock markets during 2007–2013 and observes cointegration between Islamic markets. The recent study of Rizwanullah et al. (2020) finds an evidence of cointegration in Asian markets, however, they observe opportunities of portfolio diversification across these markets.

Few of the studies also display segmented markets (Claus and Lucey, 2012; Guidi et al., 2016; Jayasuriya, 2011; Phylaktis and Ravazzolo, 2005; Purnomo and Rider, 2012). There are few studies who also observed partially segmented markets (Boubakri and Guillaumin, 2015; Alotaibi and Mishra, 2017). No previous infectious disease outbreak has had such a strong impact on the stock market as the COVID-19 pandemic (Baker et al., 2020). Corbet et al. (2021) observe the term “corona” associated with the corporate identity. They also observed Chinese financial market as a determined epicentre of COVID-19 financial contagion.

3 Data and methodology

To capture the cointegration relationship, several studies have used different techniques such as Johansen cointegration, Engle and Granger cointegration, DCC-GARCH, Granger causality test, VAR, etc. (Sharma and Seth, 2012). Engle and Granger (1987), Johansen (1988) and Johansen and Juselius (1990) are known for the study of co-integration relations. Most of these statistical tests require variables with an equal order of integration (Bekhet and Matar, 2013).

Table 1 Details of markets understudy

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Name of market</th>
<th>Country</th>
<th>Continent</th>
<th>2019 market capitalisation to GDP (%)</th>
<th>2019 COVID-19 confirmed cases</th>
<th>2019 COVID-19 confirmed deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ASX 200</td>
<td>Australia</td>
<td>Australia</td>
<td>102.33</td>
<td>7,068</td>
<td>99</td>
</tr>
<tr>
<td>2</td>
<td>SSE Composite Index</td>
<td>China</td>
<td>Asia</td>
<td>70.20</td>
<td>84,065</td>
<td>4,638</td>
</tr>
<tr>
<td>3</td>
<td>BSE Sensex</td>
<td>India</td>
<td>Asia</td>
<td>76.88</td>
<td>106,750</td>
<td>3,303</td>
</tr>
<tr>
<td>4</td>
<td>IBEX 35</td>
<td>Spain</td>
<td>Europe</td>
<td>63.48</td>
<td>232,555</td>
<td>27,888</td>
</tr>
<tr>
<td>5</td>
<td>FTSE 100</td>
<td>UK</td>
<td>Europe</td>
<td>111.67</td>
<td>248,818</td>
<td>35,341</td>
</tr>
<tr>
<td>6</td>
<td>Dow Jones Industrial Average</td>
<td>USA</td>
<td>North America</td>
<td>150.28</td>
<td>1,528,568</td>
<td>91,921</td>
</tr>
</tbody>
</table>

Note: Total confirmed cases and confirmed deaths as on 20 May 2020 from www.ourworldindata.org.

The present study is unique in terms of the approach threefold. First, we used the ARDL approach (Pesaran et al., 2001) to study the long-run and short-run relationships. The rationale for adopting the ARDL approach is that it provides a greater benefit over other tests in establishing the relationship at a dissimilar order of integration. Nevertheless, the approach will crash due to the existence of an integrated stochastic trend of I(2) (Acquah, 2010). It provides the freedom to incorporate structural breaks and the regime change in due course. The stock prices often have structural breaks due to the change in the economic, political, and international environment. Secondly, the research attempts to investigate the short-run and long run cointegration association among highly affected
countries due to COVID-19 outbreak from continents like Australia, Asia, Europe, and North America. Thirdly, we investigate the relationship among the markets using daily prices from 2 January 2011 to 7 May 2020, which captures the COVID-19 outbreak period. We report the details of markets understudy in Table 1.

We have collected daily closing prices of six markets from Yahoo Finance during the period 2 January 2011 to 7 May 2020. Elyasiani et al. (1998) argue that daily returns are preferable to lower frequencies such as weekly or monthly, since extended periods usually produce unclear, ephemeral responses to innovations that can last for a few days.

4 Process and econometric models

In our study, we employ the ARDL approach. Initially, the stationarity of the series by conducting unit root tests are checked (Augmented Dickey Fuller test, Phillip-Perron, and Kwiatkowski-Phillips-Schmidt-Shin test) on the level as well as first differenced log series of the stock prices. The integration of series likewise is required by the traditional cointegration techniques such as Engle-Granger and Johansen cointegration test. However, the ARDL approach allows I(0) or I(1) to integrate, which implies that the series are stationary either at I(0) or I(1). Stock market adjustments are ephemeral because of cross border holdings of institutional investors; hence, the ARDL approach helps us to take different lags for the independent variables (Ozturk and Acaravci, 2011).

