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Research Article

Impacts of Voice and Accountability upon Innovation in Pakistan: Evidence from ARDL and Maki Cointegration Approaches

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Innovative capacity has a decisive and crucial role in determining who is prospering in the global arena. Innovation is crucial for value creation, high productivity, economic growth, employment, and sustainable development that benefit the consumers, firms, businesses, and economy as a whole. Several institutional, political, and social conditions lead to different responses of innovation. For instance, low voice and accountability may lead to low institutional setting, cronyism, and favoritism in allocation of resources, which can harm innovation. Similarly, the terrorist attack of 9/11 caused horrific scales of destructions, which caught the countries on various fronts such as economic, political, and technological. Further, sound infrastructure and savings rates are essential to enhance innovation. Applying the ARDL approach to cointegration, this study investigates the impact of voice and accountability, terrorism, infrastructure, and savings on innovation in Pakistan. The empirical evidence shows that low voice and accountability and terrorism have adverse impacts on innovation in the short- and long-run periods. Further, findings reveal that inadequate infrastructures and low savings adversely affect the innovation in both periods. Various robust checks such as Maki cointegration, Johansen cointegration test, fully modified ordinary least square, dynamic ordinary least square, and canonical cointegration regression corroborate the results. The findings of the study would be of substantial implications for government and policymakers.

1. Introduction

Innovation is a crucial driver of sustainability is widely accepted by government representatives, industry professionals, and scholars [1]. Sustainable Development Goals (SDG-9) of the United Nations highlight the importance of innovation and reports that economic growth and development of a nation largely depend on innovation [2]. Innovation is essential for sound economic growth and sustainable development that benefit the consumers, firms, businesses, and the economy as a whole [1, 3]. Sound innovation capability has a great significance and importance to sustain economic growth in all the countries, particularly in developing economies [4].

The SDG-16 of the United Nations aims to develop effective, transparent, and accountable institutions at all levels. This goal aims at ensuring inclusive, responsive, representative, and participatory decision-making at all levels. Practitioners report that governance indicators (control of corruption, political instability, regulatory quality, government effectiveness, rule of law, and voice and accountability) are valuable metrics for the formal institutional fabric of the world countries [5]. Among these governance indicators, voice and accountability is a vital part of the governance structure [6], which enables a country's citizens to express and exercise their views in an effective manner. These views have the potential to influence government processes and priorities. Voice and accountability

also encompasses military involvement in politics and democratic accountability, which increase corruption and decrease confidence of the investors and FDI inflows [7–9]. Besides, it entails the aspects of freedom of expression, free media and press, political rights, and civil liberties [10, 11].

Peace is at the heart of sustainable development. SDG-16 of the United Nations emphasizes the vital role of peace in bringing sustainable development [12, 13]. A peaceful, stable, and terrorism-free environment of a country is of great importance for smooth business and market operations, foreign direct investment (FDI) inflows, and economic growth. On the other hand, terrorist activities adversely affect the economy of a country by decreasing confidence of investors and FDI inflows. Further, it also damages the essential infrastructure, causes financial instability, high economic cost, and increases counterterrorism costs [14–16].

Previous studies reveal that investment in R&D expenditures and educational resources and patent protection encourage the innovation process [17]. General wisdom suggests that these views hold because investment in such elements accelerates the pace of innovation. According to Ege and Ege [17], however, it is improper to assume that patent protection and subsidies in R&D are sufficient to spur innovation. Innovation is a multifaceted and complex phenomenon [18]; therefore, several institutional, political, and social conditions lead to different responses of innovation [19]. Economic factors are not the only determinants of innovation, and that noneconomic factors can also affect innovation. However, past research is extensively focused on economic factors in studying the phenomenon of innovation, but the noneconomic and institutional factors have received scarce research attention in the extant literature. For instance, at the macrolevel, few studies have investigated the relationship between political instability, regulatory quality, government effectiveness, control of corruption, and innovation [20, 21]. Voice and accountability is also an essential dimension of the governance structure, and the empirical relationship between voice and accountability and innovation is still unexplored, specifically in laggard economies. Similarly, past studies reported that terrorism has an adverse impact on growth [22], FDI inflows [23], and tourism [24]. However, the empirical relationship between terrorism and innovation is overlooked in the literature. Therefore, the relationship between voice and accountability, terrorism, and innovation is an important research gap, and this study aims to fill it. Besides, the past research reports that savings can improve resource allocation and boost technological innovation [25]. Likewise, the physical infrastructure is essential as it attracts FDI inflows, enhances economic growth, and retains foreign firms, talent, and entrepreneurs [26]. These factors (savings and infrastructure) can also influence innovation. Considering this background, this study hypothesizes the four relationships. In sum, the impacts of these mix of variables (i.e., considering these variables in a single econometric model) on innovation is unexplored, and this study aims to explore it.

Practitioners report that the sound body of innovation literature focused primarily on developed and fast-growing economies, and the low-income economies have received less research attention [27, 28]. Scholars report that laggard economies have the lowest level of patents per million person [29]. In this regard, the present study intends to extend the research on innovation in laggard economies. To serve this purpose, this study specifically focuses on Pakistani dynamics to study the causes of its low innovation capability. Similarly, the ample body of innovation studies has focused on cross-country evaluation [21, 29]. Practitioners are in the view that cross-country studies provide only a general understanding of the relationship between variables [27, 30]. Therefore, detailed and comprehensive implications for each country cannot be drawn from such results [31, 32]. Studying innovation in laggard economies could be an exciting and essential context, which can help to draw policy formulations for laggard states. The lack of research evidence regarding laggard countries and noneconomic factors motivates us to investigate reasons for low innovation performance of Pakistan. This research is distinct from other studies in innovation domain in the following ways. First, it focuses its investigation in a laggard economy, which is an unexplored area of study. Second, it examines the impacts of voice and accountability, terrorism, infrastructures, and savings upon innovation in a laggard economy (Pakistan) by employing robust cointegration approaches (ARDL and Maki) and several other econometric approaches (Johansen cointegration test, dynamic ordinary least square, fully modified ordinary least square, and canonical cointegration regression), which have not been employed in this particular research context. To sum, the econometric model (set of variables) and estimation econometric methodologies are distinctive, which have not been considered before in this particular research context. The main contributions of this study are summarized as follows: (i) it confirms that low voice and accountability is a hurdle in the innovation path; (ii) it validates the negative relationship between terrorism and innovation; (iii) findings show that low savings is an obstacle in the innovation path of laggard economies; (iv) finally, findings reveal that the inadequate infrastructure has adverse impacts on innovation.

2. Review of Literature and Hypothesis Development

2.1. Voice and Accountability and Innovation. Quality of the governance structure is essential for economic development and sound economic outcomes [5, 33]. Voice and accountability is an essential dimension of a good governance structure [6]. "A higher level of voice and accountability should mean the presence of the needed climate for the growth of various associations and civil society groups and guarantee more strength to business associations, which should, as the literature on NIS suggests, lead to a better innovational system" [5]. Voice and accountability has several dimensions. For example, it include the aspects of military involvement in democratic accountability and politics [7]. A higher level of military involvement in politics can encourage armed opposition, generate corruption, and create an uneasy environment for foreign investors [9],

which may hinder them to invest in such countries. Multinational enterprises invest across the border in the form of FDI, which is a desirable channel for diffusions of knowledge [34]. Several studies have reported a positive relationship between FDI inflows and innovation in developing economies [29, 35]. In the same time, Busse [36] and Harms and Ursprung [37] argued that multinational firms are more likely to invest in democratic countries.

Busse and Hefeker [8] studied the data of 83 developing economies from the period of 1984–2003. They examined the relationship between military involvement in politics and FDI inflows. The report showed a negative correlation between both. Stasavage [38] reported a sound relationship between presence (absence) of political checks and balances and inflows of FDI. He concluded that the average long-run impact would be increased by 16% in private investment if an authoritarian system (fewer checks and balance) turns to a political system (multiple and higher checks and balances). Trust in a democratic setup and fewer chances and threats of military involvement boost the confidence of the global and domestic investors, which increases the rate of investment, business, and market operations within the country. Similarly, a stable political and business environment also encourages entrepreneurs to come up with novel ideas and innovative products as well as services. This has a positive impact on the overall innovation rate of a country. On the other hand, military involvement/military takeovers could discontinue the economic, business, educational, and development policies, which may harm the economic growth of such countries. Perceived threats of military coups create uncertainty in the overall environment of a country which can rattle economic, financial, business, entrepreneurial, productive, and innovative activities. Military intervention causes instability in the overall environment of the country, and thus unfavorable for economic development of a country. Technology transfer requires long-term projects in the shape of FDI inflows. However, an unstable political environment of a country discourages potential investors to invest in such countries [15] which can adversely affect the innovation [39].

