ISSN 2090-3359 (Print)
ISSN 2090-3367 (Online)

ΑΔΣ

Advances in Decision Sciences

Volume 26
Special Issue in Honour of Michael McAleer
2022 - 2023

亞洲大學
ASIA UNIVERSITY

Published by Asia University, Taiwan

Analyzing The Impacts of Terrorism on Innovation Activity: A Cross-Country Empirical Study

Bisharat Hussain Chang
Department of Business Administration,
Sukkur IBA University, Sukkur, Pakistan
**Corresponding Author* Email: bisharat.chang86@gmail.com

Khalil Ahmed Channa
Department of Business Administration,
Sukkur IBA University, Sukkur, Pakistan
Email: khalilchanna@iba-suk.edu.pk

Emmanuel Uche
Department of Economics,
Abia State University, Uturu, Nigeria.
School of Economics,
College of Business and Economics,
University of Johannesburg, South Africa.
Email: uche.emmanuel@abiastateuniversity.edu.ng

Osamah Ibrahim Khalaf
Department of Solar, Al-Nahrain Research Center for Renewable Energy,
Al-Nahrain University, Jadriya, Baghdad, Iraq
Email: usama81818@nahrainuniv.edu.iq

Waheed Ali
Department of Management Sciences
SZABIST Larkana, Larkana, Pakistan
Email: waheed.ali@lrk.szabist.edu.pk

Received: June 7, 2023; First Revision: July 10, 2023;

Last Revision: July 18, 2023; Accepted: July 19, 2023;

Published: July 22, 2023

Abstract

Purpose: Many studies have analyzed the impact of terrorism on economic growth, but the terrorism-innovation nexus is very rare in academic literature. Hence, this study aims to theoretically and empirically examine the effect of terrorism on innovation activity.

Study design/methodology/approach: We employ OLS, system GMM, and quantile regression on a panel dataset of 31 economies for 1990-2022.

Findings: The study's findings indicate that terrorism negatively and significantly impacts innovation activity. Various robustness checks further support the results of this study. Moreover, the study findings also identify possible channels, such as domestic investment, foreign direct investment, and trade openness, through which terrorism affects innovation activity.

Originality/value: The outcomes of this study will not only provide policy recommendations for sustainable national innovation and offer a better understanding of the subject matter.

Keywords: Terrorism, innovation activity, Panel data, OLS, System GMM, Quantile regression

JEL Classfication: O31, O33, H65, F51, C33

1. Introduction

The definition of terrorism is often ambiguous in economics and legal studies literature. The United Nations Security Council defines terrorism as a criminal act against civilians that causes death, acute injuries, and property damage. According to the Global Terrorism Index, terrorism refers to an offense, violence, or illegal use of force by non-state actors to achieve political, social, economic, or religious goals through pressure, fear, and coercion. The distinction between common crime and terrorism is also unclear, as some terrorists often commit kidnapping, drug trafficking, and blackmail. In general, terrorism refers to any activity that harms a country's economy and damages its human and physical capital (Chang, 2020; Noman et al., 2023; Collier, 1999).

Peace and security are essential for economic growth and sustainable development. Terrorism is a prominent issue, with numerous researchers investigating its effects, determinants, and consequences. Many academic studies have found that terrorism negatively impacts macroeconomic variables such as investment, consumption, and government development expenditures (Gohar, et al., 2022b, 2022c; Gaibulloev & Sandler, 2008; Crain & Crain, 2006). Specifically, terrorism reduces foreign direct investment, tourism, output, economic growth, and trade while increasing security costs and insurance premiums (Chang et al., 2022a, 2022b; Maydybura, et al., 2022; Keefer & Loayza, 2008). Terrorism creates uncertainty, which leads to a reduction in short- and long-term public and private investment projects. Governments often increase spending on security at the expense of public spending on education and infrastructure, negatively affecting economic growth (Bird, Blomberg & Hess, 2008). Additionally, terrorism deteriorates physical capital and reduces trade flows due to risk and lower returns on investment (Abadie & Gardeazabal, 2008). Terrorist attacks create uncertainty and increase insecurity for investors, leading to economic distortion and inefficiencies (Chang et al., 2018, 2020a, 2020b; Brück, 2006; Tufail, 2010).