This process ensures the pre-condition of the ARDL model where no series are integrated at order (2). The second step involves finding out the structural break in the time series using Zivot-Andrews unit root tests to ensure stable and accurate estimates. The third step comprehends the ARDL model specification, considering the dummy variable for structural change based on Schwarz Bayesian criterion (SBC). The SBC often offers a specification that is more parsimonious (Pesaran and Shin, 2012). The Bayesian information criterion is consistent in longer time series, and outperforms AIC to choose the appropriate asymmetric relationship between variables (Wang and Xia, 2006; Wang and Liu, 2006). The other reason to select the SBC is that it offers shorter lag lengths because the stock prices adjust rapidly due to the cross border holding of institutional investors across the world markets. We then use the bound test approach to investigate the cointegrating relation between dependent and regressors to estimate the long and short-run relationship. The relationship among the world stock markets are dynamic over time. Hence, the error correction model is estimated as follows;

$$
\Delta \text{Ind} = \alpha_0 + \phi_1 \text{Dum} + \alpha_1 \ln \text{Ind}_{t-1} + \alpha_2 \ln \text{Aus}_{t-1} + \alpha_3 \ln \text{China}_{t-1} + \alpha_4 \ln \text{Spain}_{t-1} + \alpha_5 \ln \text{UK}_{t-1} + \alpha_6 \ln \text{USA}_{t-1} + \sum_{i=1}^{n} \alpha_{7i} \Delta \text{Ind}_{t-i} + \sum_{i=1}^{n} \alpha_{8i} \Delta \text{Aus}_{t-i} + \sum_{i=1}^{n} \alpha_{9i} \Delta \text{China}_{t-i} + \sum_{i=1}^{n} \alpha_{10i} \Delta \text{Spain}_{t-i} + \sum_{i=1}^{n} \alpha_{11i} \Delta \text{UK}_{t-i} + \sum_{i=1}^{n} \alpha_{12i} \Delta \text{USA}_{t-i} + \mu_t
$$

(1)
Integration of stock markets using ARDL bounds test approach

\[ \Delta \text{Aus} = \beta_0 + \phi_2 \text{Dum} + \beta_1 \ln \text{Ind}_{t-1} + \beta_2 \ln \text{Aus}_{t-1} + \beta_3 \ln \text{China}_{t-1} + \beta_4 \ln \text{Spain}_{t-1} \]
\[ + \beta_5 \ln \text{UK}_{t-1} + \beta_6 \text{USA}_{t-1} + \sum_{i=1}^{n} \beta_i \Delta \text{Ind}_{t-i} + \sum_{i=1}^{n} \beta_i \Delta \text{Aus}_{t-i} \]
\[ + \sum_{i=1}^{n} \beta_0 \Delta \text{China}_{t-i} + \sum_{i=1}^{n} \beta_1 \Delta \text{Spain}_{t-i} + \sum_{i=1}^{n} \beta_1 \Delta \text{UK}_{t-i} \]
\[ + \sum_{i=1}^{n} \beta_2 \Delta \text{USA}_{t-i} + \mu_i \]

\[ \Delta \text{China} = \gamma_0 + \phi_2 \text{Dum} + \gamma_1 \ln \text{Ind}_{t-1} + \gamma_2 \ln \text{Aus}_{t-1} + \gamma_3 \ln \text{China}_{t-1} + \gamma_4 \ln \text{Spain}_{t-1} \]
\[ + \gamma_5 \ln \text{UK}_{t-1} + \gamma_6 \text{USA}_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta \text{Ind}_{t-i} + \sum_{i=1}^{n} \gamma_i \Delta \text{Aus}_{t-i} \]
\[ + \sum_{i=1}^{n} \gamma_0 \Delta \text{China}_{t-i} + \sum_{i=1}^{n} \gamma_1 \Delta \text{Spain}_{t-i} + \sum_{i=1}^{n} \gamma_1 \Delta \text{UK}_{t-i} \]
\[ + \sum_{i=1}^{n} \gamma_2 \Delta \text{USA}_{t-i} + \mu_i \]

\[ \Delta \text{Spain} = \delta_0 + \phi_2 \text{Dum} + \delta_1 \ln \text{Ind}_{t-1} + \delta_2 \ln \text{Aus}_{t-1} + \delta_3 \ln \text{China}_{t-1} + \delta_4 \ln \text{Spain}_{t-1} \]
\[ + \delta_5 \ln \text{UK}_{t-1} + \delta_6 \text{USA}_{t-1} + \sum_{i=1}^{n} \delta_i \Delta \text{Ind}_{t-i} + \sum_{i=1}^{n} \delta_i \Delta \text{Aus}_{t-i} \]
\[ + \sum_{i=1}^{n} \delta_0 \Delta \text{China}_{t-i} + \sum_{i=1}^{n} \delta_1 \Delta \text{Spain}_{t-i} + \sum_{i=1}^{n} \delta_1 \Delta \text{UK}_{t-i} \]
\[ + \sum_{i=1}^{n} \delta_2 \Delta \text{USA}_{t-i} + \mu_i \]

\[ \Delta \text{UK} = \lambda_0 + \phi_2 \text{Dum} + \lambda_1 \ln \text{Ind}_{t-1} + \lambda_2 \ln \text{Aus}_{t-1} + \lambda_3 \ln \text{China}_{t-1} + \lambda_4 \ln \text{Spain}_{t-1} \]
\[ + \lambda_5 \ln \text{UK}_{t-1} + \lambda_6 \text{USA}_{t-1} + \sum_{i=1}^{n} \lambda_i \Delta \text{Ind}_{t-i} + \sum_{i=1}^{n} \lambda_i \Delta \text{Aus}_{t-i} + \sum_{i=1}^{n} \lambda_0 \Delta \text{China}_{t-i} \]
\[ + \sum_{i=1}^{n} \lambda_0 \Delta \text{Spain}_{t-i} + \sum_{i=1}^{n} \lambda_1 \Delta \text{UK}_{t-i} + \sum_{i=1}^{n} \lambda_2 \Delta \text{USA}_{t-i} + \mu_i \]