Voice and accountability addresses the question of how citizens can hold the government accountable for policy choices [10, 11]. According to Howell [7], democratic accountability is defined by how governments react to concerns of its citizens. When people raise and communicate their priorities and concerns, then the government will be more accountable, and it leads to the possibility that the government will be more accountable and responsive to their demands, needs, and preferences [40]. Similarly, political accountability means the government is responsive and considers the voice and preferences of their citizens [41]. On the other hand, less-responsive government does not consider the needs and preferences of their citizens. In this background, citizens' voice matters to convey their demand and preference to the government [33], which reflects in government policies and actions. If the citizens have low speaking power, there are no or little chances that their views, opinions, and preferences will be reflected in government policies and priorities [33]. Low voice and accountability lead to misallocation of resources, favoritism in resources, and cronyism [5]. For example, in the majority of the developing countries, governments initiate projects (without considering the needs, demands, and preferences of the citizens) that are linked with high kickbacks, bribes, and suited to their personal interests. Low accountability can divert government attention from key areas, and they do not make investment in key areas such as R&D investment, education and training, and other vital areas that are considered essential to enhance investment, growth, productivity, and innovation activities. Researchers argued that the government is trying to protect inefficient industries for the sake of its personal relations or business cronies [42], and thus such businesses are less willing to engage in technological upgrading and innovation [42, 43]. Therefore, such practices may have an adverse impact on the overall innovation activities of a country.

Voice and accountability also measures the degree through which citizens can freely participate and express their opinions and thoughts. Regarding community participation in the decision-making process, Brock et al. [40] state "an informal, self-organised network of peers with diverse skills and experience in a common area of professional practice. Members interact regularly to share ideas and strategies, determine solutions, and build innovation." Recent research reported that innovation incubates and emerges within an environment especially if it is a friendly one [17]. Higher voice and accountability means sound coordination, exchange of information, and the needed climate for the growth of business associations and civil societies which may lead to a higher rate of innovation [5].

Voice and accountability covers the aspects of free media, freedom of expression, and association [44]. A free media induces governments to provide adequate business and investment climate and to work in the best interests of their citizens [45]. A free press enhances the flow of information and ideas, which leads to new discoveries and innovation [46]. Varsakelis [47] reported a positive relationship between freedom of press and innovation. In the same vein, Dutta et al. [46] reported a positive relationship between free media and entrepreneurship. Innovativeness is an essential attribute in the psyche of entrepreneurs, which can create an impact on the overall innovation system of a country [39, 48, 49].

In addition, there may be several other possible channels through which a free media and press can have a positive impact on innovation. For example, freedom of press and media can significantly affect innovation via four possible means such as institutional quality, asymmetric information, efficiency effect, and image effect. As for the first factor, freedom of press is an essential pillar of democracy with transparent election and the rule of law; and it is one of the essential and most important indicators of the institutional quality. It is showed that quality of institutions plays a vital role to nourish and attain technological progress [50]. Similarly, DiRienzo and Das [51] state that the rule of law (i.e., strong property right system) is essential to incentivize the process of innovation.

Regarding the asymmetric information, free media and free press are essential factors that shape public beliefs and

opinions and play a key role in the political decision-making process [52]. Free media should work in the best interest of the country and public and could be beneficial because free media facilitate to decrease the information asymmetry between government and citizens [53]. Access to information is essential for innovation process [17], and the freedom of press facilitates the government to communicate with the highly globalized world. A free media helps the government to reduce the information gap with the world by providing accurate news, which helps the government to get feedback and (re)design policies [52]. Therefore, such practices are essential to update or (re)design business, economic, and financial policies, promote domestic investment, and attract global investors, multinational firms, etc. These can have a positive impact on the overall innovation activities. Regarding the efficiency effect, free press and free media increase government accountability and generate greater monitoring power, which leads to a decrease in corrupt practices and corruption [54, 55]. Free press and free media buffer government corruption, enhance institutional quality, provide efficiency in government work, and bring clarity in governmental policies. Previous research shows that the quality of institutions and decrease in corruption help to enhance innovation [50, 56].

Finally, on the image effect, freedom of media and press not only gets national attention, but also global. It attracts the attention of a large community such as global investors, multinationals firms, and business communities. A free media provides reliable information to global investors and foreign firms and encourages them to invest in such countries [52]. However, restrictions on press and media can be regarded as a potential signal to shift towards the non-democratic regime, which can dampen the country's image and portray a negative image of the country globally. Similarly, it can also be considered as a political separation from a highly globalized world. A partially or nonfree press and media fail to mirror the events and policies in a country and restricts the flow of information. This can discourage the potential domestic and global investors, entrepreneurs, multinational firms, and businesses to invest in such countries. Thus, we propose the following hypothesis.

H1: low voice and accountability can affect innovation in a laggard country.

2.2. Terrorism and Innovation. Scholars argued that innovation is a closed/open system. Few studies considered it as a closed system [57, 58]. Gong and Keller [59] argued that it is an open system because a country participating in the international trade and endeavoring to attract FDI could benefit from advanced technologies to become innovative. The rapid increase in economic integration makes the traditional approach (closed system) less relevant because the openness to the FDI and the international trade results in technology diffusion, global innovation, and economic growth [59, 60].

FDI inflows facilitate the host countries to acquire tangible and intangible assets such as managerial skills, capital formation, and modern technologies and obtain the related physical assets [61, 62]. Koh [39] said that inward FDI is an essential mechanism for developing countries to attain leading-edge technologies and best business practices. Salim et al. [35] found that the most crucial aspect of FDI is the technology spillover in the host country. Developing countries aimed at attracting FDI inflows and advance foreign technologies which facilitate them to enhance their innovation [63]. It also answers the question of how latecomer economies close the gap in their innovation with more developed countries [29]. FDI facilitates the transfer of technologies, increases total factor productivity [64, 65] and stimulates the technological change through the adoption of foreign advanced technologies, skills, and capital to increase the level of productivity and innovation [29, 66, 67]. Thus, FDI is also an essential driver of innovation performance [68]. Selaya and Sunesen [69] report that FDI inflows have the potential to enhance knowledge, competitiveness, and entrepreneurial activities. Innovativeness is an essential trait in the psyche of entrepreneurs, and FDI inflows have a positive spillover impact on entrepreneurship [48, 49], which could positively influence the overall rate of innovation in a country [39].

Terrorism and its impact on the economic growth received considerable scholarly attention, and previous studies reported the negative relationship between terrorism and economic growth [22, 70]. Terrorist attacks of 9/11 caused horrific scale of destruction, which caught the countries on various fronts such as economic, political, military, and technological [39]. Terrorism not only leads to deaths and damages to property, but also adversely affects the global and national economies, as well as the confidence of the investors [71]. Devastating consequences of terrorist activities include lower FDI inflows [39, 71] and economic, business, and market isolation. It also restricts its access to the international market and the latest technologies and international research collaboration activities. All such restrictions hinder technological capabilities of a terrorism-prone country. Speakman [72] states that market failure can hinder the rate of innovation of a country. Technology transfer requires long-term investment in the form of FDI inflows. Terrorism increases economic uncertainty and country-specific risks. It compels foreign investors to move away from high-risk countries and invest in low terrorism-prone countries, this is called flight-to-safety effect [23, 73]. A decrease in inflows of FDI could slow down the transfer of technologies and impede economic growth and technological advancement [39].

