RESEARCH

General election effect on the network topology of Pakistan's stock market: network-based study of a political event

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Abstract

To examine the interdependency and evolution of Pakistan's stock market, we consider the cross-correlation coefficients of daily stock returns belonging to the blue chip Karachi stock exchange (KSE-100) index. Using the minimum spanning tree network-based method, we extend the financial network literature by examining the topological properties of the network and generating six minimum spanning tree networks around three general elections in Pakistan. Our results reveal a star-like structure after the general elections of 2018 and before those in 2008, and a tree-like structure otherwise. We also highlight key nodes, the presence of different clusters, and compare the differences between the three elections. Additionally, the sectorial centrality measures reveal economic expansion in three industrial sectors—cement, oil and gas, and fertilizers. Moreover, a strong overall intermediary role of the fertilizer sector is observed. The results indicate a structural change in the stock market network due to general elections. Consequently, through this analysis, policy makers can focus on monitoring key nodes around general elections to estimate stock market stability, while local and international investors can form optimal diversification strategies.

Keywords: Minimum spanning tree, Centrality measures, General elections, Emerging market, Pakistan, Stock market network

Introduction

Political risk is a key factor affecting the performance of a country's financial market. There are many ways political risk can take place, such as a change in legislation, general elections, or a political regime shift. According to (Pantzalis et al. 2000), positive stock returns are expected after the resolution of political uncertainty. Additionally, political events capture investor attention due to the possible revision of their investment strategies, depending on the outcome of the event (Pástor and Veronesi 2013). Previous research proposes various methods to study the impact of elections on stock markets [e.g., GARCH and Cumulative abnormal volatility (CAV) (Białkowski et al. 2008), Support vector regression (Chiu et al. 2012), Cumulative average abnormal returns (CAAR) and Abnormal returns AR (Oehler et al. 2013; Savita and Ramesh 2015), Regression analysis (Abidin et al. 2010; Liew and Rowland 2016) Granger

cointegration and Johansen test (Goodell et al. 2015), and DCC bivariate GARCH (Sultonov and Jehan 2018)].

We extend the financial network literature by studying the impact of general elections on the network topology of Pakistan's stock market. Network-based methods are widely applied by researchers to study interdependency and the evolution of stock markets, such as minimum spanning tree (MST) (Mantegna 1999; Onnela et al. 2003b; Zhao et al. 2018; Yao and Memon 2019), threshold networks (CT) (Boginski et al. 2005; Lee and Nobi 2018), planar maximally filtered graphs (PMFG) (Tumminello et al. 2005; Yan et al. 2015; Musmeci et al. 2016), wavelet (Wang et al. 2017), and multiple criteria decision making (MCDM) (Kou et al. 2014). We have chosen MST, a main network mapping methodology extensively used to analyze various financial crisis (Wiliński et al. 2013; Majapa and Gossel 2016; Coletti and Murgia 2016; Xia et al. 2018; Memon and Yao 2019; Kou et al. 2019), currency crisis (Jang et al. 2011; Sultornsanee et al. 2013), sovereign debt crisis events (Dias 2012), as well as macroeconomic phases (Zhang et al. 2011). Therefore, this paper examines the interdependency and evolution of Pakistan's stock market by using MST before and after the general elections of 2018, 2013, and 2008.

In the summary, our study has made two contributions. First, we fill a research gap by examining the stock market's structural change and topological evolution around a political event: general elections. Unlike previous studies, that apply network-based methods to examine crisis related events of stock markets (Onnela et al. 2003a; Yang et al. 2014; Radhakrishnan et al. 2016), assesses structural change of stock market around other political event (Yao and Memon 2019), and does not take into consideration structural change and topological evolution particularly across general elections. Second, we apply MST around the three general elections in an emerging stock market instead of a developed stock market. Thus, understanding the state and structures of stock market across general elections is important for local and institutional investors in forming diversified strategies and estimating stock market stability for policy makers.

The rest of this paper is organized as follows. In Section 2, we describe the data, the MST methodology, and network topology centrality measures. In Section 3, we present and discuss the results. Finally, Section 4 presents our concluding remarks.

Data and methodology

Data

We use cross-correlations in the daily closing prices of 82 major stocks listed on the Pakistan stock exchange (PSX) for the blue chip companies' index, which is also known as the Karachi stock exchange (KSE-100) index, before and after three general elections in Pakistan to determine MST maps. The division of the data around the three general elections is shown in Table 1.

To study the role of every stock and the topological evolution, we construct six MSTs for before and after the general elections, where each sub-sample comprises 40 trading days. Additionally, companies are divided based on their economic activities for sectorial analysis. All 82 companies (acting as nodes in the network), individual sectors, and color for identification in the MST network are presented in Table 2. The data are obtained from the websites of (OpendoorsPK 2018), and (BusinessRecorder 2018).

Table 1 General elections dates and sub-sample division of the Pakistan stock market

Event	Election date	Before election	After election	Trading days
1	July 25, 2018	May 25, 2018 to July 24, 2018	July 26, 2018 to September 27, 2018	40
2	May 11, 2013	March 15, 2013 to May 10, 2013	May 13, 2013 to July 05, 2013	40
3	February 18, 2008	December 14, 2007 to February 15, 2008	February 19, 2008 to April 15, 2008	40