\[ \Delta \text{USA} = \psi_0 + \phi_2 \text{Dum} + \psi_1 \ln \text{Ind}_{t-1} + \psi_2 \ln \text{Aus}_{t-1} + \psi_3 \ln \text{China}_{t-1} + \psi_4 \ln \text{Spain}_{t-1} \]
\[ + \psi_5 \ln \text{UK}_{t-1} + \psi_6 \text{USA}_{t-1} + \sum_{i=1}^{n} \psi_i \Delta \text{Ind}_{t-i} + \sum_{i=1}^{n} \psi_i \Delta \text{Aus}_{t-i} \]
\[ + \sum_{i=1}^{n} \psi_0 \Delta \text{China}_{t-i} + \sum_{i=1}^{n} \psi_1 \Delta \text{Spain}_{t-i} + \sum_{i=1}^{n} \psi_1 \Delta \text{UK}_{t-i} \]
\[ + \sum_{i=1}^{n} \psi_2 \Delta \text{USA}_{t-i} + \mu_i \]
In these models, we have represented markets with the country names, because it will be very convenient for readers to relate the relationship. Price series are transformed to the natural log series.

Where \textit{Ind} is BSE Sensex (India), \textit{Aus} is ASX 200 (Australia), \textit{China} is Shanghai SE Composite Index (China), \textit{Spain} is IBEX 35 (Spain), \textit{UK} is FTSE 100 (UK), and \textit{USA} is Dow Jones (USA). The dependent variables in all the equations are change in the log series. We introduced the dummy variable in each of the equations for a structural break in the interception suggested by Zivot and Andrews (1992).

In the above equation, the null hypothesis is that there is no cointegrating relationship among the stock indices. To check the existence of long-run relationships, we conducted the bounds test using Microfit 5.5, which provides F-statistics and W-statistics. If the F-statistics and W-statistics estimated over the critical value \([I(1)]\) then the cointegration relationship occurs in the equation. In case, if both statistics are under the critical value \([I(0)]\), then the cointegration relationship does not exist. Nonetheless, the outcome of cointegration is inconclusive if the statistics fall between the critical limit.

5 Results and discussion

Figure 1 portrays the daily movement of all six markets indices understudy. From the graphical presentation, we observe that the movement pattern of India, Australia and the USA seem identically upward trend, whereas Spain and the UK look identical. However, the pattern of China differs from the rest of the markets. The outbreak of COVID-19 has burst the volatility in most of the markets. We can observe a steep fall in all the market indices after the period of COVID-19 outbreak post in January 2020, except China. SSE, China is the least affected market. From 2 January 2020 to 7 May 2020, the Spain market is corrected by 35.86%, followed by India 27.42%, UK 24.77%, Australia 21.60% and the USA 17.10%. However, the Chinese market is only corrected to the extent of 6.35% during this interval.

![Figure 1](https://example.com/figure1.png)
Integration of stock markets using ARDL bounds test approach

Figure 1  Daily movement of markets indices (continued) (see online version for colours)

Table 2  Statistics (returns) and correlation matrix

<table>
<thead>
<tr>
<th>Variable</th>
<th>BSE Sensex (India)</th>
<th>ASX 200 (Australia)</th>
<th>SSE (China)</th>
<th>IBEX 35 (Spain)</th>
<th>FTSE 100 (UK)</th>
<th>DJIA (USA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.0212</td>
<td>0.0061</td>
<td>0.0003</td>
<td>–0.0190</td>
<td>–0.0006</td>
<td>0.0353</td>
</tr>
<tr>
<td>Median</td>
<td>0.0454</td>
<td>0.0610</td>
<td>0.0502</td>
<td>0.0502</td>
<td>0.0367</td>
<td>0.0718</td>
</tr>
<tr>
<td>Maximum</td>
<td>8.595</td>
<td>6.767</td>
<td>5.692</td>
<td>7.528</td>
<td>8.666</td>
<td>10.764</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>1.1776</td>
<td>1.0552</td>
<td>1.4426</td>
<td>1.5228</td>
<td>1.0965</td>
<td>1.1626</td>
</tr>
<tr>
<td>Skewness</td>
<td>–1.1377</td>
<td>–0.9032</td>
<td>–0.8053</td>
<td>–1.0706</td>
<td>–0.8479</td>
<td>–0.8970</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>23890.29</td>
<td>10220.51</td>
<td>3125.617</td>
<td>9384.733</td>
<td>12033.38</td>
<td>45094.64</td>
</tr>
<tr>
<td>Probability</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>BSE Sensex (India)</th>
<th>ASX 200 (Australia)</th>
<th>SSE (China)</th>
<th>IBEX 35 (Spain)</th>
<th>FTSE 100 (UK)</th>
<th>DJIA (USA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSE Sensex (India)</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASX 200 (Australia)</td>
<td>0.4250*</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSE (China)</td>
<td>0.2347*</td>
<td>0.2730*</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IBEX 35 (Spain)</td>
<td>0.4135*</td>
<td>0.3678*</td>
<td>0.1425*</td>
<td>1.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTSE 100 (UK)</td>
<td>0.4780*</td>
<td>0.4776*</td>
<td>0.2274*</td>
<td>0.7509*</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>DJIA (USA)</td>
<td>0.3550*</td>
<td>0.3835*</td>
<td>0.1466*</td>
<td>0.5912*</td>
<td>0.6530*</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Note: * indicates significant at 1% level.

