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Investigating the financial market development and shadow economy nexus in the presence of country risk in an emerging economy

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ABSTRACT

This research study examined the influence of financial market development on the shadow economy and the moderating effect of country risk (political, economic, and financial) in this nexus in Pakistan. Using data from 1995 to 2018, the study applied the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests, followed by the *F*-bounds test to investigate stationarity and cointegration in the series, respectively. The study utilized the Autoregressive Distributed Lag (ARDL) approach to estimate the long-run relationship, and to examine the possible causal relationship among the variables, the study employed Breitung and Candelon's (2006) spectral test. The study identified that financial market development is negative, and the country's risk determinants are positively associated with the shadow economy's size. Moreover, the study found that country risk positively moderates the influence of financial market development on the shadow economy. The results also highlighted a unidirectional relationship from economic and financial risk towards the shadow economy. Finally, based on the empirical findings, the study recommends some policy implications to the regulators of financial markets and the shadow economy.

1. Introduction

The shadow economy (SEc), also known as the informal, illegal, black, or underground economy, consists of economic activities that fall outside the formal or legal economy [1]. There has been an ongoing debate regarding the SEc since the 1970s, especially after Gutmann [2] study, which estimated the size of the SEc in the United States [3]. Despite providing employment opportunities, the SEc affects the flow of investment and resource allocation, reducing government revenue, and thus, decreasing government spending on the public [4,5]. Moreover, economies with informal economic activities will have error-based economic policies due to biased

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estimations of macroeconomic indicators. This has been an obstacle for many countries, particularly for developing countries, where about 75% of the total production occurs in the informal sector [4]. Pakistan is one of the developing countries where 30% to 50% of businesses (% of GDP) operate in the informal sector [3]. Research studies have discussed various determinants for controlling shadow economic activities, such as the tax burden, unemployment, strict regulations, and weaker institutional quality [6,7,8]. Recently, the lack of financial access has been considered one of the drivers of the SEc [9]. The financial sector provides low-cost financial credit and other financial services to businesses, which attract economic agents to move their operations into the legal or official sector of the economy [10]. However, the quality of institutions (political, economic, and financial) affects financial markets and institutions' performance [11]. Therefore, this study investigates the influence of financial market development (FMD) on the SEc nexus, considering the moderating effect of country risk.

Literature has confirmed that increasing financial development promotes economic growth by increasing business access [12]. Financial sector development, particularly financial institutions, attracts shadow economic activities into the formal sector by providing credit and other facilities [10,13]. Besides financial institutions, financial markets (both stock and bond markets) also perform the same role, providing funds to businesses to perform their business activities [14,15]. The financial markets are important for transferring funds to the best return opportunities, providing asymmetric information (price signals) that helps investors to allocate their investments to the maximum return opportunities and reduces business risk. Moreover, financial markets leverage entrepreneurship specialization and development by providing long-term funds to acquire new technology [16,17], attracting economic agents to switch their business operations into the formal sector of the economy. However, it is widely recognized that any kind of country risk (i.e., political, economic, or financial risk) is highly associated with stock and bond markets (financial markets), raising investment risk in the financial markets [18]. In an environment with high political risk, investors are not likely to predict the long-run economic policies due to the uncertain political environment, corruption, lower institutional quality and contract enforcement issues etc. [19]. Political risk affects the nature of investment and the demand for business factors, which adversely affects economic growth and investment in the formal sector [20]. Dang, Nguyen and Tran [21] suggested that corruption and institutional quality are the key determinants that positively and negatively affect the SEc. Moreover, in the case of economic risk (representing the economic situation of a country in the future), a country faces high inflation, budget deficit, current account deficit, and high default risk. These indicators cause investors to reduce or cease their investments in the economy, affecting the speed of investment in financial markets and hence, the size of the SEc. In addition, in a high financial risk environment, economic agents predict that a country cannot pay its foreign debt and could face a financial crisis [22]. Hence, financial risk affects the financial markets and consequently influences the SEc. Thus, it is vital to determine whether a country's risk affects the nexus between FMD and the SEc in Pakistan, and consequently, the study answers the following research questions. (a) Does FMD and country risk (political, economic and financial) affect SEc? (b) Does country risk (political, economic and financial) moderate the FMD and country risk nexus?

In addition, according to the International Labor Organization (ILO), the size of the SEc is almost 40% in Pakistan, which is comparatively higher than in other developing countries. Moreover, considering the current situation in Pakistan, the unfavorable political and economic environment adversely affects its financial situation, increasing its default risk [23]. However, because of its higher potential to raise institutional quality, the country could reduce the present risk, which can positively influence its financial markets and hence, the SEc [24].

By focusing on the size of the SEc in Pakistan, the study aims to investigate the impact of FMD on the SEc and the direct and moderating effect of country risk in the abovementioned nexus. The study offers several new contributions to the available literature. This study examines the impact of FMD (stock and bonds) on the size of the SEc, and to the best of the authors' knowledge, this is the first study to examine the role of FMD on the SEc in Pakistan. The study found that FMD is negatively associated with the size of the SEc, while country risk generally promotes the shadow economic activities in Pakistan. The study also highlights the moderating impact of country risk in the FMD and SEc relationship. It is vital to explore since the country risk affects the speed of FMD, which is crucial in determining the size of the SEc [7,18]. The results indicated that country risk determinants moderate the effect of FMD on the SEc, indicating that the country risk factor plays a critical role in controlling shadow economic activities through FMD in Pakistan. Moreover, this study adopts Svirydzenka [25] proxy of the IMF for FMD, which broadly covers efficiency, access, and depth of financial markets.

Finally, the other sections of the study are organized as follows; Section 2 highlights the previous studies; Section 3 demonstrates the data, variables, and methodological techniques; Section 4 discusses the empirical results and discussion; and Section 5 provides the conclusion and recommendations of the study.

2. Literature review

2.1. Financial development and shadow economy

Research studies have explored whether tax burden [26], corruption [27], foreign direct investment (FDI), institutional quality [8], and trade openness [28] are the key determinants of the SEc. Recently, literature has argued that the financial sector reduces the size of the SEc. For instance, Berdiev and Saunoris [10] examined the nexus between financial development and the SEc using 161 countries' data from 1960 to 2009. Employing vector autoregression analysis (VAR), the study revealed an adverse effect of financial development on the SEc. Habibullah, Din, Yusof-Saari and Baharom [29] investigated the nonlinear linkage between financial sector expansion and shadow economic activities, employing data from 1971 to 2013 in Malaysia. The study found an inverted U-shaped curve between the SEc and financial development. This further clarifies that as the financial sector develops (financial access develops), the size of the SEc shrinks. Imamoğlu, Katircioğlu and Payaslioğlu [30] analyzed the spillover effect of financial sector

development on informal economy in European Union during 2010 to 2014. Using GMM approach, the stud found an inverted U-shaped relationship between financial development and the informal economy. Ajide [31] examined the nexus between financial inclusion and the SEc in African countries, using data from 2005 to 2015. Employing the Toda and Yamamoto causality technique, the study reveals that controlling corruption (a political risk factor) and financial inclusion help to decrease shadow economic activities. Moreover, Katircioglu and Imamoglu [32] validated a U-shaped long-run relationship between informality and financial development in Turkey, using data from 1970 to 2017. The study revealed that informal economic activities tend to increase over time in the initial stages of the expansion of the financial sector. However, the informality later rises with the increase in financial development. In contrast, Njangang, Nembot and Ngameni [33] analyzed the impact of financial development and the SEc, in sub-Saharan Africa, using fixed and random effect models. The study identified a U-shaped relationship between financial sector development and the SEc. Safuan, Habibullah and Sugandi [34] examined the impact of financial development on the SEc in Indonesia from 1980 to 2020. The study found an inverted U-shaped relationship between financial sector development and the SEc, suggesting that the SEc initially increases with financial development before subsequently decreasing at a later stage. Mar'i and Cavusoglu [35] examined the SEc, economic growth, and financial development nexus for 156 countries using data from 1991 to 2015. Employing Panel VAR and Panel Quantile Regression, they identified that financial development (domestic credit) negatively affects the informal activities in the economy. However, banking concentration and private credit positively affect the SEc. In the case of Jordan, Abu-Lila, Ajlouni and Ghazo [36] also found an inverted U-shaped relationship between financial sector development and the SEc. Khan, Abdul Hamid and Rehman [37] analyzed the influence of financial development in determining the size the SEc in 141 countries, during 1991 to 2015. Employing GMM approach, the study identified a negative impact of the financial sector development on shadow economic activities. The mixed findings in the literature on the financial development and SEc nexus have motivated us to re-examine this relationship by utilizing a broader proxy of financial development.