Methodology

Let $P_i(t)$ be the closing price of stock i at time t, while logarithm return $r_i(t)$ of a stock is defined as:

$$r_i(t) = \ln(P_i(t)) - \ln(P_i(t-1)). \tag{1}$$

We construct correlation matrix $C = (c_{ij})$ of size $N \times N$ among stocks i and j as follows:

$$C_{ij} = \frac{\langle r_i r_j \rangle - \langle r_i \rangle \langle r_j \rangle}{\sqrt{\left(\langle r_i^2 \rangle - \langle r_i \rangle^2\right)\left(\langle r_j^2 \rangle - \langle r_j \rangle^2\right)}} \tag{2}$$

where r_i and r_j are the logarithm returns of stocks i and j, respectively, and $\langle...\rangle$ is the statistical average for the period under investigation. Following the methodology of (Mantegna 1999), the correlation matrix of (82×82) is transformed into a distance matrix among each pair of stocks i and j, being given by:

$$d_{ij} = \sqrt{2\left(1 - C_{ij}\right)}. \tag{3}$$

The MST is a backbone network of correlation tree that uses $N-1$ linkages from $N(N-1)/2$ cross-correlation coefficients by minimizing the sum of all edges. The 82 stocks on PSX are the nodes in the network joined by edges and characterized by weights W. We apply (Kruskal 1956) algorithm to an undirected graph (G) of form $G = (N, E, W)$ into the MST.

To monitor the sectorial properties of Pakistan's stock market network, we examine three centrality measures—degree, closeness, and betweenness centrality—in the periods before and after the general elections. The degree of centrality of stock i is given by:

$$C_D(i) = \frac{\sum_{j=1}^{N} A_{ij}}{N-1}, \tag{4}$$

where A_{ij} is the component in the i-th row and j-th column of adjacency matrix A. The higher the value of $C_D(i)$ is, the more power stock i carries in influencing other stocks in the network (Marsden 2015).

Closeness centrality (Sabidussi 1966) is utilized to examine the amount of influence attached to an individual node in a network. This measure aims to examine the closeness of nodes with other nodes or sectors in the network and is defined as:

Table 2 The 82 stocks in the KSE-100 index. Company names are in chronological order

ID	Node	Company Name	Sector	Color
1	ABL	Allied Bank Limited	Commercial Banks	Blue
2	ABOT	Abbot Laboratories (Pakistan) Limited	Pharmaceuticals	Khaki
3	ACPL	Attock Cement (Pakistan) Limited	Cement	Red
4	AICL	Adamjee Insurance Company Limited	Insurance	Cream
5	AKBL	Askari Bank Limited	Commercial Banks	Blue
6	APL	Attock Petroleum Limited	Oil & Gas Marketing Companies	Yellow
7	ARM	Allied Rental Modarba	Modarabas	Coral
8	ATLH	Atlas Honda Limited	Automobile Assembler	Cyan
9	ATRL	Attock Refinery Limited	Refinery	Charcoal
10	BAFL	Bank Al-Falah Limited	Commercial Banks	Blue
11	BAHL	Bank Al-Habib Limited	Commercial Banks	Blue
12	BATA	Bata Pakistan Limited	Leather & Tanneries	Olive
13	BNWM	Bannu Woollen Mills Limited	Woolen Products	Green
14	BOP	Bank of Punjab Limited	Commercial Banks	Blue
15	BWCL	Bestway Cement Limited	Cement	Red
16	BYCO	Byco Petroleum Pakistan Limited	Refinery	Charcoal
17	CHCC	Cherat Cement Company Limited	Cement	Red
18	COLG	Colgate Palmolive (Pakistan) Limited	Chemical	Grey
19	CPPL	Cherat Packaging Limited	Paper & Board	Lime
20	DAWH	Dawood Hercules Corporation Limited	Fertilizer	Brown
21	DGKC	D.G. Khan Cement Company Limited	Cement	Red
22	EFUG	EFU General Insurance Limited	Insurance	Cream
23	ENGRO	Engro Corporation Limited	Fertilizer	Brown
24	FABL	Faysal Bank Limited	Commercial Banks	Blue
25	FCCL	Fauji Cement Company Limited	Cement	Red
26	FFBL	Fauji Fertilizer Bin Qasim Limited	Fertilizer	Brown
27	FFC	Fauji Fertilizer Company Limited	Fertilizer	Brown
28	FML	Feroze 1888 Mills Limited	Textile Composite	Green
29	GADT	Gadoon Textile Mills Limited	Textile Spinning	Green
30	GATI	Gatron Industries Limited	Synthetic & Rayon	Green
31	GHGL	Ghani Glass Limited	Glass & Ceramics	Purple
32	GLAXO	GlaxoSmithKline (Pakistan) Limited	Pharmaceuticals	Khaki
33	HBL	Habib Bank Limited	Commercial Banks	Blue
34	HCAR	Honda Atlas Cars (Pakistan) Limited	Automobile Assembler	Cyan
35	HMB	Habib Metropolitan Bank Limited	Commercial Banks	Blue
36	HUBC	Hub Power Company Limited	Power Generation & Distribution	Orange
37	HUMNL	Hum Network Limited	Technology & Communication	Salmon
38	ICI	I.C.I. Pakistan Limited	Chemical	Grey
39	INDU	Indus Motor Company Limited	Automobile Assembler	Cyan
40	INIL	International Industries Limited	Engineering	Light Blue
41	JGICL	Jubilee General Insurance Company Limited	Insurance	Cream
42	JLICL	Jubilee Life Insurance Company Limited	Insurance	Cream
43	KAPCO	Kot Addu Power Company Limited	Power Generation & Distribution	Orange
44	KEL	K-Electric Limited	Power Generation & Distribution	Orange

Table 2 The 82 stocks in the KSE-100 index. Company names are in chronological order *(Continued)*