Source: Author’s calculations from Eviews
Table 2 describes the descriptive statistics of the markets understudy. DJIA gave the highest daily returns (0.0353%) followed by BSE Sensex (0.0212%) while IBEX 35 had the lowest returns (−0.0190), followed by FTSE 100 (−0.0006%) during the sample period. We observed the highest volatility in IBEX 35 (1.52%) and the lowest in ASX 200 (1.06%). The returns distribution is negatively skewed and leptokurtic. Jarque-Bera displays non-normal distribution; this is obvious for a large time series. The correlation suggests the primary evidence of cointegration among the markets. Highest correlation is observed between FTSE 100 and IBEX 35 (0.7509). It is partly due to their belonging to the same continent. The FTSE 100 and DJIA also have a strong correlation (0.6530). We observe the lowest correlation between IBEX 35 and SSE (0.1425). The SSE has least correlation with the rest of the indices, while the FTSE 100 has a stronger correlation with the other indices, followed by IBEX 35.

The primary condition of ARDL states that the series should not be integrated at order I(2) to avoid spurious results. To confirm the null hypothesis of unit roots, three unit root tests namely ADF, PP and KPSS are considered. The level series of stock prices are trend, so we applied unit root tests on the level series based on a constant and time trend, but we incorporated only constant in the first difference. With the confirmation of all the tests, we determine the order of integration at 1% significance level. In Table 3, we show the outcomes of unit root tests.

Table 3  
Results of unit root tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>Level</th>
<th>First difference</th>
<th>Order of integration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADF</td>
<td>PP</td>
<td>KPSS</td>
</tr>
<tr>
<td>BSE Sensex (India)</td>
<td>−2.933</td>
<td>−3.184</td>
<td>0.213**</td>
</tr>
<tr>
<td></td>
<td>0.152</td>
<td>0.088***</td>
<td></td>
</tr>
<tr>
<td>ASX 200 (Australia)</td>
<td>−3.022</td>
<td>−3.129</td>
<td>0.237*</td>
</tr>
<tr>
<td></td>
<td>0.126</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>SSE (China)</td>
<td>−2.06</td>
<td>−2.149</td>
<td>0.453*</td>
</tr>
<tr>
<td></td>
<td>0.567</td>
<td>0.517</td>
<td></td>
</tr>
<tr>
<td>IBEX 35 (Spain)</td>
<td>−2.022</td>
<td>−2.111</td>
<td>0.419*</td>
</tr>
<tr>
<td></td>
<td>0.589</td>
<td>0.539</td>
<td></td>
</tr>
<tr>
<td>FTSE 100 (UK)</td>
<td>−2.788</td>
<td>−2.826</td>
<td>0.304*</td>
</tr>
<tr>
<td></td>
<td>0.202</td>
<td>0.188</td>
<td></td>
</tr>
<tr>
<td>DJIA (USA)</td>
<td>−3.456</td>
<td>−3.588</td>
<td>0.199**</td>
</tr>
<tr>
<td></td>
<td>0.045**</td>
<td>0.031**</td>
<td></td>
</tr>
</tbody>
</table>

Notes: *, **, *** indicates significant at 1%, 5% and 10% level of significance, respectively.
Critical values of KPSS at 1%, 5% and 10% are 0.216, 0.146 and 0.119, respectively.
Source: Author’s calculations from Eviews

Table 3 reports the results of unit root tests at a level and first differenced series. The null of ADF and PP is that there is a unit root problem; while in the case of KPSS, it is reverse. BSE Sensex (India) seems stationary at the first difference; however, the PP test confirms the stationarity at 10% on level series. DJIA (USA) also looks stationary at 5% with ADF and PP test on a level; however, the KPSS rejects the null of stationarity. We
have established the order of integration only when all the unit root tests confirm the results at a 1% level of significance. Further, the results of unit root tests confirm that none of the series is I(2), which satisfies the first condition of ARDL.

Stock prices often react to economic and political reforms. The ADF, PP and KPSS does not consider the existence of a structural break in the series. Hence, we used (Zivot and Andrews, 1992) unit root test to avoid spurious models in the presence of a structural break in the time series. Table 4 shows the outcomes of structural break. The log prices in the presence of structural breaks reveal the unit root problem at a level. Yet, at first differenced the series becomes static that confirms the unit root tests statistics of I(1). The structural break stalks within log series of India, Australia, China, Spain, UK and USA on 14 February 2014, 19 November 2012, 28 October 2014, 18 July 2013, 19 November 2012 and 7 November 2016 respectively is shown in Table 4.

Table 4  Zivot-Andrews structural break unit root test

<table>
<thead>
<tr>
<th>Markets</th>
<th>At level</th>
<th>First difference</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>T-statistics</td>
<td>T-statistics</td>
<td>Break date</td>
</tr>
<tr>
<td>lnShanghai SE composite – China</td>
<td>–4.837</td>
<td>28 October 2014</td>
<td>–43.806*</td>
<td>15 June 2015</td>
</tr>
</tbody>
</table>

Notes: * indicates 1% level of significance. Critical values: 1%: −5.34, 5%: −4.80, 10%: −4.58. Lag selection based on BIC.