2.2. Financial markets development and country risk

Various research studies have examined the significant association between financial indicators and country risk factors [38,39,40,41]. Country risks, which consist of political, financial, and economic risks, are further comprised of various indicators. These factors are likely to affect the performance of financial markets, especially in emerging economies [18].

Research studies [42,43] have found that political instability is negatively associated with stock market performance. For instance, Rajan and Zingales [44] proposed interest group politics theory and its implications for financial development. The study argued that political groups hinder financial development when their political interests are endangered because this increases competition, which decreases their rents. Girma and Shortland [45] examined the influence of democratic accountability and political instability on financial development. The study found that political stability is likely to positively promote the speed of financial development (stock market capitalization). Yartey [46] proposed that political risk indicators are important determinants of the financial market (stock market) in emerging countries to highlight the country's political situation and the role of institutions in financial development. Cheng, Hou, Ho and Westerlund [47] analyzed the impact of financial system development on economic growth under different scenarios of country risk systems for panel data over the period of 1976 to 2003 for 28 countries. The study's findings identified that a country's stock markets expand in low-risk and low-volatility scenarios, thus increasing economic growth. Law, Tan and Azman-Saini [48] examined the influence of globalization on financial development while considering the role of institutional quality in eight Asian countries. The study argued that globalization positively influenced financial development in the presence of sound institutions from 1984 to 2008. Williams [49] further highlighted the role of political institutions' development in analyzing the credit market and economic development in emerging economies using data from 1970 to 2014. The study found that democratic quality influences the credit market deepening and economic growth nexus. It is argued in the above literature that country risk factors are associated with investors' financing and investment decisions. This argument was confirmed by Ref. [50], who stated that financial risk premium is significantly related to stock market variation. The study found that the country's financial risk accounts for 12% of the annual volatility in the stock market in Latin America. Kirikkaleli [18] examined the country risk and stock market nexus in Taiwan, using the ARDL approach with data covering the period from 1997 to 2015. The study revealed that political, economic, and financial risks are negatively associated with increasing stock market development. Damodaran [51] reported that corruption, external and internal conflict, bureaucratic quality, and the rule of law are the country risk (political risk) factors that could affect investor and business decisions and their cost of doing business. Khai Nguyen and Cuong Dang [52] argued that financial technology development is negatively associated with financial stability. Dang, Nguyen and Tran [21] determined that corruption and institutional quality positively and negatively affect the SEc in 29 Asian countries. This indicates that institutional or country risk factors are the key determinants that are related to financial markets and the SEc.

Literature shows that financial sector development, comprising financial markets and institutional development, affects shadow economic activities. However, the influence of FMD on the SEc is largely ignored in the literature. Moreover, political stability, economic efficiency, and financial soundness (country risk) influence financial sector development, which is critical in controlling the SEc. Hence, it is vital to investigate the overlooked role of country risk in the FMD and SEc relationship. However, viewing the available literature, no specific study has focused on exploring the FMD and country risk influence on the size of SEc. Therefore, to fill this gap in the literature, the current study investigates the influence of FMD on the SEc, considering the direct and moderating impact of country risk in Pakistan.

3. Methodology

3.1. Theoretical framework

The study analyzes the association between FMD and the SEc, considering the impact of country risk while controlling the influence of the tax burden and economic growth. Theoretically, Becker [53] explored the integration of the financial system and informal economy in the "economic crime" theory. The study concluded that a rational individual analyzes the privileges of operating in the SEc (tax evasion and avoidance of regulations) with the punishment, cost of production (financial cost), and opportunity cost of the SEc. Financial markets provide long-term financing to businesses in the formal sector, thus reducing their financial cost which attracts economic agents into the formal sector [9]. In contrast, businesses need to declare their income and assets for financial access. This shows that financial development is a major concern for the overall framework of shadow economic activities [54]. Therefore, the current study expects that FMD significantly influences the size of the SEc. Moreover, the "law and politics" theory [55] demonstrates that financial development is linked to a country's political and governing system. In other words, a country's political and regulatory procedures significantly impact the operation of its financial markets, thus affecting the SEc. Thus, we expect that country risk indirectly influences the size of the SEc through the channel of FMD.

3.2. Construction of research model

In previous studies, Canh and Thanh [9], Bose, Capasso and Andreas Wurm [13], Blackburn, Bose and Capasso [54] and Safuan, Habibullah and Sugandi [34] argued that financial development has a significant impact on the SEc, using banking or financial institutions as a proxy. Rather than considering financial institutions' development, the current study focuses on investigating the role of FMD in the size of the SEc. However, Kirikkaleli [18] underlined that country risk influences FMD, which could affect the size of the SEc. Based on these studies, this study developed the following research model as represented in equation (1), equation (2), equation (3), equation (4), equation (5), and equation (6) as below:

$$lnSEc_t = \beta_0 + \beta_1 lnFMD_t + \beta_2\, ln\, \mathrm{PR_t} + \beta_3\, ln\, \mathrm{Z_t} + \varepsilon_t \quad (1)$$

$$lnSEc_t = \beta_0 + \beta_1 \mathrm{lnFMD_t} + \beta_2\, ln\, \mathrm{ER_t} + \beta_3\, ln\, \mathrm{Z_t} + \varepsilon_t \quad (2)$$

$$lnSEc_t = \beta_0 + \beta_1 \mathrm{lnFMD_t} + \beta_2\, ln\, \mathrm{FR_t} + \beta_3\, ln\, \mathrm{Z_t} + \varepsilon_t \quad (3)$$

$$lnSEc_t = \beta_0 + \beta_1 \mathrm{lnFMD_t} + \beta_2\, ln\, \mathrm{PR_t} + \beta_3\, ln\, \mathrm{FMD}^*\, ln\, \mathrm{PR_t} + \beta_4\, ln\, \mathrm{Z_t} + \varepsilon_t \quad (4)$$

$$lnSEc_t = \beta_0 + \beta_1 \mathrm{lnFMD_t} + \beta_2\, ln\, \mathrm{ER_t} + \beta_3\, ln\, \mathrm{FMD}^*\, ln\, \mathrm{ER_t} + \beta_4\, ln\, \mathrm{Z}_t + \varepsilon_t \quad (5)$$

$$lnSEc_t = \beta_0 + \beta_1 \mathrm{lnFMD_t} + \beta_2\, ln\, \mathrm{FR_t} + \beta_3\, ln\, \mathrm{FMD}^*\, ln\, \mathrm{FR_t} + \beta_4\, ln\, \mathrm{Z_t} + \varepsilon_t \quad (6)$$

In the above equations, SEc represents the shadow economy, FMD denotes financial market development, PR represents political risk, FR represents financial risk, ER represents economic risk, Z represents the control variables (GDP and Tax burden), ε_t is the error term, β_0 shows the slope and β_1, β_2, β_3, β_4, in the models represent the coefficients of the independent variables. Moreover, FMD*PR, FMD*ER, and FMD*FR represent the interaction between FMD and country risk.

3.3. Data and descriptive statistics

The study used annual data from 1995-2018,[1] which was selected based on the availability of the data. Table 1 explains the data sources and descriptive statistics of the variables. Studies have used various indicators for FMD; for example, Soumaré and Tchana Tchana [56], Ali, Ramakrishnan, Faisal, Ghazi H Sulimany and Bazhair [14,15] used the stock market and banking development, respectively. However, following Canh and Thanh [9], the current study used a broader proxy of FMD, consisting of both stock and bond market development. Further, following Kirikkaleli [18], Wang, Dong, Li and Wang [57], Adebayo, Kartal, Ağa and Al-Faryan [58], Kirikkaleli and Kayar [59], and Ur Rahman, Faisal, Sami and Schneider [7], the study used the Principal Component Analysis (PCA) technique to generate indices for each country risk (political, economic and financial) using PRS Group data. If proxies or indicators of a single variable are related to one another, it creates a multicollinearity issue in the series. Therefore, to overcome this issue, a single proxy can be generated by utilizing the PCA technique [14,60,61]. Moreover, for empirical estimations, the data were transformed into the natural log to reduce heterogeneity among the variables.