According to Fu et al. [74], FDI is not an unalloyed blessing to transfer technology. Pietrobelli [75] states that technology can be diffused through various other channels like movement of goods through the international trade, outward foreign direct investment (OFDI), R&D expenditure, international research collaboration, travel of migration of skilled people, and travel of foreign education workers and students. For example, trade openness is an essential mechanism for catching-up economies to attain leading-edge technologies and best business practices [39]. Koh [39] states that terrorism-related concerns such as strict monitoring and inspection of shipping containers may slow

down the international trade, and thereafter the rate of innovation. Similarly, R&D expenditures are the core of the innovation process to explore new things and experiments for novelty [76]. Increase in defense spending due to terrorism may crowd out R&D spending and productive investment [39], resulting in a lower rate of innovation in the country. Besides, scholars reported that the counterterrorism cost may have crowding-out effect on R&D investment and slow down the growth and innovation rate in a country [77]. Multinational enterprises are considered essential driving forces for R&D activities around the world [74] and expected to have a positive spillover effect through technology transfer and technical know-how [78]. Similarly, the interaction between foreign and local firms supports innovative process and activities [79, 80]. However, the desired results can be achieved only when technology receiving countries have a peaceful, stable, and terrorism-free environment.

Terrorism-prone countries experience the shocks of skilled labor force migration [81]; this affects the rate of innovation in such countries. Cuhls [82] called brain drain as "innovation migration." According to Bosetti et al. [83], skilled migration has a positive impact on innovation in recipient countries. Entrepreneurs bring new technologies and products and services [49], and they are much concerned about the potential events of terrorism when planning, organizing, or establishing their businesses. Terrorist activities directly affect the entrepreneurs and reduce their willingness to run their business in such areas and thus showed adverse impact on the overall rate of innovation of a country [39, 84]. The following hypothesis is proposed.

H2: terrorism activities can adversely affect innovation.

2.3. Infrastructure Development and Innovation. The importance of infrastructures for economic development of a country cannot be gainsaid. It plays a major role in the economy and greases the wheels, if not the engine of development. Infrastructural development is a key driver for economic growth [85]. Evidence revealed that a sound infrastructure played a significant role in Chinese economic revolution. For instance, factors such as average commute time—from main ports, airports, and industrial parks—feature prominently in China's capacity to attract and retain talent, foreign companies, and entrepreneurs [86]. Sound infrastructure of a country helps to attract modern industries/companies, investors, FDI inflows, and entrepreneurs to invest because it facilitates to reduce several types of costs such as operational cost, transportation cost, and cost of doing businesses [26]. Similarly, such types of investments and FDI inflows may comprise investments from technological firms and business and technology transfer contracts, which can enhance innovative activities in the recipient countries. Similarly, infrastructures affect entrepreneurial growth [87] and entrepreneurial growth affects innovation [39]. Last but not the least, physical infrastructures also include universities, research labs, and technology centers, which can also a significant impact on overall innovation rates of a country. Thus, the following hypothesis is proposed.

H3: infrastructural development positively affects the innovation.

2.4. Savings and Innovation. Savings plays an important role in achieving the targets of the economic growth of a country [88]. Economic growth attained from savings is more sustainable compared to growth achieved through borrowed capital. Thus, the interaction between savings and economic growth is crucial for the development policy. Savings meets the investment requirements and capital accumulation, and resultantly it generates a higher rate of growth [89]. However, the direction of causality between both is still debatable among practitioners [90]. The economic growth of several economies such as China, India, Thailand, South Korea, Singapore, and Malaysia is attributed to high savings rates. Contrastingly, many Latin American and sub-Saharan African countries have low save rates, which results in low economic growth in these countries [88]. Low savings rates do not allow the countries to invest in key projects that are essentially intensive to technological innovation. Better savings can improve resource allocation and boost technological innovation [25, 91]. Practitioners report that savings matter for innovation because domestic savings allows the domestic banks to cofinance projects and attract foreign investors [91]. Such projects and investments may include operations related to technology firms and businesses, which can influence the overall innovation rate in the country. Likewise, abundant savings allow China to make outward FDI and enhance its innovation capability [92]. These syntheses lead us to assume that higher savings can influence innovation. Thus, we propose the following hypothesis.

H4: savings can positively influence innovation.

3. Data and Model Specification

This study examined the model by using data from the period 2002Q1 to 2016Q4. To cope with the problem of short sample size, the annual data were transformed into quarterly data in Eviews version 10. Scholars report that annual frequencies are insufficient to get sound results, so using more observations increases the soundness of the statistical results [93]. Similarly, the transformation of data from low to high frequency has been done in several past studies [23, 24, 94, 95] (several researchers applied the econometric technique to transform data from low to high frequency; for example, Kumar [96] transformed the 7 years of annual data into quarterly data from the period 2010 to 2016. Similarly, Kumar et al. [97] and Obradović et al. [95] transformed the data from low to high frequency for the period of 2009 to 2014 (6 years) and 2007 to 2014 (8 years), respectively). This study is limited to this sample period due to the following reasons. First, Pakistan faced a worse terrorism wave after 9/11, and therefore, this study aims to investigate the impact of terrorism on innovation. Secondly, 1996 was the first year when the World Bank recorded the governance indicators, but the governance indicators are missing in the years 1997, 1999, and 2001 and became continuously available from the

year 2002 to onward. Finally, 2002 was the first year when the WIPO started to record the patent information. Patent data are widely used in past and recent studies to measure innovation. A proxy to measure innovation is our dependent variable; data were obtained from the World Intellectual Property Organization (WIPO). The data of terrorism were obtained from [98]. The data of voice and accountability were obtained from the Worldwide Governance Indicators (WGI). The data of gross fixed capital formation and domestic savings are obtained from the World Development Indicators (WDI) of the World Bank. Table 1 describes the variables and data sources.

The general form of the innovation function considering voice and accountability, terrorism, physical infrastructures, and savings main determinants is modeled as follows:

$$\mathrm{lnINN}_t = \left(\mathrm{VAA}_t, \mathrm{TSM}_t, \mathrm{INF}_t, \mathrm{SAV}_t\right). \tag{1}$$

For the empirical purpose, all the variables are transformed into the natural logarithm except index following [15]. The multivariate model containing relationship between voice and accountability, terrorism, infrastructure, savings, and innovation is expressed in the form of the following equation:

$$\begin{aligned}\ln \mathrm{INN}_t &= \varnothing_0 + \varnothing_1 \mathrm{VAA}_t + \varnothing_2 \ln \mathrm{TSM}_t + \varnothing_3 \ln \mathrm{INF}_t \\ &\quad + \varnothing_4 \ln \mathrm{SAV}_t + \varepsilon_t,\end{aligned} \tag{2}$$

where ln INN, VAA, ln TSM, ln INF, and ln SAV, respectively, represent the innovation, voice and accountability, terrorism, infrastructure, and savings; constant is denoted as $\varnothing_0$, while ε_t is the error term; $\varnothing_1$, $\varnothing_2$, $\varnothing_3$, and $\varnothing_4$ are the coefficients of voice and accountability, terrorism, infrastructure, and savings, respectively.

4. Methodology

4.1. Unit Root Test. A nonstationary series may violate the basic assumptions in the econometric model [99, 100]. Before proceeding towards the autoregressive distributive lag (ARDL) approach, the first step is to ascertain the unit root properties of the series. The commonly used unit root tests are by Dickey and Fuller [101] (ADF), Phillips and Perron [102] (PP), Dickey–Fuller Generalized Least Squares by Elliott et al. [103] (DF-GLS), and Kwiatkowski et al.[104] (KPSS). The null hypothesis of ADF, PP, and DF-GLS is nonstationarity against the alternative hypothesis of stationarity. The KPSS unit root test has the null hypothesis of stationary against the alternative hypothesis of nonstationary.