Source: Author’s calculations from Stata

Table 5 states the outcomes of ARDL bounds test. The estimated F-statistics and W-statistics exceed 95% upper bound, which indicates the null of no cointegration cannot be accepted for India equation (model 1), China equation (model 3), and the UK equation (model 5). Therefore, there exists the cointegration relationship among the countries when India, China, and the UK are kept as a dependent variable (model 1, model 3 and model 5 respectively). This shows that India, China, and the UK respond to the shock in the other countries. The null of no cointegration for Australia equation (model 2), Spain equation (model 4), and USA equation (model 6) cannot be rejected. This shows long-run movement in Australia, Spain, and USA are independent to the movement of the rest of the countries’ markets. Many studies found a strong influence of USA on the other markets. For example, Huang et al. (2000) observe predictability on the price change in Hong Kong and Taiwan with the previous price of the USA market. Mukherjee and Bose (2008) argued that US and other Asian markets dominate the Indian stock returns. Huyghebaert and Wang (2010) argued that there is a strong influence of USA on the returns in East Asia. Once the cointegration relationship is established, we estimated the long-run coefficient for three equations namely India, China, and the UK. Table 6 shows the long-run cointegration results.
### Table 5  
ARDL Bound Co integration test results and the critical values

<table>
<thead>
<tr>
<th>Model (co-integration null hypothesis)</th>
<th>Lag structure#</th>
<th>F-stat</th>
<th>W-stat</th>
<th>Outcome at 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 F (lnIndia, lnAus, lnChina, lnSpain, lnUK, lnUSA)</td>
<td>(1, 1, 1, 1, 1, 2)</td>
<td>7.342**</td>
<td>44.050**</td>
<td>Co-integration</td>
</tr>
<tr>
<td>2 F (lnAus, lnInd, lnChina, lnSpain, lnUK, lnUSA)</td>
<td>(2, 1, 1, 0, 2, 3)</td>
<td>3.467</td>
<td>20.804</td>
<td>Inconclusive</td>
</tr>
<tr>
<td>3 F (lnChina, lnAus, lnInd, lnSpain, lnUK, lnUSA)</td>
<td>(1, 1, 1, 1, 0)</td>
<td>4.599**</td>
<td>27.598**</td>
<td>Co-integration</td>
</tr>
<tr>
<td>4 F (lnSpain, lnAus, lnInd, lnChina, lnUSA, lnUK)</td>
<td>(1, 1, 0, 0, 1, 1)</td>
<td>3.676</td>
<td>22.057</td>
<td>Inconclusive</td>
</tr>
<tr>
<td>5 F (lnUK, lnAus, lnInd, lnChina, lnSpain, lnUSA)</td>
<td>(2, 1, 1, 1, 2)</td>
<td>4.795**</td>
<td>28.771**</td>
<td>Co-integration</td>
</tr>
<tr>
<td>6 F (lnUSA, lnAus, lnInd, lnChina, lnSpain, lnUK)</td>
<td>(2, 1, 1, 0, 1, 3)</td>
<td>1.993</td>
<td>11.956</td>
<td>No co-integration</td>
</tr>
</tbody>
</table>

The critical value of bounds test*

<table>
<thead>
<tr>
<th>Model</th>
<th>F-statistic</th>
<th>W-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>95%</td>
<td>95%</td>
</tr>
<tr>
<td></td>
<td>LB</td>
<td>UB</td>
</tr>
<tr>
<td>Model 1</td>
<td>3.048</td>
<td>4.142</td>
</tr>
<tr>
<td>Model 3</td>
<td>3.059</td>
<td>4.152</td>
</tr>
<tr>
<td>Model 4</td>
<td>2.988</td>
<td>4.154</td>
</tr>
</tbody>
</table>

Notes: # Selected based on SBC.
** indicates more than 95% upper bound from the critical value table.
LB and UB represent lower bound and upper bound respectively.
*Critical values are determined using stochastic simulations with 5,000 replications.

Source: Author’s calculations from Microfit 5

The long-run equation for India shows that Spain is influencing BSE Sensex movement positively and significantly. This shows that there is 1% increase in Spain propels BSE Sensex by 0.2452% and all the rest remains the same. The US market plays a significant role in the Indian market. From the long-run relationship, it is observed that there is 1% increase in the USA market that leads the Indian market by 0.8656%; this is significant at 1% level. China and UK influence negatively to the returns of India; however, this was insignificant. Positive and statistically significant dummy variable suggested by the ZA at 1% indicates that the market reacted positively after the break date. In May 2014, the Bhartiya Janta Party-led NDA party won 336 seats in the Lok Sabha election. This victory was massive after the 1984 election when late Shri. Rajiv Gandhi led Indian National Congress party won with 414 Lok Sabha seats. We also notice that China and
Integration of stock markets using ARDL bounds test approach