[1] The data for this article has also been used in our previous study in a panel of 11 Economies 7. Ur Rahman, S. et al. (2023) Does country risk moderates the financial market development and shadow economy nexus? Evidence from fast-emerging countries analysis. International Journal of Emerging Markets ahead-of-print (ahead-of-print). including Pakistan. Since, this study used only the data for Pakistan for these variables. Only the data related to Pakistan has been analyzed.

Table 1
Variable details and descriptive statistics.

Variables	Economic Risk	Political Risk	Financial Risk	Economic Growth	Tax Burden	Shadow Economy	Financial Market Development
Symbols	ER	PR	FR	lnGDP	TB	SEc	FMD
Source	PRS Group	PRS Group	PRS Group	World Bank	Heritage Foundation	World Bank (MIMIC estimations)	IMF
Mean	0.041	0.065	0.095	25.992	74.992	35.929	0.280
Median	0.415	0.862	0.606	26.043	78.500	35.550	0.303
Maximum	2.258	2.246	2.471	26.481	82.100	37.900	0.463
Minimum	−5.380	−4.240	−3.251	25.550	59.100	34.200	0.035
Std. Dev.	1.784	2.193	1.633	0.287	6.614	1.083	0.140
Skewness	−1.549	−0.711	−0.620	−0.001	−0.790	0.412	−0.182
Kurtosis	5.259	1.966	2.065	1.763	2.422	2.060	1.662
Jarque-Bera	14.702	3.091	2.413	1.530	2.832	1.564	1.921
Probability	0.642	0.213	0.299	0.465	0.243	0.458	0.383

Note: The high PR, ER and FR ratings (0–100) represent lower risk. while the lower PR, ER and FR scores indicate higher risk. Please see: https://www.prsgroup.com/wp-content/uploads/2014/08/icrgmethodology.pdf.

4. Econometric strategy

4.1. Unit root test

Time series data are typically non-stationary at level, but become stationary after the first difference [14]. Regressions using differenced variables are likely to increase the chances of losing important long-run information. Consequently, cointegration is the best technique to keep the long-run information for differenced variables [62]. Therefore, before examining the long-run relationship among the variables, studies [63,64,65] have used the Dickey and Fuller [66] and Phillips and Perron [67] unit root tests for examining stationarity in the series. Usually, studies use traditional cointegration techniques, such as Engle and Granger [68], Granger [69], and Johansen [70], if the series is stationary at first difference. However, such cointegration tests cannot be applied if the series is stationary at level [71]. Moreover, these tests are also not applicable in the case of a mixed order of integration [62]. Therefore, the ARDL approach, proposed by Pesaran, Shin and Smith [72], is an appropriate procedure that can be applied on data with a mixed order of integration. Moreover, it is necessary to investigate the integration order in the data series before using cointegration techniques. This study uses the ADF and PP unit root tests to estimate the order in the series. ADF and PP unit root tests are applicable ARDL testing procedures that are employed for estimating long-run coefficients. Moreover, the ADF test is regarded as superior due to its widespread use and popularity. By including the explanatory variable's lagged difference term, this test adjusts the PP approach to consider the possible autocorrelation problem. Further, these tests are easier to apply than other unit root tests [62].

4.2. F-bounds test

After examining stationarity in the series, cointegration among the variables must be explored. If one cointegrating vector is present, the Johansen and Juselius [73] cointegration test is not applicable. Thus, the Pesaran and Shin [74] and Pesaran, Shin and Smith [72] cointegration tests are recommended, irrespective of the integration order. Consequently, the ARDL bounds testing procedure gives reliable estimations. Unlike Johansen and Juselius [73] cointegration test, the ADRL bounds test highlights cointegration vectors [62]. Moreover, this test helps to avoid pre-testing requirements when a single long-run relationship exists between the variables. Further, this test estimates the *F*-Wald statistics, and the *F*-bounds cointegration test is used to find evidence of cointegration. Pesaran, Shin and Smith [72] argued that if the estimated *F*-Stat value is less than the lower bound at the order I(*0*), the H_0 (null hypothesis) is accepted. If the *F*-stat value is greater than the upper bound at the order I(*1*), the null hypothesis is rejected, and the variables are cointegrated. Lastly, if the *F*-stat value is in between the lower bound values and upper bounds values at the order I(*0*) and I(*1*), a decision cannot be made (inconclusive). In such a situation, it is appropriate to analyze the ECT_{t-1} value [75] to make a decision. The coefficient of ECT_{t-1} must be negative, and the value of the coefficient must lie between 0 and 1, showing the system's stability.

4.3. ARDL bounds test

Conventional cointegration results are unreliable when the data include structural breaks [76]. Thus far, the study employed the autoregressive distributive lag (ARDL) bounds technique proposed by Pesaran, Shin and Smith [72] to estimate the long-run relationship among the variables. Moreover, due to various reasons, the study applies the ARDL testing technique. The study's sample size is comparatively small, and the ARDL methodology is appropriate for a small data size. Further, to apply the ARDL approach, it is not essential that the variables must be integrated at a specific order. In addition, this technique estimates the error correction term (ECT_{t-1}), which shows the ability of the variable (dependent) to return to its normal position from disequilibrium [72]. Empirically, the relationship among the study variables through the ARDL bounds test can be stated as equation (7), equation (8), equation (9),

equation (10), equation (11) and equation (12):

$$ln\ SEc = \beta_0 + \sum_{i=0}^{p} \beta_i lnSEc_{t-i} + \sum_{j=0}^{q} \beta_j lnFMD_{t-j} + \sum_{k=0}^{r} \beta_k ln\ PR_{t-k} + \sum_{l=0}^{s} \beta_l ln\ Z_{t-1} + \lambda_{SE} lnSEc_{t-1} + \lambda_{FMD} lnFMD_{t-1} + \lambda_{PR} lnPR_{t-1} + \lambda_Z\ ln\ Z_{t-1} + v_t \quad (7)$$

$$lnSEc = \beta_0 + \sum_{i=0}^{p} \beta_i lnSEc_{t-i} + \sum_{j=0}^{q} \beta_j lnFMD_{t-j} + \sum_{k=0}^{r} \beta_k ln\ ER_{t-k} + \sum_{l=0}^{s} \beta_l ln\ Z_{t-1} + \lambda_{SE} lnSEc_{t-1} + \lambda_{FMD} lnFMD_{t-1} + \lambda_{PR} lnER_{t-1} + \lambda_Z\ ln\ Z_{t-1} + v_t \quad (8)$$

$$lnSEc = \beta_0 + \sum_{i=0}^{p} \beta_i lnSEc_{t-i} + \sum_{j=0}^{q} \beta_j lnFMD_{t-j} + \sum_{k=0}^{r} \beta_k ln\ FR_{t-k} + \sum_{l=0}^{s} \beta_l ln\ Z_{t-1} + \lambda_{SE} lnSE_{t-1} + \lambda_{FMD} lnFMD_{t-1} + \lambda_{PR} lnFR_{t-1} + \lambda_Z\ ln\ Z_{t-1} + v_t \quad (9)$$

$$lnSEc = \beta_0 + \sum_{i=0}^{p} \beta_i lnSEc_{t-i} + \sum_{j=0}^{q} \beta_j lnFMD_{t-j} + \sum_{k=0}^{r} \beta_k ln\ PR_{t-k} + \sum_{l=0}^{s} \beta_l ln\ FMD^{*} lnPR_{t-k} + \sum_{m=0}^{t} \beta_m \Delta ln\ Z_{t-l} + \lambda_{SE} lnSEc_{t-1} + \lambda_{FMD} lnFMD_{t-1} + \lambda_{PR} lnPR_{t-1} + \lambda_{PR*FMD}\ ln\ FMD^{*} lnPR_{t-1} + \lambda_Z\ ln\ Z_{t-1} + v_t \quad (10)$$