4.2. ARDL Approach to Cointegration. The ARDL approach to cointegration has been a widely accepted econometric tool to examine the long-run relationship between variables. The ARDL approach to cointegration was developed by Pesaran et al. [105]. The ARDL approach has several advantages over the conventional approaches to cointegration [106, 107]. For instance, these traditional approaches require that all the variables under consideration be integrated at the same integration order (i.e., $I(1)$). This assumption of the same integration order makes them less prominent. The ARDL approach has several advantages over the conventional cointegration approaches. First, the ARDL approach to cointegration can be applied even if the variables are not integrated at the same order of integration. It means that the ARDL approach can be utilized even if the variables are in the form of $I(1)/I(1)$ or $I(1)/I(0)$. Secondly, another advantage of the ARDL approach is that it provides reliable results for both the short-run and the long-run periods. Third, this cointegration approach is suitable for a small sample size. Fourthly, the ARDL approach distinguishes between dependent and independent variables, and it also separates the short-run and long-run results. Finally, long-run results calculated through ARDL are unbiased even if some of the regressors are endogenous [24]. For the ARDL approach to cointegration, equation (1) is transformed into an unrestricted error correction model (UECM) in the form of the following equation:

$$\begin{aligned}\Delta \ln \mathrm{INN}_t &= a_0 + \sum_{i=1}^{l} b_i \Delta \ln\mathrm{INN}_{t-i} + \sum_{i=1}^{l} c_i \Delta \mathrm{VAA}_{t-i} \\ &\quad + \sum_{i=1}^{l} d_i \Delta \ln\mathrm{TSM}_{t-i} + \sum_{i=1}^{l} e_i \Delta \ln\mathrm{INF}_{t-i} \\ &\quad + \sum_{i=1}^{l} f_i \Delta \ln\mathrm{SAV}_{t-i} + \beta_1 \ln\mathrm{INN}_{t-1} \\ &\quad + \beta_2 \mathrm{VAA}_{t-1} + \beta_3 \ln\mathrm{TSM}_{t-1} \\ &\quad + \beta_4 \ln\mathrm{INF}_{t-1} + \beta_5 \ln\mathrm{SAV}_{t-1} + \varepsilon_t,\end{aligned} \tag{3}$$

where Δ represents the first difference operator, a_0 is a constant, b_i, c_i, d_i, e_i, and f_i, respectively, represent the coefficients of ln INN, VAA, ln TSM, ln INF, and ln SAV, and ε_t denotes the error term.

Two steps are involved performing the ARDL approach. The first step involves investigating the F-statistic and long-run relationship. The null hypothesis of nonexistence of long-run relationship among variables is H_0: $\pi_1 = \pi_2 = \pi_3 = \pi_4 = 0$, while the alternative hypothesis is Ha: $\pi_1 \neq \pi_2 \neq \pi_3 \neq \pi_4 \neq 0$. The asymptotic distributions of the test statistics are nonstandard, and either variables are integrated into the form of $I(0)$ or $I(1)$. Two sets of asymptotic critical values were computed by Pesaran et al. [105]. The first set is on the assumption that variables are integrated in the form of $I(0)$, and the second set assumes that the variables are integrated in the form of $I(1)$. The first value [$I(0)$] is called as the lower critical bound (LCB), and the second value [$I(1)$] is called as the upper critical bound (UCB). Whether the cointegration exists or not is decided on the following rule. If the calculated value of F-statistic is higher than the UCB, the null hypothesis with the assumption of no cointegration is rejected, and it can be concluded that the dependent variable and its regressors cointegrate for a long-run relationship. If the computed value of F-statistic is less than the LCB, the null hypothesis with the assumption of no cointegration

Table 1: Description of variables.

Sr. no	Variable name	Variable sign	Measure of variable	Source
1	Patents	ln INN	Innovation is measured in terms of patent granted	WIPO
2	Voice and accountability	VAA	Index of voice and accountability	WGI
3	Terrorism	ln TSM	Total number of casualties in terrorist incidents	GTD
4	Gross fixed capital formation	ln INF	GFCF as % of GDP	WDI
5	Domestic savings	ln SAV	Domestic savings as % of GDP	WDI

among variables cannot be rejected. It implies that variables included in the empirical model do not have a long-run relationship. However, if the computed value of F-statistic falls between UCB and LCB, the cointegration among variables is undecided [108]. The alternative way to establish the cointegration is to test the significant negative lagged error correction term (ECT) [24].

The second step involves investigating the short-run coefficients and ECT. In other words, after estimating the long-run association between variables, the error correction model (ECM) is validated to calculate the short-run relationships and ECT. The ECM is expressed as follows:

$$\begin{aligned}\Delta \ln \mathrm{INN}_t = {} & \delta_0 + \sum_{i=1}^{l} \delta_{1i} \Delta \ln \mathrm{INN}_{t-i} + \sum_{i=1}^{l} \delta_{2i} \Delta \mathrm{VAA}_{t-i} \\ & + \sum_{i=1}^{l} \delta_{3i} \Delta \ln \mathrm{TSM}_{t-i} + \sum_{i=1}^{l} \delta_{4i} \Delta \ln \mathrm{INF}_{t-i} \\ & + \sum_{i=1}^{l} \delta_{5i} \Delta \ln \mathrm{SAV}_{t-i} + \phi \mathrm{ECT}_{t-1} + \varepsilon_t,\end{aligned} \tag{4}$$

where Δ represents the first difference operator, δ_2, δ_3, δ_4, and δ_5 indicate the short-run coefficients of VAA, ln TSM, ln INF, and ln SAV, respectively, δ_0 is the constant, and the error correction term, i.e., ECT_{t-1}, shows the speed of adjustment.

4.3. Maki's Approach to Cointegration. The extant literature has several cointegration approaches with structural breaks such as by Gregory and Hansen [109] and Hatemi-J [110]. Recent research reveals that these approaches failed to perform better results [111, 112] compared with the recently developed Maki cointegration approach, which allows multiple structural breaks [113]. Maki cointegration is easy to perform, and during the investigation of cointegration analysis, it provides information about five unknown structural breaks in the data. Four alternative models are proposed by the test as shown in equations (5)–(8):

Level shift (break in the intercept and without trend):

$$x_t = \mu + \sum_{i=1}^{r} \mu_i D_{i,t} + \beta' Z_t + u_t. \tag{5}$$

Level shift with trend (break in the intercept and coefficients and without trend):

$$x_t = \mu + \sum_{i=1}^{r} \mu_i D_{i,t} + \beta' Z_t + \sum_{i=1}^{r} \beta_i' Z_t D_{i,t} + u_t. \tag{6}$$

Regime shift (break in the intercept and coefficients and with the trend):

$$x_t = \mu + \sum_{i=1}^{r} \mu_i D_{i,t} + \delta t + \beta \prime Z_t + \sum_{i=1}^{r} \beta_i' Z_t D_{i,t} + u_t. \tag{7}$$

Regime shift with trend (Break in the intercept, coefficients, and trend):

$$x_t = \mu + \sum_{i=1}^{r} \mu_i D_{i,t} + \delta t + \sum_{i=1}^{r} \delta_i t D_{i,t} + \sum_{i=1}^{r} \beta_i' Z_t D_{i,t} + u_t, \tag{8}$$

where x_t is the dependent variable and D_i is the dummy variable.

5. Empirical Results and Discussion

Descriptive statistics of all the variables are reported in Table 2. Before the ARDL approach, unit root properties of the variables under consideration are investigated via PP, ADF, DF-GLS, and KPSS unit root tests. Table 3 reports the results of unit root tests. The empirical results show that all variables are stationary at their first differences.

A significant problem associated with the above reported traditional unit root tests is that they do not consider the structural break in the series. In overcoming this, Clemente et al.'s [114] (CMR) structural break unit root test was applied to study the structural break in the series. This study prefers to use CMR structural break unit root over Zivot and Andrews's [115] (ZA) unit root test. One major weakness of the ZA unit root is that it considers only one structural break in the series [116]. However, the CMR unit root test provides information about two unknown structural break points in the series by offering two models, namely, (i) innovational outliers (IO) and (ii) additive outliers (AO) [117]. The former indicates the gradual shift in the mean of the series, and the latter informs about a sudden change in the mean of a series. The results of the CMR unit root test are reported in Table 4.

Overall, the structural breaks relate to events of the national and international level. The period of 2008 attributed to the global financial crisis. The great global recession had not only adversely affected the countries with strong macroeconomics, but also economically weak countries like Pakistan. Pakistan enjoyed the double amount of FDI inflows in 2005 compared to the year 2004. The period of 2007 was associated with the highest weave of terrorist activities and fatalities in Pakistan. Similarly, the year 2007 is the witness of emergency in Pakistan, and the assassination of former prime ministers of Pakistan. The sample period of study from 2002 to 2008 was also linked

Table 2: Descriptive statistics.

	ln INN	VAA	ln TSM	ln INF	ln SAV
Mean	5.600	−0.889	6.666	2.804	3.116
Median	5.968	−0.843	7.000	2.800	3.090
Maximum	6.156	−0.672	8.156	2.973	3.337
Minimum	4.843	−1.174	4.843	2.639	2.810
Standard deviation	0.502	0.149	1.027	0.104	0.129
Skewness	−0.408	−0.642	−0.708	0.261	−0.140
Kurtosis	1.292	2.317	1.954	1.726	2.969
No. of observations	60	60	60	60	60

Table 3: Results of ADF, PP, DF-GLS, and KPSS unit root analysis.