ID	Node	Company Name	Sector	Color
45	KOHC	Kohat Cement Limited	Cement	Red
46	KTML	Kohinoor Textile Mills Limited	Textile Composite	Green
47	LUCK	Lucky Cement Limited	Cement	Red
48	MARI	Mari Petroleum Company Limited	Oil & Gas Exploration Companies	Yellow
49	MCB	MCB Bank Limited	Commercial Banks	Blue
50	MEBL	Meezan Bank Limited	Commercial Banks	Blue
51	MLCF	Maple Leaf Cement Factory Limited	Cement	Red
52	MTL	Millat Tractors Limited	Automobile Assembler	Cyan
53	MUREB	Murree Brewery Company Limited	Food & Personal Care Products	Magenta
54	NATF	National Foods Limited	Food & Personal Care Products	Magenta
55	NBP	National Bank of Pakistan	Commercial Banks	Blue
56	NCL	Nishat Chunian Limited	Textile Composite	Green
57	NESTLE	Nestle Pakistan Limited	Food & Personal Care Products	Magenta
58	NML	Nishat Mills Limited	Textile Composite	Green
59	NRL	National Refinery Limited	Refinery	Charcoal
60	OGDC	Oil and Gas Development Company Limited	Oil & Gas Exploration Companies	Yellow
61	OLPL	Orix Leasing Pakistan Limited	Leasing Companies	Navy
62	PAKT	Pakistan Tobacco Company Limited	Tobacco	Chocolate
63	PICT	Pakistan International Container Terminal Limited	Transport	Black
64	PIOC	Pioneer Cement Limited	Cement	Red
65	PKGS	Packages Limited	Paper & Board	Lime
66	PMPK	Philip Morris (Pakistan) Limited	Tobacco	Chocolate
67	POML	Punjab Oil Mills Limited	Vanaspati & Allied Industries	Maroon
68	PPL	Pakistan Petroleum Limited	Oil & Gas Exploration Companies	Yellow
69	PSMC	Pak Suzuki Motor Company Limited	Automobile Assembler	Cyan
70	PSO	Pakistan State Oil Company Limited	Oil & Gas Marketing Companies	Yellow
71	PTC	Pakistan Telecommunication Company Limited	Technology & Communication	Salmon
72	SCBPL	Standard Chartered Bank Limited	Commercial Banks	Blue
73	SEARL	The Searle Company Limited	Pharmaceuticals	Khaki
74	SHEL	Shell Pakistan Limited	Oil & Gas Marketing Companies	Yellow
75	SHFA	Shifa International Hospitals Limited	Miscellaneous	Silver
76	SML	Shakarganj Limited	Sugar & Allied Industries	Teal
77	SNBL	Soneri Bank Limited	Commercial Banks	Blue
78	SNGP	Sui Northern Gas Pipelines Limited	Oil & Gas Marketing Companies	Yellow
79	SSGC	Sui Southern Gas Company Limited	Oil & Gas Marketing Companies	Yellow
80	THALL	Thal Limited	Automobile Parts & Accessories	Cyan
81	TRG	TRG Pakistan Limited	Technology & Communication	Salmon
82	UBL	United Bank Limited	Commercial Banks	Blue

$$\mathrm{Cc}\,(k) = \frac{1}{\sum_{h \in G} d_G(k,h)}, \tag{5}$$

where $d_G(k,h)$ represents the minimum distance between nodes k and h. Finally, to analyze the intermediary role of a node in the network, betweenness centrality is used to evaluate the frequency of a node acting as shortest link among two nodes and in transferring valuable information to the network:

$$C_B(k) = \sum_{s \neq k \neq t \epsilon V} \frac{\sigma_{st}(k)}{\sigma_{st}}, \tag{6}$$

where σ_{st} is the number of shortest paths between nodes s and t.

Results and discussion

Here, we present six MSTs of 82 stocks in KSE-100 of Pakistan stock market before and after three general elections (2018, 2013, and 2008). The stocks (nodes) are colored based on their business sectors, as per Table 2.