$$ln\ SEc = \beta_0 + \sum_{i=0}^{p} \beta_i ln\ SEc_{t-i} + \sum_{j=0}^{q} \beta_j lnFMD_{t-j} + \sum_{k=0}^{r} \beta_k ln\ ER_{t-k} + \sum_{l=0}^{s} \beta_l ln\ FMD^{*} lnER_{t-k} + \sum_{m=0}^{t} \beta_m ln\ Z_{t-l} + \lambda_{SE} lnSEc_{t-1} + \lambda_{FMD} lnFMD_{t-1} + \lambda_{ER} lnPR_{t-1} + \lambda_{ER*FMD}\ ln\ FMD^{*}\ ln\ ER_{t-1} + \lambda_Z\ ln\ Z_{t-1} + v_t \quad (11)$$

$$lnSEc = \beta_0 + \sum_{i=0}^{p} \beta_i lnSEc_{t-i} + \sum_{j=0}^{q} \beta_j lnFMD_{t-j} + \sum_{k=0}^{r} \beta_k ln\ PR_{t-k} + \sum_{l=0}^{s} \beta_l ln\ FMD^{*} lnFR_{t-k} + \sum_{m=0}^{t} \beta_m ln\ Z_{t-l} + \lambda_{SE} lnSEc_{t-1} + \lambda_{FMD} lnFMD_{t-1} + \lambda_{FR} lnFR_{t-1} + \lambda_{FR*FMD}\ ln\ FMD^{*}\ ln\ FR_{t-1} + \lambda_Z\ ln\ Z_{t-1} + v_t \quad (12)$$

4.4. Diagnostic tests

The study further employed various tests to examine stability in the study research models. Following Udeagha and Muchapondwa [77], serial correlation in the models is examined by using the Breusch–Godfrey LM test, the Breusch-Pagan-Godfrey test is utilized to test for homoskedasticity, the Ramsey Reset test is employed for model specification, and Jarque-Bera is used to check the normality of the residuals in the models. Moreover, stability tests including CUSUM and CUSUM square were also applied to plot the stability of the

Table 2
Unit root test (ADF & PP).

Unit Root tests				
Models	Variables	ADF	PP	
Intercept and trend (level)	lnSE	−2.438	−1.948	I(*0*)
	lnFMD	−1.603	−2.432	
	lnPR	−1.75	−1.75	
	lnER	−1.362	−3.81	
	lnFR	−1.495	−1.379	
	lnFMD*lnPR	−2.273	−1.706	
	lnFMD*lnER	−1.632	−4.72	
	lnFMD*lnFR	−2.959	−0.995	
	lnTB	−3.147	−2.6750	
	lnGDP	−4.873	−1.894	
Intercept and trend (First Difference)	lnSE	−4.431*	−4.913*	I(*1*)
	lnFMD	−4.079**	−4.66*	
	lnPR	−3.752**	−4.118*	
	lnER	−5.129**	−3.716*	
	lnFR	−4.033*	−4.688*	
	lnFMD*lnPR	−11.296*	−4.033**	
	lnFMD*lnER	−5.177*	−5.078*	
	lnFMD*lnFR	−3.844*	−8.679*	
	lnTB	−5.406***	−3.648**	
	lnGDP	−5.4057*	−5.692*	

Note: *, ** and *** represent significance at 1% and 5%, respectively.

long-run coefficient.

4.5. Granger causality

Finally, the direction of the causal relationship among the variables must be examined, which will help to design better policy implications. Therefore, the study utilized the Breitung and Candelon [78] spectral causality test to check the causality at different time domains with different frequencies. Granger [79] proposed the causality approach to examine the temporal causal relationship between time series variables. This approach defines the model, and some of the model's coefficients pertinent to X's past and present are identified, and their significance is then examined [80,81]. Consequently, this test is simple to perform, and the regression model would benefit from using this approach due to its simplicity [81]. However, this approach is generally not suitable for distinguishing between long-run and short-run effects due to its dependence on one period ahead predictions [82]. As a result, Ding, Chen and Bressler [83] proposed that frequency domain causality is an appropriate approach for achieving short-term and long-term (dynamic) causality. The frequency domain causality allows the causality to be calculated for various frequencies. Therefore, the current study applies Breitung and Candelon [78] spectral causality test for frequency domain Granger causation.

This methodology is based on Geweke [84] and Hosoya [85] earlier proposed test. The "time domain" in the [78] Granger causality indicates that when changes happen in a series, the "frequency domain" estimates the degree of changes in the time series [86]. Breitung and Candelon [78] argued that the whole spectral dependence between the two series may be decomposed into a sum of "instantaneous," "feedforward," and "feedback" causality terms. This is how they interpret the frequency domain Granger causality.

5. Results discussion

The study initially employs conventional unit root tests to identify the stationarity order in the series, the results of which are reported in Table 2. Both tests suggest that the study variables are integrated at first difference. Therefore, this suggests that the null hypothesis of no-cointegration can be rejected since the series is integrated of the first order or I(*1*). Thus, this indicates that the ARDL technique can be applied to identify the cointegration among the variables in the model.

After confirming the stationarity level among the variables in the time series, we examine cointegration among the variables by employing the *F*-bounds test. Table 3 shows the results of the *F*-bounds testing technique. The estimated *F*-stat values are significant (higher than tabulated values) at 1%, 5%, and 10% significance levels, suggesting the presence of cointegration among the variables in all study models. According to Narayan [87], all variables are cointegrated at the specified range of significance (percentage), rejecting the null hypothesis that there is no cointegration. Therefore, the null hypothesis that lnFMD, lnSE, lnPR, lnER, lnFR, lnGDP, and lnTB are not cointegrated, which indicates that these variables have a long-run relationship in Pakistan.

6. Results of the ARDL bounds test

After identifying the cointegration, the long-run elasticities must be estimated under the ARDL framework, for which the study utilized the ARDL bounds testing procedure. Table 4 presents the variables' long-run relationship coefficients, consisting of two sub-sections. The first section presents the coefficients of the first three models (without interaction terms), which report the impact of FMD and country risk on the SEc. The second sub-section illustrates the models' estimations with interaction terms, indicating the indirect influence of country risk on the SEc through the channel of FMD. Moreover, the study only reports long-run coefficients because most policymakers focus on long-term financial and economic objectives.

Table 4 shows that FMD is significant and negatively related to the SEc in Pakistan, indicating that FMD significantly reduces shadow economic activities. More specifically, keeping the other determinants constant, a 1% rise in FMD reduces the size of the SEc from 0.008% to 0.011% in the long run, statistically significant at 1–5%. This implies that promoting stock and bond markets in Pakistan can attract economic agents to move their operations into the formal sector, decreasing the size of the SEc. Further, this also indicates that in Pakistan, not only small and medium businesses (SMEs), but also large businesses are involved in informal economic activities, which can be controlled by promoting financial markets. Our findings are consistent with the results of Canh and Thanh [9], who argued that financial market access negatively influences the SEc in a sample of 114 countries.

Moreover, the estimated coefficients of political risk are significant and positive in the long run, indicating that a 1% reduction in political risk (decrease in ratings) increases the SEc by 0.004% in the long run. This implies that strengthening institutional factors, such as control of corruption, government stability, internal and external conflicts, law and order, etc., in Pakistan help to control the SEc. In the low-political risk scenario, the government authorities efficiently monitor and control the informal economic activities; hence, the chance of being found engaged in informal activity is substantially higher. Moreover, long-term political stability boosts the investors' confidence to invest in formal sector activities because economic agents believe that consistency in policies will give them higher returns. The results of this study are congruent with those of [20], who found that decreasing political risk reduces the growth of the SEc.

The results show that economic risk coefficients are statistically significant and positive (decrease in ratings) in the long run, implying that a rise in economic risk significantly increases the SEc in Pakistan. A 1% increase in economic risk raises the SEc by 0.019%. This implies that economic risk factors (inflation, lower budget balance and current account deficit) cost the formal economy. Moreover, the unstable economic situation in Pakistan lowers investment in official economic activities, reducing government revenue. Hence, the government increases taxation on the formal sector businesses, increasing the prices of goods and services. Thus, because of the tax burden, official business activities are likely to switch their operations into the informal sector to reduce the cost of

Table 3
F-bound test.