	ADF	PP	DF-GLS	KPSS	ADF	PP	DF-GLS	KPSS
	Level				First difference			
	Trend + intercept				Trend + intercept			
Variables	*T*-stat	*T*-stat	*T*-stat	LM-stat	*T*-stat	*T*-stat	*T*-stat	LM-stat
ln INN	−1.552	−2.321	−1.614	0.155**	−7.170***	−4.733***	−3.386**	0.046
VAA	−2.844	−2.380	−2.858	0.184**	−3.583**	−4.340***	−3.726***	0.072
ln TSM	−1.432	−0.460	−1.720	0.300***	−3.695**	−4.408***	−3.308**	0.065
ln INF	−1.986	−1.522	−2.044	0.296***	−3.482**	−4.380***	−3.162**	0.077
ln SAV	−2.228	−1.847	−1.989	0.207**	−4.183***	−3.922**	−4.261***	0.113

Note. **and ***Significant levels at 5% and 1%.

Table 4: CMR structural break unit root test.

Variables	AO-model *T*-stat	TB1	TB2	IO-model *T*-stat	TB1	TB2	Results
Level							
ln INN	−3.948	2012Q3	2010Q3	−3.675	2013Q4	2010Q4	I(0)
VAA	−2.645	2007Q2	2004Q3	−2.639	2004Q2	2004Q4	I(0)
ln TSM	−3.815	2006Q1	2010Q4	−3.903	2005Q4	2012Q2	I(0)
ln INF	−3.178	2005Q1	2007Q2	−3.782	2010Q2	2007Q2	I(0)
ln SAV	−3.165	2009Q3	2009Q1	−3.252	2008Q4	2004Q1	I(0)
First difference							
ln INN	−5.847***	2010Q1	2008Q2	−5.782***	2010Q1	2009Q1	I(1)
VAA	−6.627***	2004Q2	2006Q1	−6.662***	2006Q1	2006Q2	I(1)
ln TSM	−5.598***	2007Q1	2005Q1	−5.510***	2007Q1	2005Q1	I(1)
ln INF	−6.609***	2008Q1	2007Q2	−8.190***	2008Q1	2008Q1	I(1)
ln SAV	−5.072***	2005Q1	2011Q1	−5.930***	2011Q1	2011Q3	I(1)

Note. ***Significant levels at 1%.

with military dictatorship having low voice and accountability practices. We incorporate some of the most important structural breaks in the econometric model and calculate the long- and short-run results of the ARDL approach to cointegration. The findings are reported in Table 5.

Further, to examine the impact of structural breaks identified by the CMR structural break unit root test, we developed three dummies (D1 2005, D2 2007, and D3 2008). We incorporate these dummies in the econometric model and calculate the long- and short-run results of the ARDL approach to cointegration. The findings are reported in Table 5. The findings reveal that all structural breaks have no effect in the long run. However, in the short run, we note that the structural break for dummy 2005 has a positive and significant impact, which may be due to higher FDI inflows in the said period. On the other hand, the break dummy for 2007 has a negative and significant impact. This adverse impact is most likely to be linked with higher terrorist activities, emergency in the country, and assassination of the former prime minister of Pakistan. Finally, the break dummy for 2008 has an adverse impact, which is most likely to be associated with global recession.

This study prefers to apply the ARDL approach to cointegration due to its several advantages over traditional cointegration approaches to investigate the long- and short-run relationship among variables. It is imperative to choose the appropriate lag length before applying the ARDL approach because the lag length is very sensitive to *F*-statistic. The lag length selection criteria was determined via the Akaike Information Criterion (AIC). Afterwards, the ARDL regressions were conducted for voice and accountability, terrorism, infrastructure, savings, and innovation to examine the significance of the *F*-statistic. Table 6 reports the computed value of the *F*-statistic. The computed value of the

Table 5: ARDL long- and short-run estimates with year dummy.

Variable	Coefficient	Standard error	T-statistic
Long-run estimates			
Constant	11.212	22.627	0.495
VAA	−8.901	3.669	−2.425**
ln TSM	−0.022	0.550	−0.041
ln INF	−4.372	3.674	−1.189
ln SAV	−0.675	2.982	−0.226
D1 2005	0.945	1.049	0.900
D2 2007	0.555	1.665	0.333
D3 2008	0.012	1.178	0.010
Short-run estimates			
Δln INN (−1)	0.878	0.077	11.3137***
VAA	−17.156	1.386	−12.3743***
ΔVAA(−1)	16.218	1.623	9.987***
ln TSM	−0.532	0.122	−4.340***
Δln TSM(−1)	0.440	0.129	3.414***
ln INF	−5.152	0.883	−5.833***
Δln INF(−1)	5.627	0.951	5.915***
ln SAV	−2.848	0.764	−3.727***
Δln SAV(−1)	2.569	0.827	3.105***
D1 2005	0.617	0.137	4.487***
Δ D1 2005	−0.671	0.157	−4.260***
D2 2007	−0.958	0.130	−7.360***
Δ D2 2007	0.897	0.152	5.886***
D3 2008	−0.497	0.132	3.754***
Δ D3 2008	−0.606	0.142	−4.251***
ECT(−1)	−0.138	0.023	−5.886***
R-square	0.978		
Adjusted R-square	0.963		
F-statistic	65.173		
Prob(F-statistic):	0.000		
Lag length selection criteria	AIC		
Bound testing cointegration analysis (F-statistic values)	3.12*		

Note. *, **, and ***Significant level at 10%, 5%, and 1%.

Table 6: Results of bound testing for the ARDL model.

Estimated model	ln INN = f(VAA, ln TSM, ln INF, ln SAV)	
Lag order	(4, 3, 5, 5, 5)	
F-statistic value	13.851	
Critical bound value		
Significance level	$I(0)$ bound	$I(1)$ bound
10% level	2.345	3.280
5% level	2.763	3.813
1% level	3.738	4.947

F-statistic is 13.851, higher than the UCB (4.947) and statistically significant at the level of 1%. It therefore, implies that a long-run relationship exists between innovation and its regressors.

According to the bound testing approach, VAA, ln TSM, ln INF, and ln SAV appear to be the long-run forcing variables to explain the ln innovation. The error correction term (Table 7) for equation (4) is ϕ = -0.323 and significant at 1%. It implies that long-run relationship exists between innovation and its regressors. The sign of ECT is negative and statistically significant, with a magnitude of 32%, which implies that 32% adjustments are made every year.

Table 7 reports the short-run and long-run results of the ARDL approach to cointegration. Regarding voice and accountability, results show that low voice and accountability has an adverse impact on innovation in both long run and short run. Practitioners report that policies which aim to enhance accountability procedures, reduce corruption, and improve political and civil rights are crucial to enhance innovation [47]. On the other hand, a report by scholars show that democratic rights and accountability in Pakistan and low voice and accountability portray a dismal picture in Pakistan [118, 119]. Governments in Pakistan are less accountable regarding their actions and policy choices. Departments and agencies that can hold accountable the government regarding policy choices of the government are also not much efficient and productive. Regarding Pakistan, it is reported that "an organization, such as the Accountability Bureau, serves more as the agents of the government in power than autonomous, nonpartisan" [119]. Low accountability and struggle over power often provoke people in the government to spin the law towards their own interests and (mis)use state institutions to reach political ends. Such practices undermine the quality of institutions and lead to loss of government exchequer and national and financial interests of a country. In the same manner, weak accountability leads towards corruption and corrupt practices,

Table 7: Long- and short-run estimates.