UK’s shocks are negative to India, but they are not statistically significant. The long-run equation for China also suggests that Spain positively and significantly affects the movement to China. 1% increase in Spain results in 0.5964% change in China. Spain affected both India’s and China’s market. The ZA structural break test is also statistically significant at 1%. In 2014, using purchasing power parity, China overtook the USA in gross domestic product1. The movement of the US market negatively affected China’s market; on the other hand, this relation is not statistically significant. We also observe significant long-run relationship between the US and the UK’s market. The rise of 1% in the US market corresponds to an increase of 0.3011% in the UK market. The dummy for the structural break is positive and significant at 10%. This was primarily because of the economic performance of the UK after 2013. The findings are consistent with Mukherjee and Mishra (2007) who observe India’s contemporary relationship with France, Russia, Italy, Britain, Spain and Germany. The USA significantly influences India (Aityan et al., 2010; Mensi et al., 2016; Modi et al., 2010; Mukherjee and Bose, 2008). There are many studies who found the USA does not significantly influence the Chinese market. For example, Yi et al. (2009) identified strong ties between China and Hong Kong market excluding the US market. Huyghebaert and Wang (2010) argued that except for Mainland China, the US has a strong influence on the returns in East Asia. Lehkonen and Heimonen (2014) also observed similar results. These results are consistent with the literature.

Table 6  Long-run coefficient estimates

| Independent variables | India equation (model 1) |  |  | China equation (model 3) |  |  | UK equation (model 5) |  |  |
|-----------------------|--------------------------|  |  | --------------------------|  |  | --------------------------|  |  |
| India                 | ----                     | ----                      | 0.1576 [0.439]          | 0.3589 [0.720]          | -0.0776 [0.1625] | -0.4774 [0.633]          |                     |  |                     |  |
| Australia             | 0.0867 [0.2201]          | 0.3938 [0.694]           | 0.3146 [0.608]          | 0.5175 [0.605]          | -0.0099 [0.2583] | -0.0383 [0.969]          |                     |  |                     |  |
| China                 | -0.0168 [0.0541]         | -0.3107 [0.756]          | ----                   | ----                    | 0.0157 [0.0599] | 0.2624 [0.793]           |                     |  |                     |  |
| Spain                 | 0.2452 [0.1067]          | 2.2975 [0.022**]         | 0.5964 [0.2685]         | 2.2211 [0.026**]        | 0.1216 [0.1074] | 1.1321 [0.258]           |                     |  |                     |  |
| UK                    | -0.1611 [0.2057]         | -0.7834 [0.433]          | 0.2347 [0.5706]         | 0.4112 [0.681]          | ----                   | ----                    |                     |  |                     |  |
| USA                   | 0.8656 [0.113]           | 7.6594 [0.000*]          | -0.7001 [0.4827]        | -1.450 [0.147]          | 0.3011 [0.1761] | 1.7101 [0.087***]        |                     |  |                     |  |
| Dummy                 | 0.1123 [0.0307]          | 3.6544 [0.000*]          | 0.4314 [0.0829]         | 5.2047 [0.000*]         | 0.0559 [0.0331] | 1.6874 [0.092***]        |                     |  |                     |  |
| C                     | 0.1737 [0.9648]          | 0.1801 [0.857]           | 2.7051 [2.4816]         | 1.0901 [0.276]          | 5.4298 [1.2337] | 4.4014 [0.000*]          |                     |  |                     |  |

Notes: # indicates the dummy variable in each equation as per Zivot-Andrews structural break.
* , **, *** indicates 1%, 5% and 10% level of significance respectively.
Source: Author’s calculations from Microfit 5.5
The estimation of long-run relationship is followed by short-run relationship (error correction model). Table 7 reports the short-run relationship in each of the three models.

Table 7  Short-run coefficient estimates

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>India equation (model 1)</th>
<th></th>
<th></th>
<th>China equation (model 3)</th>
<th></th>
<th></th>
<th>UK equation (model 5)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D(India)</td>
<td>---</td>
<td>0.1453 [0.0309]</td>
<td>4.7057 [0.000*]</td>
<td>0.0925 [0.014]</td>
<td>6.6126 [0.000*]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D(Australia)</td>
<td>0.2142 [0.0249]</td>
<td>8.5863 [0.000*]</td>
<td>0.2485 [0.0343]</td>
<td>7.2368 [0.000*]</td>
<td>0.1359 [0.016]</td>
<td>8.5038 [0.000*]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D(China)</td>
<td>0.0699 [0.0158]</td>
<td>4.4201 [0.000*]</td>
<td>0.0412 [0.010**]</td>
<td>4.1038 [0.000*]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D(Spain)</td>
<td>0.0878 [0.0221]</td>
<td>3.9739 [0.000*]</td>
<td>-0.0787 [0.0304]</td>
<td>-2.5857 [0.010**]</td>
<td>0.3426 [0.0118]</td>
<td>29.0117 [0.000*]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D(UK)</td>
<td>0.2299 [0.0344]</td>
<td>6.6742 [0.000*]</td>
<td>0.1961 [0.0458]</td>
<td>4.2844 [0.000*]</td>
<td>0.1127 [0.0168]</td>
<td>-6.6896 [0.000*]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D(UK(-1))</td>
<td>---</td>
<td>---</td>
<td>0.0458 [0.000*]</td>
<td>---</td>
<td></td>
<td>-0.1127 [0.0166]</td>
<td>7.6199 [0.000*]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D(USA)</td>
<td>0.0856 [0.0267]</td>
<td>3.2015 [0.001*]</td>
<td>-0.0109 [0.0073]</td>
<td>-1.4925 [0.1360]</td>
<td>0.2752 [0.0159]</td>
<td>17.2575 [0.000*]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D(USA(-1))</td>
<td>0.1176 [0.0205]</td>
<td>5.7262 [0.000*]</td>
<td>0.0067 [0.0005]</td>
<td>3.4323 [0.078***]</td>
<td>0.0009 [0.0005]</td>
<td>1.7633 [0.000*]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dummy</td>
<td>0.0033 [0.001]</td>
<td>3.3735 [0.001*]</td>
<td>0.0067 [0.0002]</td>
<td>3.4323 [0.001*]</td>
<td>0.0009 [0.0005]</td>
<td>1.7633 [0.000*]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECM(-1)</td>
<td>-0.0296 [0.0049]</td>
<td>-6.1069 [0.000*]</td>
<td>-0.0155 [0.0003]</td>
<td>-4.6510 [0.0004]</td>
<td>-0.0168 [0.004]</td>
<td>-4.2007 [0.000*]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: *, **, *** indicates 1%, 5% and 10% level of significance, respectively.