Figure 1 shows the MST map before the general election of 2018. There is no single most dominant stock, but four principal nodes[1]: Nishat Mills (NML 6), D.G. Khan Cement (DGKC 5), Kohat Cement (KOHC 5), and Sui Northern Gas (SNGP 5). Therefore, MST highlights the strong dependency of Pakistan's economy on cement, textile, and oil and gas sectors before the 2018 election. Additionally, the results show that the stocks in the cement (red) and oil and gas (yellow) sectors form clusters and connect with each other. However, companies in the commercial banks sector (blue) are split into two groups, one at the bottom left of the map and one on the middle-right side. Furthermore, a strong intermediary role is being played by SNGP, which is carrying the highest betweenness centrality score of 2265.
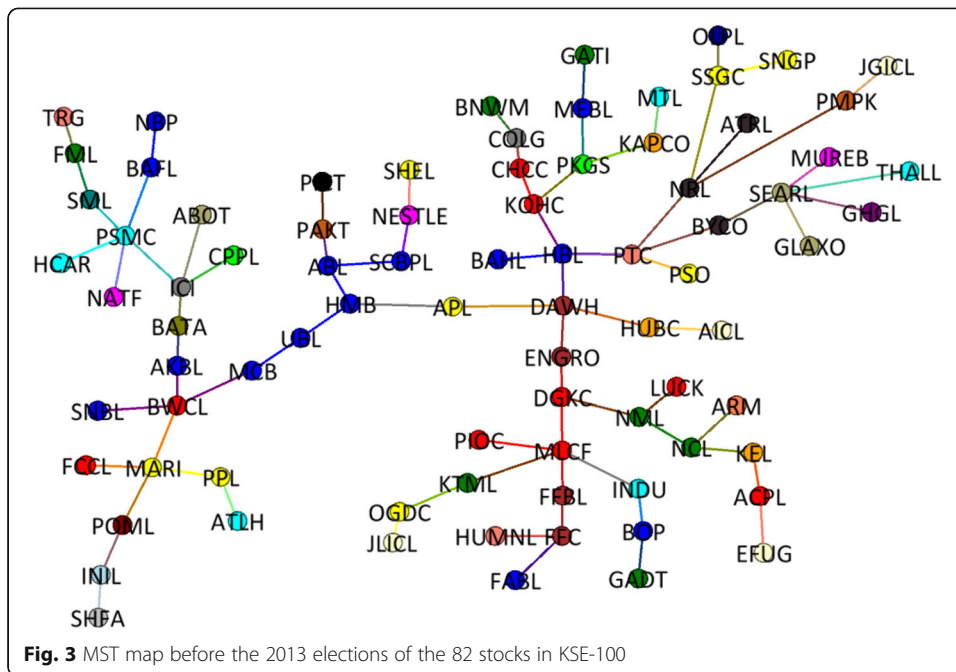
The MST map after election 2018 of the KSE-100 index companies is presented in Fig. 2. We observe the scattered pattern of the commercial banking sector, where banks are linked to companies from other sectors. Similarly, oil and gas companies are separated from one major cluster before elections 2018 to a disbursed distribution after elections period. The split of these two sectors possibly reflect different responses to the risks constituted by general elections. In terms of connectivity, a main hub node is Lucky Cement (LUCK 10), followed by three key nodes: D.G. Khan Cement (DGKC 7), ENGRO Corporation (ENGRO 5), and Kohat Cement (KOHC 5). Several emerging countries such as South Africa (Majapa and Gossel 2016), Brazil (Tabak et al. 2010), China (Zhuang et al. 2008), and India (Sinha and Pan 2007) have key nodes in the MST, which is not uncommon on Pakistan's stock market. In sum, the MST shows a star-like structure after the general elections of 2018, possibly reflecting a structural transition.

Figure 3 represents the 2013 pre-election MST map of the KSE-100 network. The figure shows a tree-like structure of the MST (Nobi et al. 2015) due to low value of centrality. The three key nodes of Mapple Leaf Cement (MLCF), Pak Suzuki Motors (PSMC), and Searle Company (SEARL) have a maximum of five connections each in the 2013 pre-election period. In addition, there is no major cluster formation and reduced connectivity in the network. Only three cement sector companies—DGKC,

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[1]The number against each stock symbol specifies the number of connections per node.

Fig. 1 MST map before the 2018 elections for the 82 stocks in KSE-100

Fig. 2 MST map after the 2018 elections of 82 stocks in KSE-100

Fig. 3 MST map before the 2013 elections of the 82 stocks in KSE-100
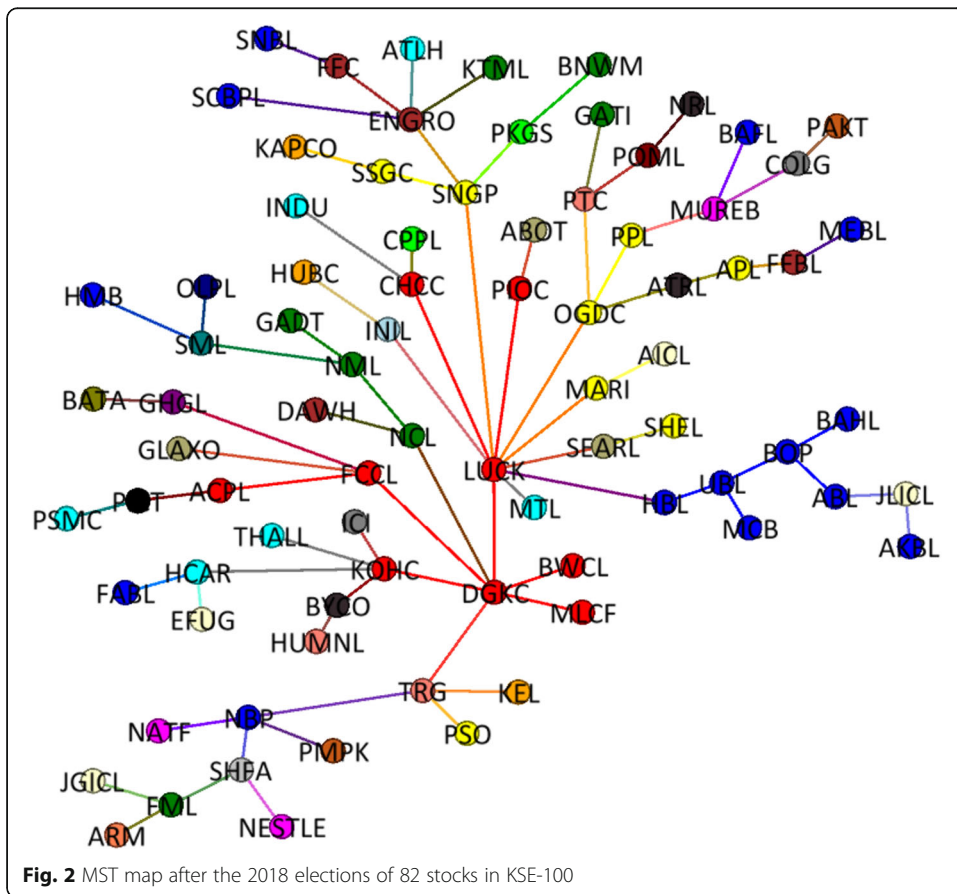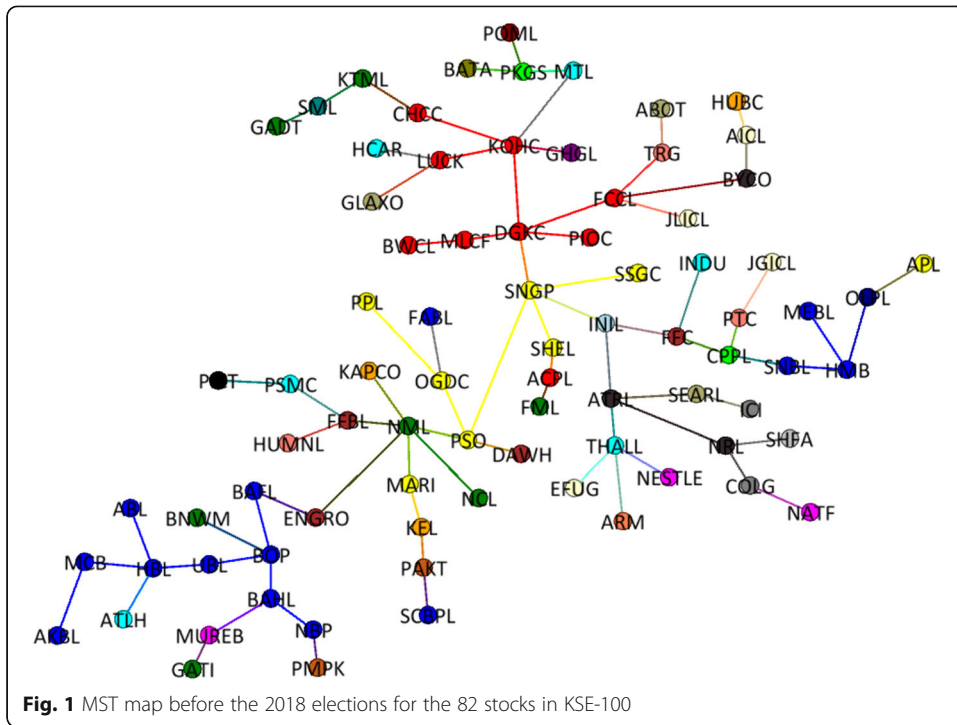
MLCF, and PIOC—connect with each other, the rest linking with companies from different sectors. Further, companies from almost all the sectors are scattered, and around 77% of nodes have two or fewer connections.