Variable	Coefficient	Standard error	T-statistic
Long-run estimates			
Constant	49.374	10.592	4.661***
VAA	−5.550	1.312	−4.229***
ln TSM	−0.594	0.235	−2.517***
ln INF	−8.433	1.597	−5.278***
ln SAV	−6.747	1.661	−4.061***
Short-run estimates			
Δln INN(−1)	0.244	0.084	2.910***
Δln INN(−2)	0.211	0.090	2.347**
Δln INN(−3)	0.127	0.065	1.953*
VAA	−7.293	1.415	−5.151***
ΔVAA(−1)	2.772	1.738	1.594
ΔVAA(−2)	2.730	1.746	1.563
ΔVAA(−3)	1.148	1.186	0.967
ΔVAA(−4)	3.355	1.061	3.161***
ln TSM	−0.838	0.113	−7.400***
Δln TSM(−1)	0.249	0.158	1.578
Δln TSM(−2)	0.231	0.152	1.517
ln INF	−3.023	0.921	−3.281***
Δln INF(−1)	1.653	1.033	1.599
Δln INF(−2)	1.630	1.061	1.535
Δln INF(−3)	0.661	0.878	0.752
Δln INF(−4)	2.758	0.846	3.257***
ln SAV	−5.149	0.700	−7.352***
Δln SAV(−1)	1.900	0.769	2.468***
Δln SAV(−2)	1.993	0.809	2.463**
Δln SAV(−3)	1.707	0.724	2.355**
Δln SAV(−4)	−2.350	0.712	−3.297***
ECT(−1)	−0.323	0.032	−9.897***

Note. *, **, and ***Significant level at 10%, 5%, and 1%.

Table 8: Model statistics and diagnostic tests.

ln INN = f(VAA, ln TSM, ln INF, ln SAV)	
R-square	0.981
Adjusted R-square	0.964
DW stat	1.59
F-statistic	56.866(0.000)
JB-normality test	4.813(0.100)
LM test (Breusch–Godfrey serial correlation)	1.006(0.379)
ARCH-heteroskedasticity test	0.011(0.918)
Breusch–Pagan–Godfrey-heteroskedasticity test	1.499(0.148)
Ramsey RESET test	0.718(0.404)

Note. P values are reported in parenthesis.

and corruption adversely affects innovation [51]. Weak practices of accountability lead to cronyism and favoritism of resources. Recent research showed that cronyism has an adverse impact on innovation [5]. Freedom of press and media is also restricted in Pakistan. Pakistan is ranked at the 142nd positions out of 180 countries regarding the freedom of press [120]. High regulations and control over media restrict the flow of information and have an adverse impact on innovation [46].

On military involvement in politics, Pakistan has swung between the civilian and military rule since its independence from Britain in 1947. According to Haq et al. [119], military in Pakistan has a great influence on civilians, political decision-making, and patronage. Pakistan has witnessed three coups, which caused discontinuation of business, economic, and financial policies. In 72 years of independence, military has ruled almost half of the period, and there is a common perception that Pakistani military has always an influential role and accused of meddling in Pakistan's politics. During a study related to Pakistan, Haq et al. [119] state that "the so called democratically elected government in power is centralized in the hand of a military dictator. Local government is weak with little administrative and financial authority." An unstable and uncertain political environment and the perceived threat of military coup can smudge the national image of the country globally. These conditions and uncertainties discourage domestic and international investors, multinational enterprises, firms, business communities, and entrepreneurs to not make investments in long-term projects in such countries. Resultantly, these circumstances adversely affect the innovation and growth opportunities of such economies.

The empirical results showed that terrorism has an adverse impact on innovation. Koh [39] stated that terrorism-related concerns decrease the rate of innovation. For instance, military expenditures increase in Pakistan due to terrorism [16], higher military spending, and counterterrorism cost crowd R&D investments [39, 77]. Naqvi [121] noted the limited role of R&D as a major obstacle to Pakistan's path to innovation. Pakistan is ranked at the 9th position in the fragile states index in 2006 [122]. Scarcity of resources do not allow fragile states (like Pakistan) to adopt or upgrade the costly but essential technologies to enhance their productivity level [123]. Technology transfer requires long-term projects in the shape of FDI inflows. Scholars report that FDI inflows are essential for Pakistan to enhance its technological development [15]. However, high country risk and terrorism-specific risks reduced the flow of investments, and investors are reluctant to invest in Pakistan [15, 124]. Several studies empirically proved that Pakistan has experienced a low pace of FDI due to terrorism [23, 125], and slow down of FDI inflows could decrease the transfer of technologies and impede technological advancement [39]. Besides, the aspect of brain drain has become the worst problem in Pakistan [126], which hinders its technological progress. Similarly, terrorist activities has resulted in massive destruction of the essential infrastructure [14], unproductive costs of 123.13 billion US $ [127], and loss of human capital in Pakistan. All these conditions have severely affected the pace of innovation in Pakistan.

Results revealed that inadequate infrastructure affects innovation in the short run and the long run. Pakistan exhibits poor infrastructure accompanied by lower budgetary allocation for the infrastructural development. Fewer resources do not allow fragile states such as Pakistan to invest adequately in infrastructural development. Lopez-Calix and Touqeer [124] reported the poor condition of infrastructure in Pakistan. Similarly, the government of Pakistan [128] acknowledged the inadequacy in infrastructure as a significant hindrance to the business growth. It is hit by a severe electricity crisis which affects various

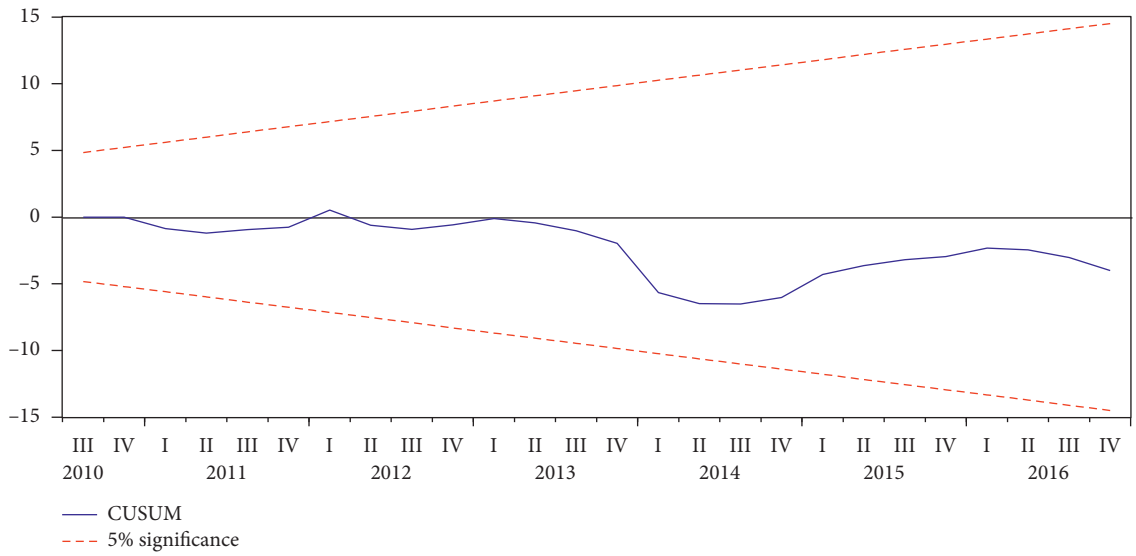

Figure 1: CUSUM.