Models	*F*-Stat	Range	Critical values	
			I(0)	I(I)
Model 1	4.324	10%	3.09	2.94
		5%	3.29	3.49
		1%	3.29	4.37
Model 2	5.674	10%	2.20	3.09
		5%	2.56	3.49
		1%	3.29	4.37
Model 3	5.646	10%	2.20	3.09
		5%	2.56	4.37
		1%	3.29	3.99
Model 4	5.741	10%	2.08	3.00
		5%	2.39	3.38
		1%	3.06	4.15
Model 5	9.028	10%	2.08	3.00
		5%	2.39	3.38
		1%	3.06	4.15
Model 6	3.223	10%	2.08	3.00
		5%	2.39	3.38
		1%	3.06	4.15

Note: (a) Models 1, 2, 3, 4, 5 and 6 are defined in the methodology section. (b) The Wald F-statistics is compared with the critical values at I (0) and I(1). In the above table, the F-statistics of Models 1–5 are significant at 1%, while in Model 6, the F-statistics is significant at 10%.

Table 4
ARDL test.

Long-run coefficients			
Variables	Coeft. [t-value]	Coeft. [t-value]	Coeft. [t-value]
lnSE	Model 1	Model 2	Model 3
lnFMD	−0.011*** [-6.577]	−0.016** [-2.814]	−0.008** [-2.395]
lnPR	−0.0039** [-3.871]	–	–
lnER	–	0.019* [1.954]	–
lnFR	–	–	−0.006** [-3.343]
lnTB	−0.096** [-4.659]	0.144* [2.160]	−0.015 [-0.715]
lnGDP	−0.198* [-2.982]	−0.207** [-2.826]	−0.083*** [-3.933]
ECT_{t-1}	−1.358*** [-8.184]	−1.033*** [-6.945]	−0.82*** [-5.677]
R^2	0.95	0.78	0.64
Adjusted R^2	0.93	0.74	0.63
Durbin-Watson	2.16	2.77	1.99
	Model 4	**Model 5**	**Model 6**
lnFMD	−0.032** [-2.75]	−0.005* [-2.085]	−0.009** [-2.697]
lnPR	0.010* [1.86]	–	–
lnER	–	−0.047** [-4.371]	–
lnFR	–	–	0.004 [0.542]
ln(FMD*PR)	0.0091* [1.877]	–	–
ln(FMD*ER)	–	0.039** [-4.584]	0.007 [1.447]
ln(FMD*FR)	–	–	–
lnTB	−0.006 [-0.234]	−0.028 [-0.787]	−0.006 [-0.213]
lnGDP	−0.156*** [-4.278]	−0.303** [-5.245]	−0.06** [-2.416]
ECT_{t-1}	−1.358*** [-8.184]	−2.728*** [-10.83]	−0.819*** [-5.677]
R^2	0.856	0.929	0.698
Adjusted R^2	0.798	0.897	0.668
Durbin-Watson	2.679	3.153	2.412

Note: (a) *, ** and *** indicate the significance level at 10%, 5% and 1%, respectively. (b) values in [ ] represent t-statistics (c) Models 1–6 are defined in the methodology section. (d) The negative signs of PR, ER, and FR indicate a positive relationship because the higher PR, ER and FR scores represent lower risk (Howell, 2013).

business, which in turn increases the SEc. The findings of the current study support the previous results of Xu, Lv and Xie [20], Canh and Thanh [9], and Canh, Schinckus and Dinh Thanh [8].

The estimated coefficient of financial risk in Table 4 is statistically significant and positive, indicating that a rise in financial risk factors such as foreign debt, exchange rate stability, debt services etc., promotes the growth of the SEc in Pakistan. This indicates that higher financial risk increases the chances of sudden financial crises and defaults, decreasing investment in the official sector. Consequently, this also raises unemployment because most manufacturing businesses are closed due to currency devaluation and

higher inflation.[2] Subsequently, the higher unemployment caused by higher financial risk induces the workers towards the economy's informal sector to compensate for personal financial needs. The results of the current study are congruent with Xu, Lv and Xie [20], who highlighted an inverse association between financial risk and SEc.

Table 4 presents that GDP is negatively associated with the growth of the SEc in Pakistan, implying that a 1% increase in GDP reduces the size of the SEc by 0.08% to 0.207% in Pakistan. This shows that economic growth is essential for reducing the size of the SEc. The higher economic growth increases the government's income through which they advance their monitoring and regulatory systems for restricting shadow economic activities. The current study's outcomes align with those of Canh, Schinckus and Dinh Thanh [8], suggesting that income (GDP per capita) significantly decreases shadow economic activities.

Furthermore, the estimated coefficients of FMD*PR and FMD*ER in the second sub-section in Table 4 are significant and negative, implying that political and economic risk deteriorate the negative relationship between FMD and the SEc. In Pakistan, the role of FMD in SEc could be linked to the stronger quality of political risk factors i.e. corruption, bureaucratic quality, democratic accountability etc. In the case of high political risk, external financing raised by companies through financial markets is again invested in informal business activities, harming the official sector of the economy and increasing shadow economic activities. The results support the previous findings reported by Law, Tan and Azman-Saini [48], Kirikkaleli [18], and Girma and Shortland [45]. Moreover, in the context of the impact of economic risk on the SEc through the channel of FMD, higher economic risk also deteriorates the FMD role in the SEc in Pakistan. In periods of higher economic instability (higher inflation, current account, and budget deficit), economic agents divert their investments into informal business activities to avoid high tax burdens and costs of business. This is because to meet external debts and increase their reserves (financial risk), the government authorities increase the tax rates on the existing businesses, encouraging them to operate in the shadow economic sector. Thus, political and economic stability are necessary for FMD and the SEc in Pakistan.

Furthermore, Table 4 also presents the ECT (error correction term) values, indicating the speed of adjustment towards the normal position after shocks in the long run. The ECT_{t-1} values (−1.35, −1.03 and −0.82) are significant at 1%, indicating that 1.35%, 1.03%, and 0.82% disequilibrium in the short-run can be rectified in the long-run [75]. The results of R^2 indicate that 95%, 78%, and 64% variations in the SEc are explained by political, financial, and economic risk along with FMD and other control variables in the long run. The Durbin-Watson acceptable value (closer to 2) suggests that no autocorrelation problem exists in the model. Furthermore, the R-squared values in the interaction panel reveal that in the long-run, 93%, 74%, and 63% variations in the size of the SE are explained by the independent variables.

7. Results of diagnostic tests

The study applied several diagnostic tests for testing heteroscedasticity, serial correlation, normality and model specification. Table 5 presents the results of the diagnostic tests carried out from the estimation of the results of the ARDL bounds test. The Breusch-Pagan-Godfrey homoskedasticity confirms that there is no heteroscedasticity (homoscedastic) in the model (*P*-value >10%). The Breusch-Godfrey LM test shows that no serial correlation effect exists on the model (P value > 10%), thus rejecting the null hypothesis. Moreover, the Ramsey Reset test and Jarque-Bera results show that the model is stable in the long run, and residuals are normally estimated.

7.1. Stability test

After satisfying the diagnostic tests of the models, the study performed stability tests by employing the CUSUM and CUSUM square testing procedures proposed by Ref. [88]. In Fig. 1–6, the graph lies significant (within red lines) at the 5% significance level. This demonstrates that the parameters in the ARDL bounds testing approach models are stable enough to produce unbiased statistical results in the selected sample period.