Source: Author’s calculations from Microfit 5

All the markets in the short-run are statistically influencing the Indian stock market. Regressors coefficients are positive and significant statistically at 1%, which implies changes in other markets that leads the Indian market to respond positively in the short-run. The Indian market is positively affected by UK and Australia to the extent of 0.2299% and 0.2142% respectively. We also observe that the current and one lag period returns of USA significantly moves the Indian market to the extent of 0.0856% and 0.1176% respectively. This confirms that the USA market strongly influences the Indian market (Aityan et al., 2010; Mensi et al., 2016; Modi et al., 2010; Mukherjee and Mishra, 2007; Mukherjee and Bose, 2008). All the short-run coefficients in the India equation are significant and positive, which implies that Indian market reacts positively with the rest of the markets. In the Dynamic model, the error correction term demonstrates the speed of adjustment, which restores to the equilibrium relationship. At 1%, the ECM term is negative and statistically significant, suggesting a stable long-run relationship between
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variables (Banerjee et al., 1998). It shows that short-run disequilibrium converges at a speed of 2.96% to long-run equilibrium. In the China equation, all the markets except the USA, significantly affect the short-run relationship. The Spain and the US coefficient is negative, meaning that in the short run, the Chinese market asserts negatively to both these markets. In the short run, India, Australia and UK are influencing the Chinese market positively whereas Spain negatively influence the Chinese market. Nevertheless, US market does not influences the Chinese market (Yi et al., 2009; Huyghebaert and Wang, 2010; Lehkonen and Heimonen, 2014). The term ECM is also negative and significant, showing a stable relationship with 1.55% adjustment speed. All the markets influence the UK market substantially. Further, the UK’s market is significantly influenced by its own historical innovations. However, Bessler and Yang (2003) indicates the US market is strongly persuaded from their own historical developments and is influenced by UK, Switzerland, Hong Kong, France and Germany market developments. The desired term ECM is also negative, which implies an adjustment speed of 1.68%. The relationship between the markets show the bilateral influencers and most of the corrections in the relationship adjust quickly. Once, we establish the long and short-run relationship; the consistency of the model needs to be checked, therefore, model diagnostics of all the three models are reported in Table 8.

Table 8  Model diagnostics

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>India equation (model 1)</th>
<th>China equation (model 3)</th>
<th>UK equation (model 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Prob.]</td>
<td>[Prob.]</td>
<td>[Prob.]</td>
</tr>
<tr>
<td>Serial LM test</td>
<td>2.3164 [0.128]</td>
<td>2.3018 [0.129]</td>
<td>1.6821 [0.195]</td>
</tr>
<tr>
<td></td>
<td>2.2018 [0.196]</td>
<td>1.8724 [0.273]</td>
<td></td>
</tr>
<tr>
<td>Ramsey functional form</td>
<td>1.5871 [0.208]</td>
<td>1.5766 [0.209]</td>
<td>0.2123 [0.645]</td>
</tr>
<tr>
<td></td>
<td>[0.21097]</td>
<td>[0.646]</td>
<td>[0.262]</td>
</tr>
<tr>
<td>Heteroscedasticity</td>
<td>2.7665 [0.096***]</td>
<td>2.7676 [0.096***]</td>
<td>65.063 [0.001*]</td>
</tr>
<tr>
<td></td>
<td>[0.096***]</td>
<td>[0.096***]</td>
<td>[0.000***]</td>
</tr>
<tr>
<td>ADF (residuals)</td>
<td>–46.263 [0.00001*]</td>
<td>–43.1322 [0.0000*]</td>
<td>–44.1406 [0.00001*]</td>
</tr>
<tr>
<td>F-statistics</td>
<td>127288 [0.0000*]</td>
<td>35767 [0.0000*]</td>
<td>39802 [0.0000*]</td>
</tr>
<tr>
<td>DW-statistic</td>
<td>2.0613</td>
<td>1.9178</td>
<td>1.9660</td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>0.0097</td>
<td>0.0136</td>
<td>0.0062</td>
</tr>
</tbody>
</table>

Notes: *, **, *** 1%, 5% and 10% level of significance, respectively.