The MST map of the KSE-100 index after the general elections of 2013 is presented in Fig. 4. We can observe a slight increase in the degree of connectivity per node for Maple Leaf Cement (MLCF 6), while four nodes—Cherat Packaging (CPPL), Hub Power (HUBC), Kohinoor Textile Mills (KTML), and Nishat Mills (NML)—have five connections each. Additionally, Searle (SEARL) and Pak Suzuki (PSMC) nodes have now two and one

Fig. 4 MST map after the 2013 elections of the 82 stocks in KSE-100
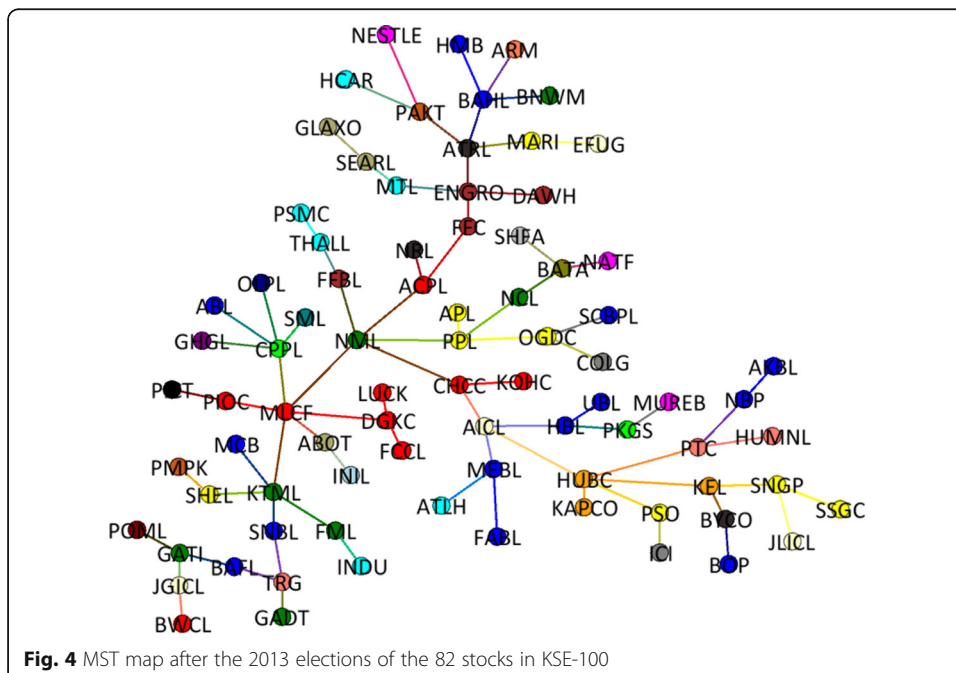
connection, respectively. This reconfiguration possibly represents the diversification of these companies after the general elections. The MST in post the 2013 election has a tree-like structure compared to the star-like structure in the post 2018 election period.
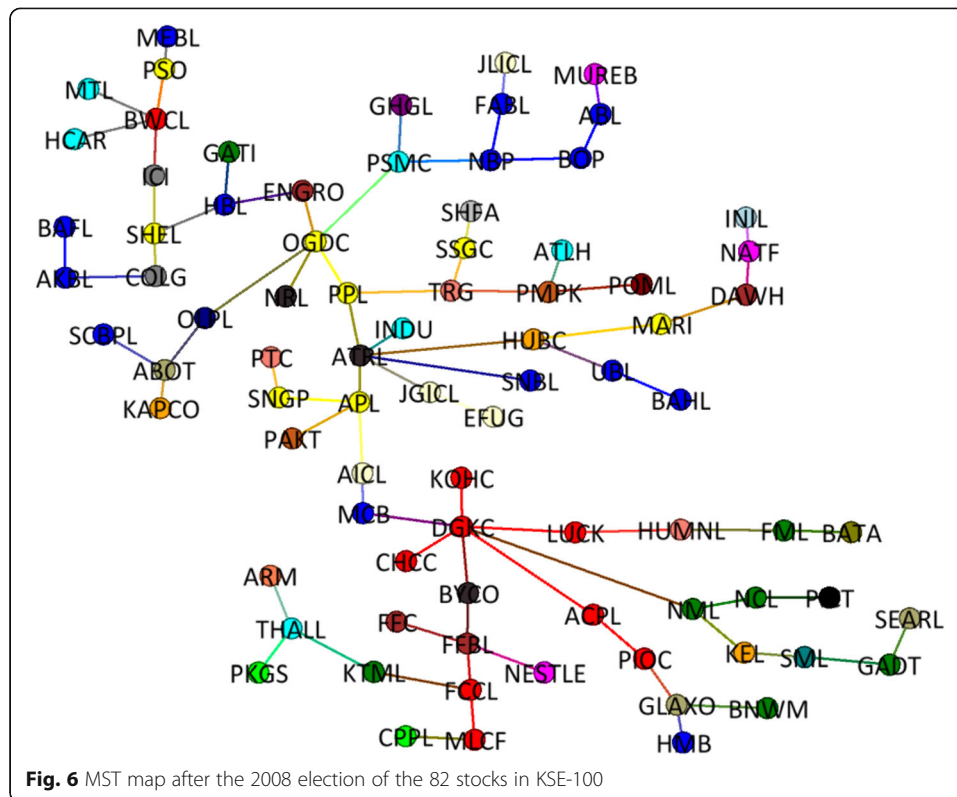
The pre-2008 election MST map of the KSE-100 index companies is presented in Fig. 5. A major node is Pakistan Petroleum (PPL 9), followed by two significant nodes—Nishat Mills (NML 7) and Muslim Commercial Bank (MCB 5). Hence, PPL is the dominating company in the network before the 2008 general elections, and companies surrounding this node will be directly influenced by any shock due to the general elections (Sharif et al. 2016). Additionally, the oil and gas sector (yellow) and commercial banking sector (blue) cluster, whereas cement sector nodes (FCCL, MLCF, CHCC, PIOC, ACPL, LUCK) are spread over the entire network.