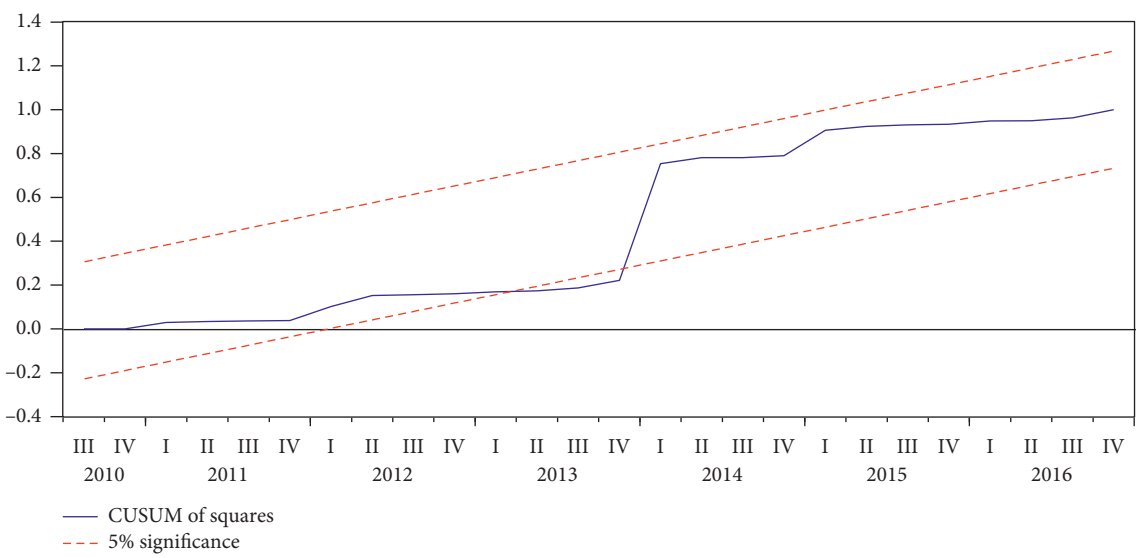

Figure 2: CUSUMq.

sectors of its economy including the textile sector, the second largest export sector. Besides, the condition of roads, highways, transport and logistics system, communication infrastructure, airports, ports, etc., are also not well developed. Scholars report that investment in infrastructure is essential for development and economic growth, and infrastructural constraints reduce business productivity by around 40 percent [26, 129]. A sound infrastructure helps to attract FDI inflows, modern industries/companies, entrepreneurs, and investors to invest in countries having adequate infrastructure because quality infrastructure helps to reduce the cost of doing business, such as operational cost, tariffs, and transportation cost [26]. On the other hand, inadequacy and low budgetary allocation in infrastructure hinder business, investment, entrepreneurial, and innovative activities in Pakistan.

Finally, low savings significantly have an adverse effect on innovation in short run and long run. Past studies report that domestic savings matter for innovation in developing countries [25, 91]. However, low savings is identified as a major constraint in the economic growth of Pakistan [124]. According to the latest available statistics with the World Bank [130], savings to the GDP ratio is 6.77% in Pakistan in 2017, which is at the lowest level from the last 32 years. In 1985, it was at 5.92%. Besides, low savings does not allow the countries like Pakistan to invest in capital, productive, R&D, and innovative projects. On the contrary, surplus savings allow countries like China to make investment in developed countries in the form of outward foreign direct investment (OFDI), which have a positive impact on innovation in the home country via the reverse spillover technology effect [92, 131].

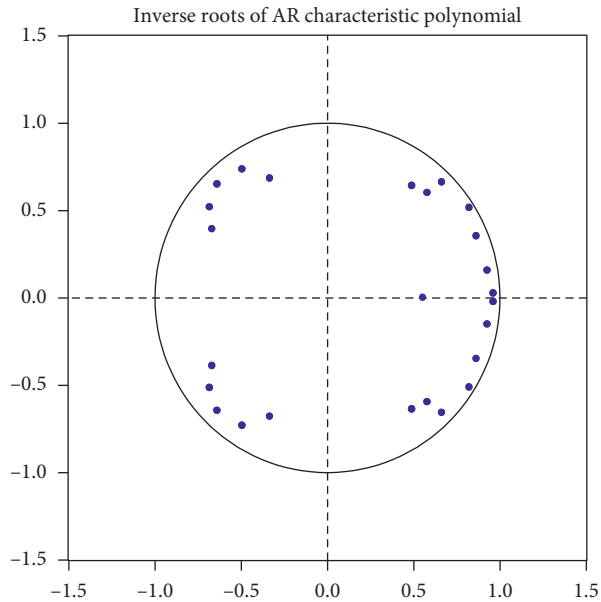

Figure 3: Inverse roots of the AR characteristic polynomial.

Table 9: Results of Johansen cointegration.

No. of coin. equ (s)	Trace test			Eigenvalue test		
	Trace statistic	0.05 CV	Prob.^{Y}	Max-eigen statistic	0.05 CV	Prob.^{Y}
None*	91.562	69.818	0.000	36.511	33.876	0.023
At most 1*	55.050	47.856	0.009	26.658	27.584	0.065
At most 2	28.392	29.797	0.071	15.226	21.131	0.273
At most 3	13.165	15.494	0.108	7.408	14.264	0.442
At most 4*	5.756	3.841	0.016	5.756	3.841	0.016

(i) Trace test (2 cointegrating eqns at the 0.05 level), (ii) Max-eigenvalue test (1 cointegrating eqn at the 0.05 level), (iii) X denotes the rejection of the null hypothesis at the 0.05 level, (iv) Y represents MacKinnon–Haug–Michelis (1999) P values, and (v) CV represents critical value.

Table 10: Maki cointegration results.

Regime	T-statistic	Break years
Level shift (break in intercept and without trend)	−13.645***	2014Q4
Level shift with trend (break in intercept and coefficients and without trend)	−13.634***	2002Q4
Regime shift (break in intercept and coefficients and with the trend)	−19.700***	2003Q2, 2004Q3, 2014Q1, 2015Q2
Regime shift with trend (break in intercept, coefficients and trend)	−15.890***	2008Q2, 2010Q1, 2011Q3, 2013Q2, 2015Q1

Note. ***Significance level at 1%.

Table 8 shows that the empirical model has passed the necessary requisite diagnostics tests. Similarly, the stability of the empirical model undergoes the test suggested by Brown et al. [132]. The findings of the CUSUM test indicate that the line stays within a 5% level of significance (Figure 1), which assures the stability of the model. Similarly, the CUSUM square test is also applied. The results of the CUSUM square are shown in Figure 2. We find that there is a little shock in the model during the period 2013Q2 to 2013Q4, thereafter the model is stable again. Therefore, the overall model is reliable.

Besides, this study applies the inverse roots of the characteristic equation associated with the ARDL to ensure the dynamic stability of the ARDL model. The results are presented in Figure 3. We noted that inverse roots lie inside the unit circle that confirms the dynamic stability of the ARDL model.

5.1. Robust Checks

5.1.1. Results of Johansen Cointegration Test. Following Nadeem et al. [24], the robustness of the ARDL long-run results is examined by applying the cointegration approach developed by Johansen and Juselius [107]. The results in Table 3 show that all the series are integrated at the first difference. As all the series are integrated at the first difference, it provides us an opportunity to make our results more robust. Therefore, we opt to apply Johansen's cointegration to ascertain the long-run relationship among

Table 11: DOLS, FMOLS, and CCR estimates.

Variable	Coefficient	Standard error	T-statistic
DOLS estimates			
Constant	30.944	6.696	4.620***
VAA	−0.437	0.647	−0.675
ln TSM	−0.506	0.167	−3.035***
ln INF	−4.403	0.834	−5.278***
ln SAV	−3.269	1.107	−2.953***
R-square: 0.732			
Adjusted R-square: 0.625			
FMOLS estimates			
Constant	17.357	6.123	2.834***
VAA	−2.964	0.720	−4.114***
ln TSM	−0.092	0.136	−0.677
ln INF	−2.732	0.999	−2.734***
ln SAV	−1.968	0.983	−2.002**
R-square: 0.335			
Adjusted R-square: 0.286			
CCR estimates			
Constant	18.768	6.671	2.813***
VAA	−2.279	0.761	−2.993***
ln TSM	−0.186	0.143	−1.298
ln INF	−2.796	1.076	−2.596***
ln SAV	−1.972	1.024	−1.925**
R-square: 0.357			
Adjusted R-square: 0.309			

Note. ** and ***Significant levels at 5% and 1%.

variables. Trace and eigenvalue tests are applied to confirm the cointegration equations. The cointegration equation(s) assures the existence of long-run relationship between variables. Table 9 shows the results of the trace and eigenvalue tests based on the Johansen cointegration approach. According to the trace and maximum eigenvalue test, the number of cointegration equations is two and one, respectively. Thus, these results confirm the long-run relationship among variables. Hence, the results of Johansen's cointegration support the results of the F-statistic.

5.1.2. Maki Cointegration Results. Maki cointegration is applied to examine the cointegration between innovation and its determinants with structural breaks. The findings of this cointegration are given in Table 10 suggesting the existence of cointegration relationship with structural breaks in all four models from equations (5) to (8). It implies that it confirms the existence of cointegration relationship among innovation, voice and accountability, terrorism, infrastructure, and savings at the level shift, level shift with trend, regime shift, and regime shift with trend.