7.2. Granger causality results

Finally, the study used Breitung and Candelon [78] spectral causality test to explore the possible causality in the variables. Table 6 shows the results of the spectral causality tests, while Figs. 7 to 13 plot the relationships among the variables on graphs. The association between the variables in the graphs is tested at frequencies of 0-1, 1-2, and 2-3, representing the short, medium, and long-run associations, respectively. The frequency at 0-1 is permanent, while 2-3 refers to temporary causality. The red and brown (upper and lower) lines in Figs. 7 to 13 represent critical bounders, while the blue curve shows the statistical test at 5 and 10% significance levels. The results in Table 6 reveal the existence of a unidirectional causality from the SEc to political risk in Pakistan, indicating that the SEc destabilizes the country's political situation. Economic and financial instability cause political instability [89]. Fig. 8(a) plots the association from the SEc to PR in Pakistan, which is significant at 1%. The unidirectional causality relationship between financial risk and the SEc in Table 6 shows that financial risk increases the SEc in Pakistan. The result confirms our previous findings from estimating the long-term relationship coefficients. Fig. 10 (a) depicts the casual relationship from financial risk towards the SEc. The result supports the findings of the current study and the previous findings of Xu, Lv and Xie [20], who found a negative association between

[2] Please see https://globaledge.msu.edu/countries/pakistan/risk.

Table 5
Results of diagnostic tests.

Diagnostics Tests	F-stat (P value)	Results
Model 1		
Serial correlation (Breusch-Godfrey LM)	0.293 (0.429)	No serial correlation exists
Homoskedasticity (Breusch-Pagan-Godfrey)	0.614 (0.685)	No heteroscedasticity exists
Normality (Jarque-Bera)	3.223 (0.199)	Residuals are normal
Ramsey RESET	1.588 (0.131)	The model is specified correctly
Model 2		
Serial correlation (Breusch-Godfrey LM)	2.602 (0.122)	No serial correlation exists
Homoskedasticity (Breusch-Pagan-Godfrey)	0.735 (0.672)	No heteroscedasticity exists
Normality (Jarque-Bera)	2.49 (0.286)	Residuals are normal
Ramsey RESET	0.241 (0.632)	The model is specified correctly
Model 3		
Serial correlation (Breusch-Godfrey LM)	1.389 (0.281)	No serial correlation exists
Homoskedasticity (Breusch-Pagan-Godfrey)	0.110 (0.993)	No heteroscedasticity exists
Normality (Jarque-Bera)	1.696 (0.428)	Residuals are normal
Ramsey RESET	0.392 (0.540)	The model is specified correctly
Model 4		
Serial correlation (Breusch-Godfrey LM)	3.075 (0.110)	No serial correlation exists
Homoskedasticity (Breusch-Pagan-Godfrey)	0.608 (0.791)	No heteroscedasticity exists
Normality (Jarque-Bera)	0.545 (0.761)	Residuals are normal
Ramsey RESET	0.068 (0.800)	The model is specified correctly
Model 5		
Serial correlation (Breusch-Godfrey LM)	4.268 (0.829)	No serial correlation exists
Homoskedasticity (Breusch-Pagan-Godfrey)	1.483 (0.308)	No heteroscedasticity exists
Normality (Jarque-Bera)	0.779 (0.677)	Residuals are normal
Ramsey RESET	0.100 (0.992)	The model is specified correctly
Model 6		
Serial correlation (Breusch-Godfrey LM)	1.389 (0.281)	No serial correlation exists
Homoskedasticity (Breusch-Pagan-Godfrey)	0.110 (0.993)	No heteroscedasticity exists
Normality (Jarque-Bera)	1.696 (0.428)	Residuals are normal
Ramsey RESET	0.241 (0.632)	The model is specified correctly

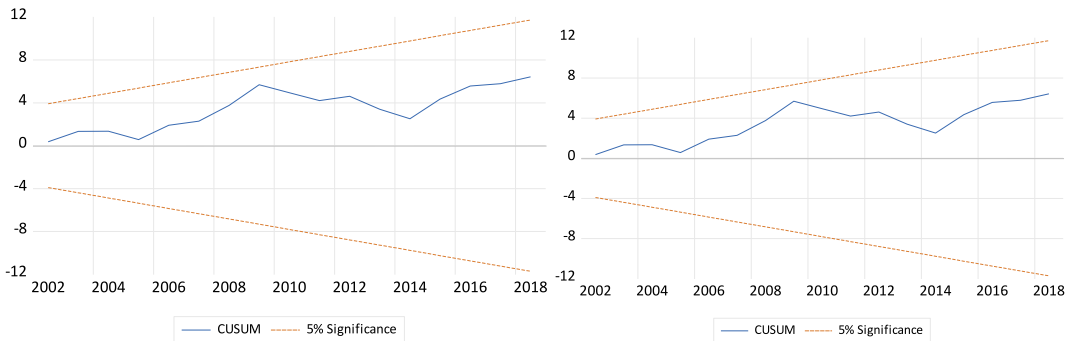

Fig. 1. The figure shows the residual stability which can be identified by the blue line in between the two redlines at the 5% level of significance for FMD and Political risk. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

financial risk and the SEc.

8. Conclusion and policy suggestions

The study explored the effect of FMD and country risk on the SEc as well as the moderating effect of country risk in this nexus in Pakistan, which has a relatively higher SEc and country risk. Employing data from 1995 to 2018, the study used the ADF and PP unit root tests to examine the series' stationarity, followed by the ARDL bounds cointegration test and ARDL technique to estimate the long-run relationship.

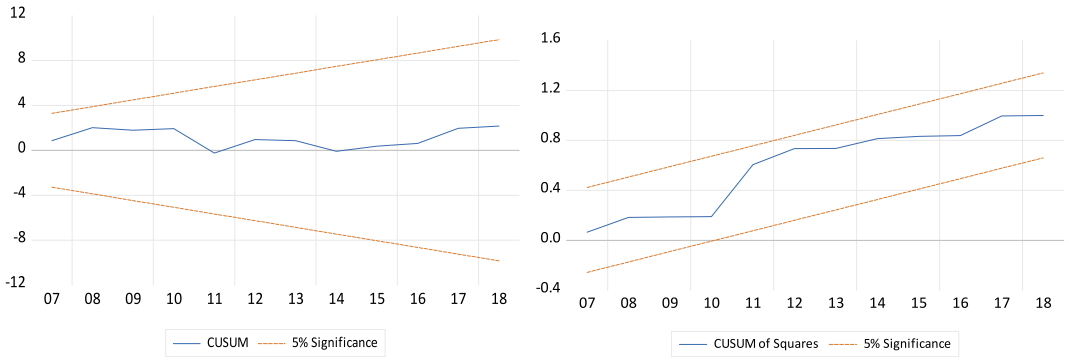

Fig. 2. The figure shows the residual stability which can be identified by the blue line in between the two redlines at the 5% level of significance for FMD and Financial risk. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

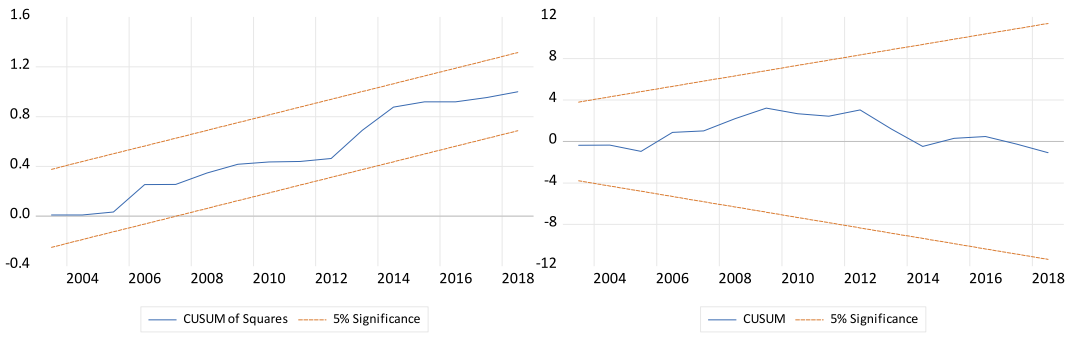

Fig. 3. The figure shows the residual stability which can be identified by the blue line in between the two redlines at the 5% level of significance for FMD and Economic risk. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

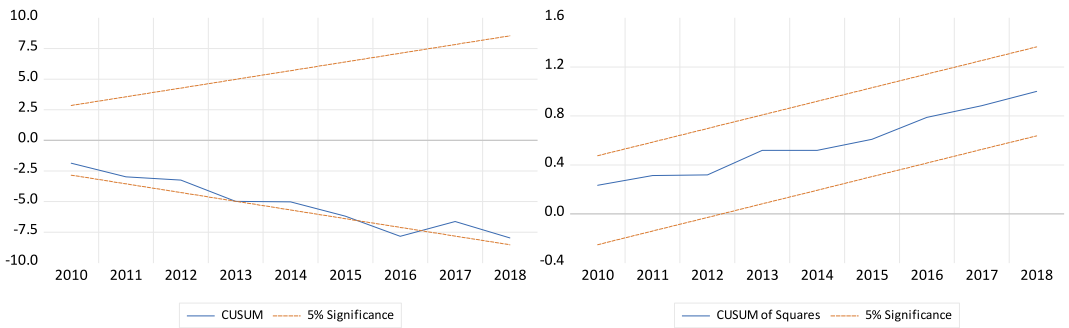

Fig. 4. The figure shows the residual stability which can be identified by the blue line in between the two redlines at the 5% level of significance for FMD and Political risk. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

8.1. Main findings

The study discovered a substantial direct relationship between country risk[3] and the SEc and a significant negative relationship between FMD and the SEc. Moreover, we found that political and economic risk positively moderates the influence of FMD on the SEc. Further, the tax burden is positive, while economic growth negatively influences the size of the SEc.