Figure 6 shows the post 2008 election MST map of KSE-100 index network. We observe a tree-like structure and reduction in the degree of connections per node compared to the star-like structure before the election. D.G. Khan Cement (DGKC 7) is the most significant and central node, followed by Attock Refinery (ATRL 6) and Oil and Gas Development Company (OGDC 5). However, PPL has moved from nine connections before election to three. Additionally, companies from the cement sector form a cluster. Overall, the results show a structural change in the network topology from before to after the 2008 general elections.
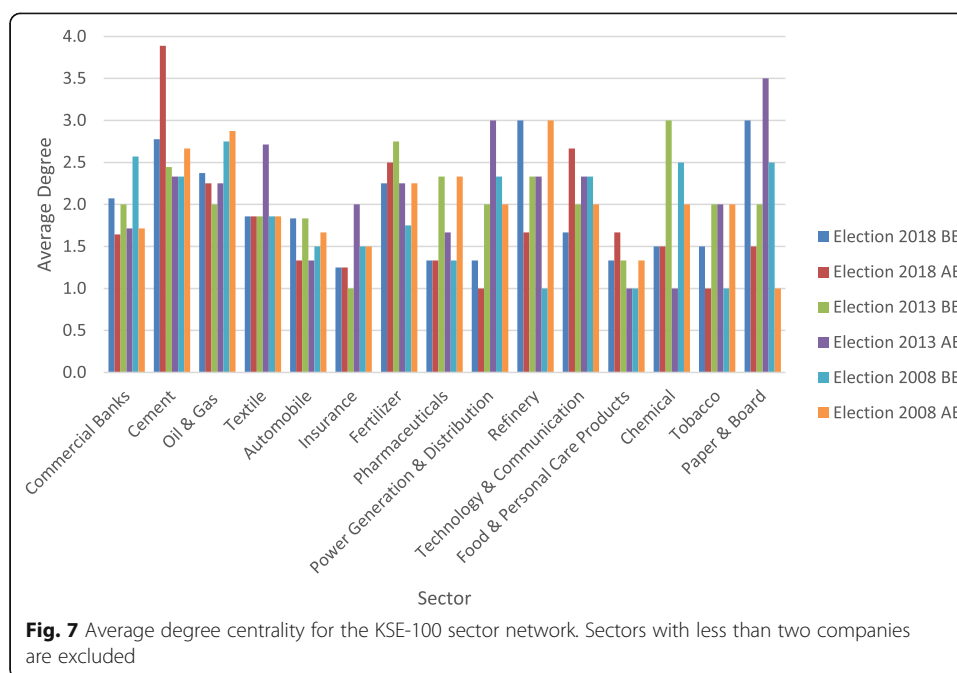
Sectorial centrality measures

We here present the sectorial centrality properties of the KSE-100 index MST network for all three general elections. As centrality measures are important in network analysis