Source: Author’s computations from Microfit 5

Table 8 reports all three models’ diagnostics. From the results of the diagnostics, we find that the India equation passes all the diagnostic tests. The null of no serial correlation is accepted in the residuals. This is justified with the serial LM test and Durbin-Watson statistic. The model is well fitted as per Ramsey functional form and the model is free from heteroscedasticity at 5% level. This study involves longer time-series data; hence, the null of normality is not tested in the residual series. Rather, more important in this
case is the stationarity of the residuals. The ADF test performed on the residuals are found stationary. However, China model and UK model suffer from violation of diagnostics. On one hand, the models suggest no serial correlation and good functional form; they suffer from the heteroscedasticity. Abraham and Madani (2012) also observe heteroscedasticity using weekly series in the residual. This is primarily because of non-synchronous price data. Hence, we performed stability checks for all the three models using CUSUM and CUSUMSQ tests. These tests help us to check whether the models are stable during the structural breaks. We present the output of the CUSUM and CUSUMSQ tests in Figures 2, 3 and 4 for model 1, 3, and 5 respectively. It is apparent that the plot of both the test in all the three models fit within critical bounds by 5%, which implies that the model confirms the stability of long-run estimates.

**Figure 2** CUSUM and CUSUMSQ plot for India equation (see online version for colours)

Source: Author’s computations from Microfit 5
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Figure 3  CUSUM and CUSUMSQ plot for China equation (see online version for colours)

Source: Author’s computations from Microfit 5

Figure 4  CUSUM and CUSUMSQ Plot for UK equation (see online version for colours)
Figure 4  CUSUM and CUSUMSQ Plot for UK equation (continued) (see online version for colours)

Source: Author’s computations from Microfit 5

To substantiate the model’s reliability, the actual and fitted plot of all the three models are presented in Figures 5, 6 and 7. All the estimated models have the power to explain the variation in the market. The fitted line (grey line) moves over the actual line (black line), which shows less explanatory power of residuals. Moreover, during the higher volatility in the COVID-19 outbreak period, the model has given satisfactory results.

Figure 5  Plot of concrete and fixed standards of model 1 – India equation (see online version for colours)
Figure 6  Plot of concrete and fixed standards of model 3 – China equation (see online version for colours)

Figure 7  Plot of concrete and fixed standards of model 5 – UK equation (see online version for colours)

Source:  Author’s computations from Microfit 5

6  Conclusions, managerial implications, and limitations

From a financial and economic perspective, stock market integration is particularly important for effectively allocating resources, controlling capital costs, and reducing the likelihood of asymmetric shocks. At the same time, to boost risk-adjusted returns, institutional investors diversify their portfolio investments into the least integrated market. An increase in the co-integration of the world’s financial markets is shown in many studies. The key underline dynamics are globalisation, liberalisation, and Deregulation.
This paper investigated the integration of the stock markets between selected countries from various continents that are highly affected by COVID-19. Using daily data from 2 January 2011 to 7 May 2020, the ARDL approach is used to study the long-run and short-run relations between six selected stock markets.

The unit root results implies an evidence against 1% significance level in all market indices. The findings revealed signs of long and short-run cointegration among the markets. The Indian, Chinese, and UK markets are co-integrated with the other markets. However, cointegration with Australia, Spain and USA to rest of the markets are not found. The USA and Spain influence India in the long-run, whereas China has long-run relationship with only Spain, and only the USA influences the UK in the long-run. In short-run, India is positively influenced by the returns of the rest of the markets, whereas China is governed by all the markets under study except USA. In addition, UK market is significantly influenced negatively by its own historical prices.

Moreover, the negative and significant error correction coefficient by 1% indicates stable long-run integration and the short-run disequilibrium in the model converges to the long-run equilibrium at a speed of 2.96% for India, 1.55% for China and 1.68% for the United Kingdom. Furthermore, the CUSUM and CUSUMQ have confirmed the stability of the short-run relationship for all the three models after considering the structural break. The results are consistent with earlier studies. For example, (Aityan et al., 2010; Mensi et al., 2016; Modi et al., 2010; Mukherjee and Mishra, 2007; Mukherjee and Bose, 2008) found USA and other markets strongly govern the Indian market. The US market does not influence the Chinese market (Yi et al., 2009; Huyghebaert and Wang, 2010; Lehkonen and Heinonen, 2014).

The study adds to the knowledge tenet by introducing literature that is more recent and applying the ARDL approach to those markets. To the best of our knowledge, these countries were explored by (Chowdhury et al., 2019; Mukherjee and Mishra, 2007; Pukthuanthong and Roll, 2009). However, none of these researches has used ARDL approach of cointegration.

These kinds of results have significant implications for institutional investors, researchers, and policy makers. International investors are still trying to boost their risk-adjusted returns. Researchers can explore this approach by taking markets region wise, union wise or fragmented. Policymakers can use this research to see the interconnection with the other markets to attract foreign investments. Finally, we suggest that the future studies can explore the pre and post-COVID-19 cointegration. The limitation of our study is that we have also considered the COVID-19 outbreak period, which may distort our results. Most of earlier findings, however, highlight increases in cointegration during the crisis period.
References


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Notes
1 Lok Sabha – the lower house of India’s bicameral parliament.
3 World Economic Outlook 2014.