[3] Increasing PR, ER and FR risk scores indicate decreasing risk and vice versa. Please see ICRG methodology: https://www.prsgroup.com/wp-content/uploads/2014/08/icrgmethodology.pdf.

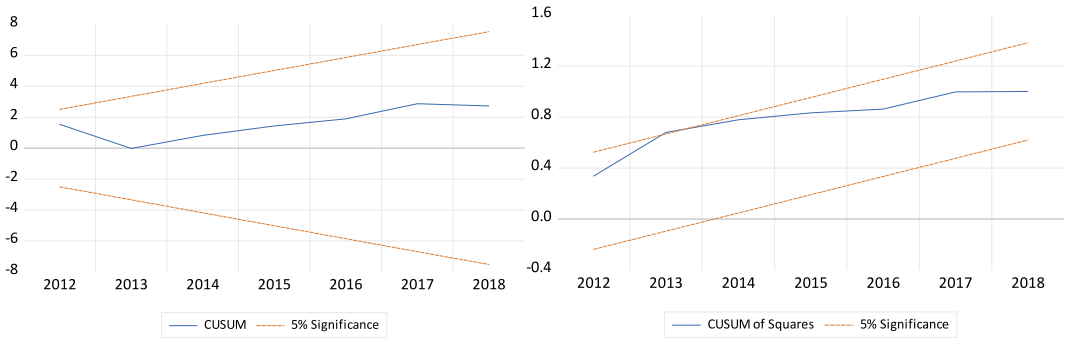

Fig. 5. The figure shows the residual stability which can be identified by the blue line in between the two redlines at the 5% level of significance for FMD and Financial risk. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

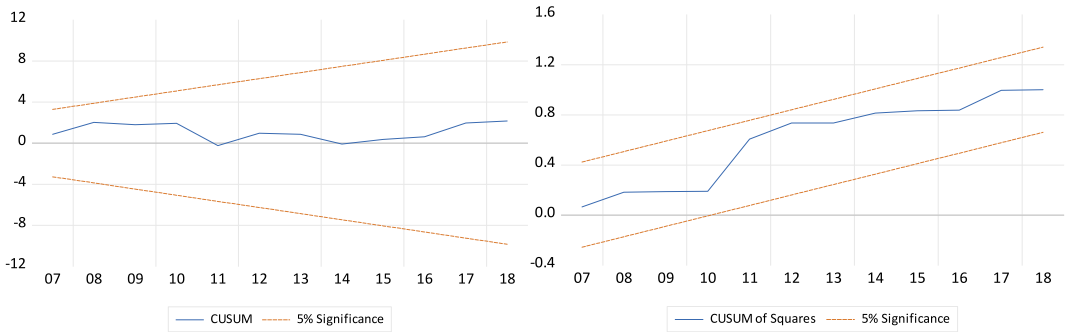

Fig. 6. The figure shows the residual stability which can be identified by the blue line in between the two redlines at the 5% level of significance for FMD and Economic risk. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 6
Spectral causality test.

Causal direction	Wald-t stat and *P*-Value
lnFMD ≠ lnSEc	1.5378 [0.4635]
lnPR ≠ lnSEc	1.1892 [0.551]
lnSEc ≠ lnPR	22.870 [0.000]***
lnER ≠ lnSEc	6.054 [0.048]**
lnSEc ≠ lnER	0.914 [0.632]
lnSEc ≠ lnFR	6.283 [0.10]
lnFR ≠ lnSEc	4.876 [0.087] **
lnSEc ≠ lnFMD*lnPR	8.640 [0.013]**
lnFMD*lnPR ≠ lnSEc	1.059 [0.588]
lnFMD*lnER ≠ lnSEc	6.552 [0.037]**
lnSEc ≠ lnFMD*lnER	0.159 [0.923]
lnSEc ≠ lnFMD*lnFR	12.141 [0.002]***
lnFMD*lnFR ≠ lnSEc	6.102 [0.047] **

8.2. Theoretical and practical implications

The study's findings have revealed several theoretical and policy implications and recommendations, particularly in the case of Pakistan. Theoretically, the current study examined the role of FMD (both stock and bond markets) in the SEc, opening a new discussion in the literature on the SEc and financial markets. Moreover, exploring the direct and moderating impact of country risk factors on the SEc could motivate researchers to further investigate the impact of each country's risk determinants on the SEc.

Regarding policy implications, FMD negatively affects the size of the SEc, suggesting that the government of Pakistan needs to promote financial markets by improving its policies that help promote the determinants of FMD (efficiency, access, and depth of financial markets). Developing financial markets facilitates investors by lowering financial constraints to funds, especially long-term financing. This will encourage the informal sector businesses to move into the formal sector, which increases government tax revenue.

Moreover, the positive and significant (direct and moderating) impact of country risk suggests that the government authorities should control political risk indicators, such as corruption, bureaucratic quality, government stability, etc., to increase investments in

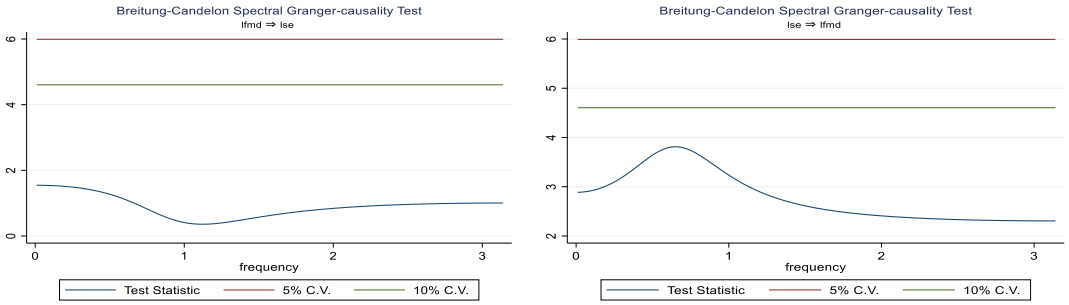

Fig. 7. lnFMD to lnSEc and lnSEc to lnFMD.

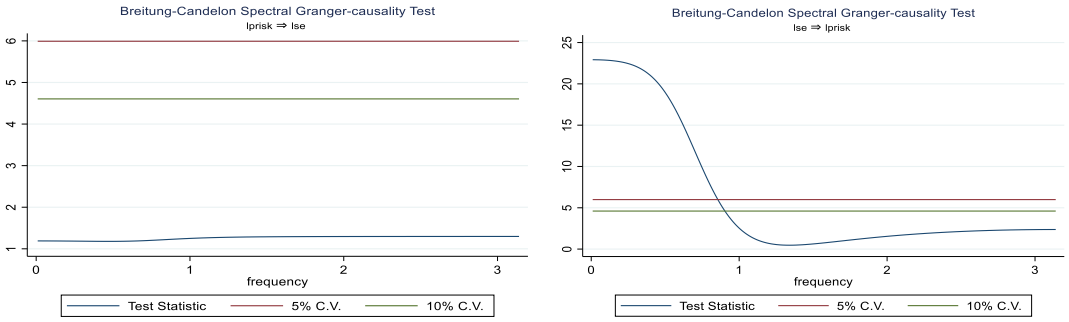

Fig. 8. lnPR to lnSEc and lnPR to lnSEc.