Fig. 5 MST map before the 2008 elections of the 82 stocks in KSE-100

Fig. 6 MST map after the 2008 election of the 82 stocks in KSE-100
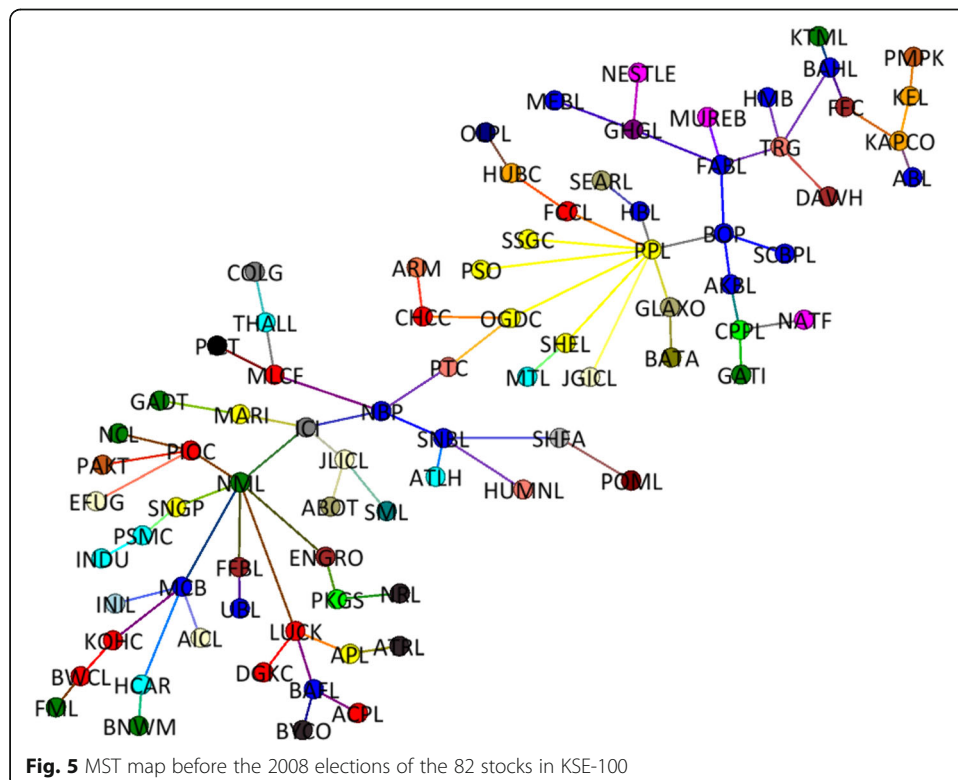
to examine the behavior of networks (Ghanbari et al. 2018), we present the average sectorial degree of centrality in Fig. 7. The figure shows the cement sector nodes have a mean of approximately three incident edges, followed closely by oil and gas and fertilizer sectors with means of two and half. We can observe a large increase in the average number of incident edges for the nodes in the cement sector after the 2018 general elections compared to any other sectors. The other sector that exhibits an increase in connectivity is the paper and board sector after the 2013 elections. This increase in the number of edges highlights an expansion in the economic activities of these sectors in the elections periods. Additionally, the results show a consistent decrease in the connectivity of commercial banks in all the three post-election periods, compared to the high average degree of connections during the pre-elections periods. The comparison between pre- and post-elections centrality metrics shows a consistent average connectivity in the textile sector during all periods, except for a substantial increase in the post 2013 election period.
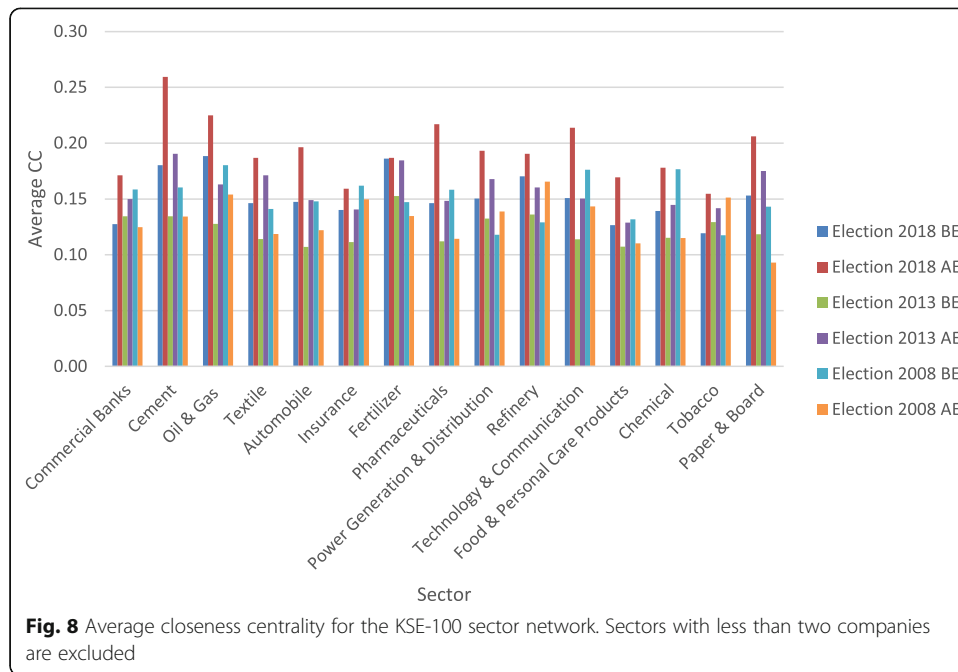
Figure 8 presents the average sectorial closeness centrality for the periods before and after the elections. The cement sector has a large average closeness centrality of 0.26 after the 2018 election, followed by the oil and gas (0.22), pharmaceutical (0.22), technology and communications (0.21), and paper and board 0.21 sectors over the same period. This could be interpreted as the key role of these sectors in the MST after the 2018 election. Additionally, the cement sector is closer to other sectors' nodes as the companies from this sector have the highest average closeness centrality. By contrast, the lowest average closeness centrality is registered by the paper and board sector (0.090 after the 2008 general elections. However, the overall average closeness centrality is 0.15 for all sectors during all periods.