5.1.3. Results of Dynamic Ordinary Least Square (DOLS), Fully Modified Ordinary Least Square (FMOLS), and CCR (Canonical Cointegration Regression). DOLS [133], FMOLS [106], and CCR [134] are then applied. The results of DOLS, FMOLS, and CCR are reported in Table 11. The results show that the coefficient of all variables retains the same sign (some variation in their magnitudes) as their ARDL counterpart. It is evident again that lower voice and accountability, terrorism, inadequate infrastructure, and low savings all impose an adverse impact on innovation. In case of DOLS, the impact of lower voice and accountability is negative but statistically insignificant. Also, according to FMOLS and CCR results, the impact of terrorism is negative but statistically insignificant. According to Nadeem et al. [24], contradictory results may be due to different backgrounds of econometric approaches. Thus, our results are robust to alternative estimation techniques.

6. Conclusion, Implications, Limitation, and Future Research Directions

By adopting the ARDL and Maki cointegration, as well as the data from 2002Q1 to 2016Q4, this study empirically investigated the impacts of voice and accountability, terrorism, infrastructure, and savings on innovation in Pakistan. The empirical results showed that low voice and accountability, high terrorism, inadequate infrastructure, and low savings have an adverse impact on innovation in the short and long run. Robust checks such as the Johansen cointegration test, dynamic ordinary least square, fully modified ordinary least square, and canonical cointegration regression corroborate the findings. This study does not claim that foreign and domestic investors, multinational enterprises, businesses, firms, and entrepreneurs always consider voice and accountability when planning to invest. This study is in the view that higher voice and accountability helps to enhance the quality of institutions and decision-making. Further, it increases community participation and decreases corruption and chances of undue intervention. All these conditions lead to strong institutional settings, continuity of policies, and better resource/fund utilization. Besides, they boost economic, business, entrepreneurial, and long-term investment opportunities and activities. Terrorism should be dealt with fair justice, equal distribution of wealth, better surveillance, coordination among various intelligence agencies at national and international level, and effective implementation of counterterrorism policies. Finally, this study suggests that sound infrastructural development and higher savings are essential for the economic development of a country and also deserved extensive government attention.

This study has significantly contributed to the innovation literature by investigating the relationship between voice and accountability, terrorism, and innovation, which was overlooked in the existing body of literature. The main contributions of this study are as follows: firstly, providing empirical support to the theoretical argument of Koh [39], who reported that terrorism can have an adverse impact on innovation. Secondly, it investigated the relationship between voice and accountability and innovation. The result showed that low voice and accountability had an adverse impact on innovation. Third, this study hypothesized the relationship between savings and innovation. Findings revealed that low savings are a hurdle in the innovation path. Finally, findings show that inadequacy in infrastructure has adverse impacts on innovation. This study fills the research gap by selecting appropriate and essential variables in an emerging economy context after 9/11 and applying the

econometric methodologies and robust checks that have not been previously employed in this particular research context of this laggard economy. Results of this study are significant contributions to the literature, and results offer new insights for future research and debate.

This study offers some policy implications. First, for capacity building at all levels, international efforts are needed to strengthen institutions in developing countries. For higher accountability, governments should provide an open climate where they remain accountable to different societal and interest groups regarding their policy matters. For this reason, it is essential for the government to ensure there is participation of citizens in decision-making process. Besides, both public-private and interfirm interaction should be encouraged to enhance the flow of information and knowledge and development of new technologies [5]. For greater accountability, it is evident that corruption cannot be curbed with the declaration of assets of politicians, government employees, or with the hollow slogans of accountability. It requires a strong will of the government to curb corruption.

Similarly, anticorruption departments should also stress the need to increase their investigation against corruption and corrupt practices further. Every corrupt individual should be tried fairly, and greater transparency is required to curb corruption. Essentially, the anticorruption departments playing a role as watchdogs must be free from political or other pressures to deliver fruitful results. Similarly, all institutions should work in their defined limits and should not interfere with others' rules of business. Finally, press and electronic media should also be free from any undue pressure. It is also the responsibility of the media to perform their duties ethically and professionally. Exaggeration of news may harm the national image and prestige of a country. Therefore, the electronic and print media are expected to play an effective and responsible role.

Secondly, our antiterrorism policy implications include three levels: terrorism, as a deep-rooted phenomenon, can be reduced through equal distribution of wealth, fair justice, and providing necessities of life to people. Secondly, law enforcement agencies must reinforce their surveillance, and coordination among various intelligence agencies must be strengthened to counter terrorism. Thirdly, the SDGs of the United Nations emphasize the vital role of peace to attain sustainable development. Terrorism is a global issue, so this study asserts that cooperation at the international level among intelligence and law enforcement agencies is essential to curb the malignant disease of terrorism.

Thirdly, infrastructure has a great importance for business and economic development and plays a vital role to attract domestic and foreign investors. In countries where infrastructural inadequacy exists, governments are needed to enhance the budgetary allocation of capital formation. China-Pakistan Economic Corridor (CPEC) can provide a great opportunity to grow business and investment activities in Pakistan. Pakistan can exploit CPEC opportunity as CPEC projects include roads and highways, railway networks, fiber optic cable, and industrial and energy projects. Moreover, the Gwadar deep seaport and the new Gwadar international airport can also be a great opportunity for Pakistan to boost its feeble economy. Improved infrastructure and higher business and economic activities in Gwadar will make it a business hub, which would also help to attract FDI inflows. This study suggests that Pakistan should put effort for early or timely completion of CPEC projects to cultivate the potential benefits of CPEC. Besides, the upgradation and maintenance of the existing infrastructure are equally important.

Finally, countries with low savings must put effort to enhance their savings. Such countries should try to increase savings by utilizing effective, efficient, and emergent measures. According to Lopez-Calix and Touqeer [124], Pakistan's tax revenue is the lowest in the world. Some possible reasons of low savings in Pakistan are low tax revenues, high nondevelopment recurring expenditures, and unnecessary subsidies and reliefs to achieve their political motives. Pakistan and similar other laggard countries are required to utilize maximum funds in development and research oriented projects instead of providing unnecessary subsidies and reliefs. Tax authorities should devote their efforts to bring the majority of people under the tax net. Besides, tax evasion in businesses and firms and corruption in tax departments should be controlled. It can be achieved through penalizing the culprits and offering incentives to dedicated and honest officers and officials. Furthermore, tax evasion can be controlled by utilizing effective and efficient measures and by means of strong coordination and liaison among related departments. Also, governments are required to introduce new financial products and tools and promote the savings culture, which would also be beneficial to increase the savings.

This study has some limitations, which provide opportunities for future research. Future studies can extend this study in the following directions. First, constraints of data restricted us to apply the CMR structural break unit root test dealing with two structural breaks in the series. Upon availability of longer time series data, we should apply Carrion-i-Silvestre et al.'s [135] test which is more suitable and deals up to five structural breaks stemming in the series for examining the integrating properties of the variables. Similarly, future research can be conducted on the running issue by applying the NARDL bounds testing approach to examine the nonlinear effect of voice and accountability, terrorism, infrastructure, and savings on innovation. Secondly, for examining extent and direction of effects of independent variables on the dependent variable, the innovative accounting approach (variance decomposition and impulse response function) is more suitable for reliable empirical results.

Thirdly, future studies can explore other noneconomic factors, which may have a positive or negative impact on innovation. Besides, healthy governance structures are the life lines for any country and crucial for long-term economic growth and development. So, future studies can investigate the separate effect of each governance indicator on innovation and can compare the results and observe the difference. Fourthly, future research may consider terrorist attacks/number of injuries as an indicator to measure

terrorism instead of the number of causalities. Similarly, they can consider domestic and transactional terrorism. Finally, although time series analysis provides fruitful results and important for policy formulation, the generalizability of findings is limited. At the same time, researchers such as Castellaci et al. [27] report that econometric models seek for more general results which are valid for large sample of statistical units (firms/sectors/regions/countries), but the process behind each units' performance remains unexplained. Every econometric methodology has its own advantages and limitations; however, future scholars are encouraged to consider the panel dataset.

Data Availability

Data used in this study are publically available, and all the data sources are mentioned. The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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