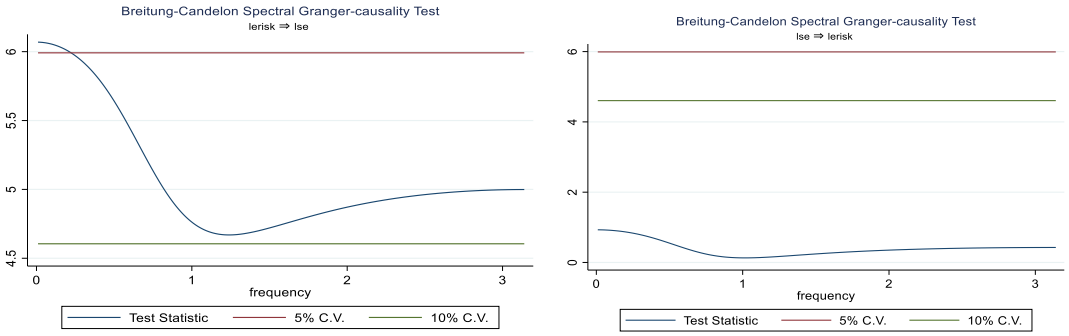

Fig. 9. lnER to lnSEc and lnSEc to lnER.

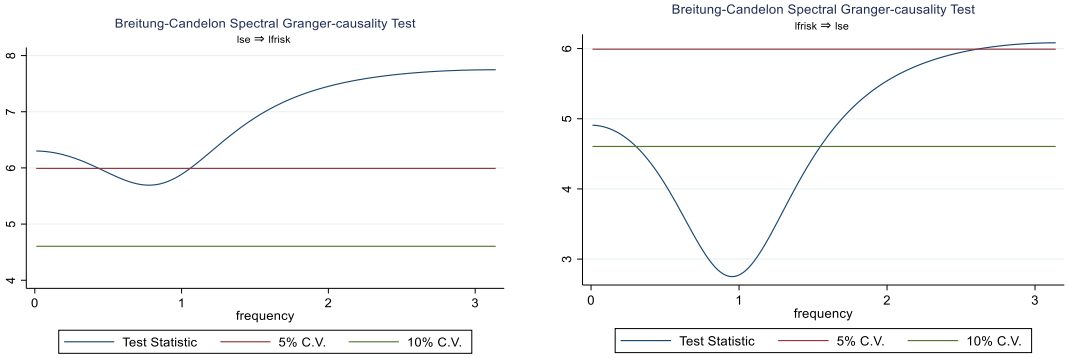

Fig. 10. lnFR to lnSEc and lnSEc to lnFR.

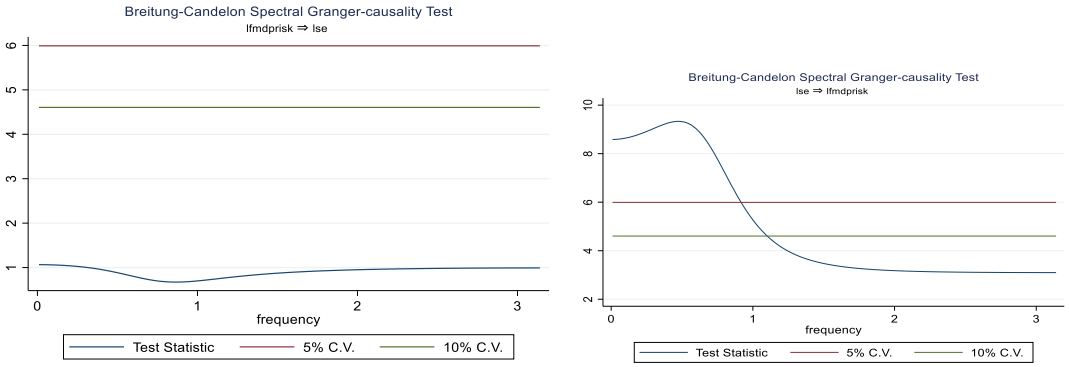

Fig. 11. lnFMD*lnPR to lnSEc and lnSEc to lnFMD*lnPR.

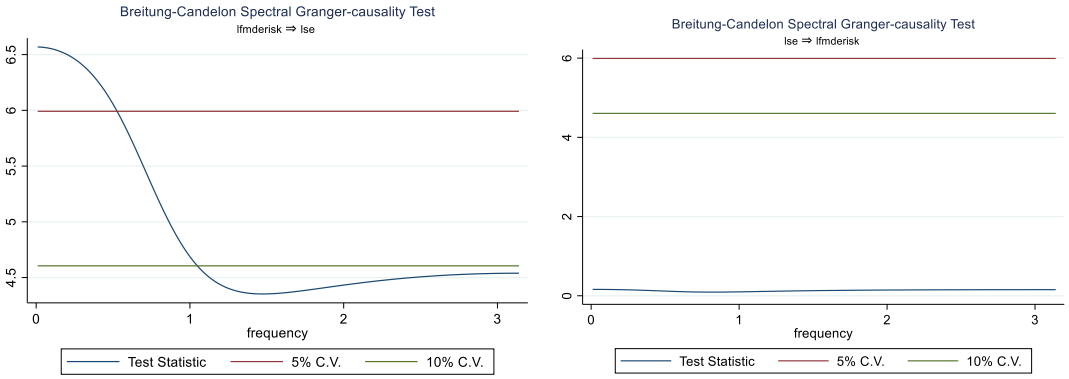

Fig. 12. lnFMD*lnER to lnSEc and lnSEc to lnFMD*lnER.

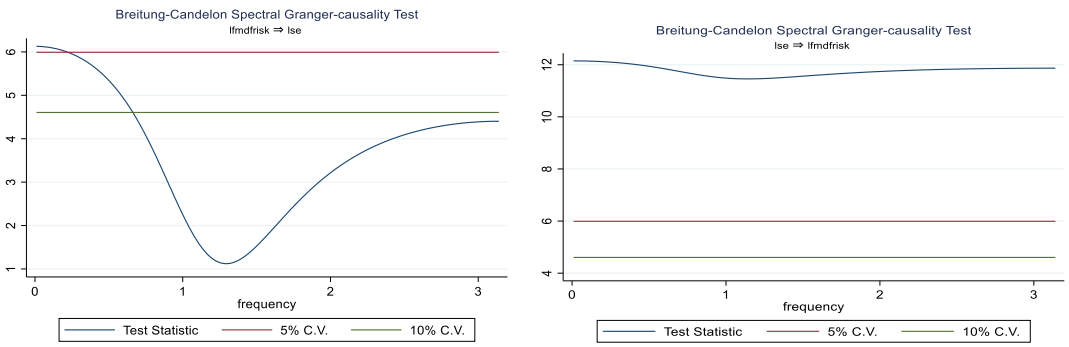

Fig. 13. lnFMD*lnFR to lnSE and lnSE to lnFMD* lnFR.

financial markets, which will help reduce shadow economic activities. Further, the government authorities should also consider the economic risk factors i.e., inflation rate, current account, and budget deficit, to attract investment in the formal sector and decrease the SEc. Additionally, the authorities are advised to ensure exchange rate stability and lower foreign debt to avoid or minimize the chances of default, which could help the government increase investor confidence and increase the investment in the formal sector, thus increasing their revenue.

8.3. Limitations and future direction

The current study considered FMD in determining the size of the SEc. However, future research studies should focus on both financial markets and institutions to compare the degree of significance of the size of the SEc. Moreover, the current study used political, economic, and financial risk indices. Other research studies should investigate the impact of the determinants of each country risk factor (political, economic, and financial) separately on the SEc to further understand the impact of country risk on the size of the

SEc. Further, future research studies should consider other developing economies because the size of the SEc is higher in developing economies than developed economies.

Author contribution statement

Sami Ur Rahman; Faisal FAISAL: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Adnan Ali: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data.

Hamid Ghazi H Sulimany; Ayman Hassan Bazhair: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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