Fig. 7 Average degree centrality for the KSE-100 sector network. Sectors with less than two companies are excluded

Regarding average sectorial betweenness centrality, Fig. 9 shows that the fertilizer sector has the maximum number of shortest routes and has a strong mediating role, especially before the 2013 elections. Additionally, the average betweenness centralities of the oil and gas and cement sectors are also high. Similarly, an increase in the mediation effect of the cement sector is also registered after the 2018 election. Furthermore, the food and personal care products, tobacco, pharmacy, and automobile sectors present the lowest overall average betweenness centrality scores, reflecting their weak mediation effects.
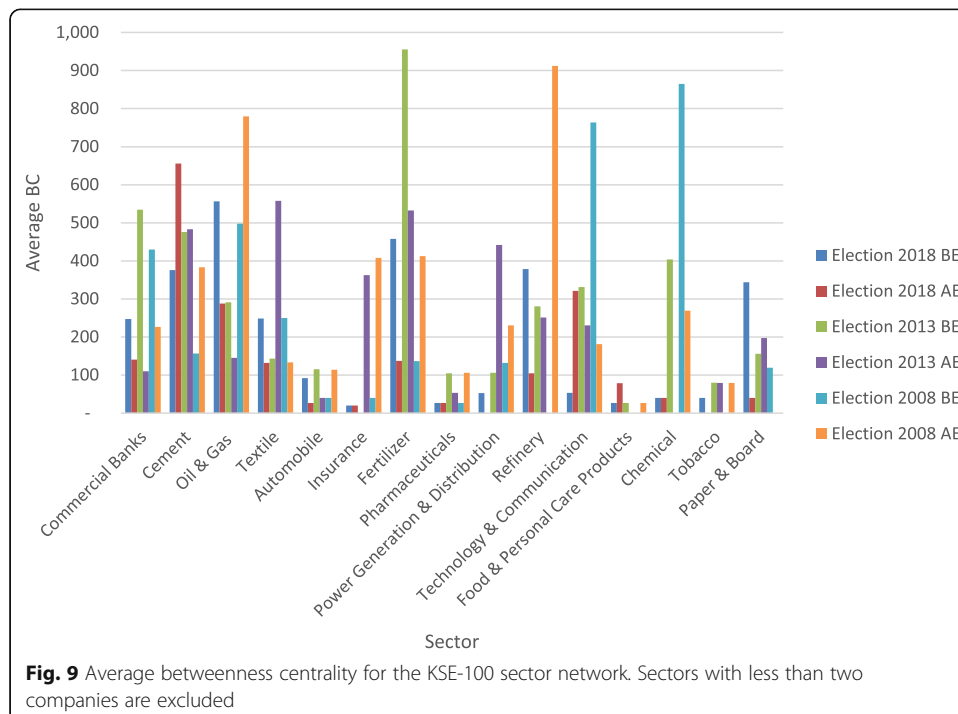
Conclusions

We presented the topology of the network formed by the 82 main stocks on the Pakistan stock market using MST for the three general elections in 2018, 2013, and 2008. We observed the status of and changes in the MST network as a result of these political events. The MST had no dominant node, but had two major clusters for the cement and oil and gas sectors and a tree-like structure before the general elections of 2018, compared to a star-like structure and a major node (LUCK) and broken clusters after the 2018 elections. Comparatively, for the 2013 elections, we found a decrease in the connectivity and scattered sectors before the elections and an improvement in connectivity due to diversification after the elections. A star-like structure of the MST is observed before the 2008 elections, with the dominating node being PPL compared to a significant drop in connections and in PPL's influence along with a tree-like structure after the 2008 general elections. In addition to the six MST maps, we also assessed our results by using degree centrality, sectorial closeness, and betweenness centrality. The average sectorial degree of centrality measure shows the economic expansion and highest number of incident edges for the cement sector nodes, followed by the oil and gas and fertilizer sectors. Similarly, the sectorial closeness and betweenness centrality

Fig. 8 Average closeness centrality for the KSE-100 sector network. Sectors with less than two companies are excluded

measures revealed the importance of the cement sector nodes and strong overall intermediary role of the fertilizer sector.

Studying stock market topology around general elections has significant implications for local and international investors for portfolio management, such as forming optimal diversification strategies. Additionally, identification of core nodes and sectors, systematic and political risk assessment is useful for policy makers or regulators in assuring stock market stability. Our study examines stock market structural change and

Fig. 9 Average betweenness centrality for the KSE-100 sector network. Sectors with less than two companies are excluded

topological evolution around general elections through MST technique. Perhaps, we could compare networks formed through alternative methods of PMFG (Tumminello et al. 2005), and asset graphs (Onnela et al. 2003b, c). In addition, we can analyze the impact of various political and macroeconomic events on rolling windows of different sizes in a temporary dynamic stock market network. Further, we can apply MST method to analyze structural change and dynamics around political event of general elections into other stock markets (e.g., developed markets or other emerging markets). The future research may address these limitations.

Authors' contributions
BAM (First & Corresponding Author) carried out the idea, designed the research, analyzed and interpreted data, applied methodology and visualization, discussed the results and wrote the article. HY (second author) supervised the research, provided necessary resources, and reviewed the article. RT (third author) helped in data collection, and revising the article. All authors read and approved the final manuscript.

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