In addition, terrorist attacks also increase insurance premiums, which, in turn, raises business costs. As the frequency of terrorist attacks rises, insurance companies perceive a higher potential risk of terrorism and subsequently increase insurance premiums. The aviation sector is particularly affected by this increase in insurance premiums, but other industries, such as tourism, construction, energy generation, and transportation sectors, are also impacted. Companies that invest in sensitive areas, such as electricity transmission lines, power stations, chemical plants, and oil and gas pipelines, face more significant security risks. The heightened security risk in these sectors leads to lower business profitability due to higher insurance costs.

There is a lack of research on the relationship between terrorism and innovation in academic literature. However, some scholars have analyzed the impact of terrorism on innovation from various perspectives. Terrorism requires a country to divert its budget from public spending to security-related expenses, reducing economic productivity. Trade openness and foreign direct investment (FDI) are critical for transmitting technology and innovation from one country to another. Terrorism increases trade costs, such as high airfreight, prolonged customs clearance processes, and restrictions on terrorism-affected countries. Terrorism also reduces domestic and foreign direct investments, crucial for economic growth, knowledge transfer, and technology diffusion, hindering innovation activities in a host country. Controlled and restricted immigration systems reduce the smooth flow of labor and technical experts, hindering the participation of foreign talent in technological innovation and research.

Although limited studies have examined the influence of terrorism on innovation, none have provided empirical evidence. Therefore, this study aims to analyze the impact of terrorism on innovation activity through theoretical and empirical analysis. This study also identifies the channels through which terrorism affects innovation in selected countries. The study has the following objectives.

- To address the lack of theoretical and empirical research on the relationship between terrorism and innovation.
- To identify the various channels through which terrorism can impact innovation activity.
- To provide policy recommendations based on the study's findings to promote sustainable innovation activity.

2. Literature Review and Hypotheses of the Study

The Global Terrorism Index defines terrorism as using illegal force, violence, or offense by non-state individuals to achieve political, social, economic, or religious goals through coercion, fear, or pressure. The distinction between common crime and terrorism is often unclear because terrorist organizations can also engage in criminal activities such as kidnapping, drug trafficking, and extortion.

Terrorism and its impacts have been widely discussed in existing literature, especially after the 9/11 attacks in the USA. Terrorism has become a major global issue since then, and its domestic and international forms can have negative social and economic effects on society. In certain situations, terrorism can be used as a political tool by local or international opponents to harm other countries (Gohar et al., 2022d; Wang et al., 2022; Sandler & Enders, 2002).

Terrorism can cause various economic damages, including reduced capital flows, declining foreign direct investment, destruction of infrastructure, reduced trade and tourism, decreased economic growth, and increased security costs (Keefer & Loayza, 2008; Gaibulloev & Sandler, 2008).

Several studies have examined the macroeconomic consequences of terrorism and found that it negatively impacts public spending, investment, and consumption (Crain & Crain, 2006; Bird et al., 2008). Ali et al. (2022), Uche et al. (2022a), and Daniel and Thomas (2013) investigated the causal link between terrorism and economic growth. They found that during the Cold War era, terrorism was unidirectional in its impact on growth, while in the post-Cold War era, growth was unilaterally caused by terrorism.

Since the 9/11 attacks, terrorist incidents have resulted in a slower investment rate from developed to developing economies due to increased risks. Additionally, heightened border controls have discouraged cross-border investors.

2.1 Terrorism and Innovation Activity

Innovation activity depends on several factors, including investment in research and development (R&D), R&D personnel, and a peaceful environment. Developed economies tend to be more innovative than developing economies due to their higher investment in R&D, which is a crucial input for innovation. Foreign direct investment (FDI) and trade openness are vital in transferring technology and knowledge to the host country. However, terrorism has been found to negatively impact economic growth and reduce innovation activities. The rise of terrorist incidents leads to increased public spending on security measures and private companies investing more in private security to secure their investments. This results in increased investment costs, which directly affects the rate of innovation by reducing productive investments by both the government and the private sector.

Additionally, the "war on terror" can force governments to shift their investments from public spending to security matters, which may increase the demand for capital and increase interest rates which, in turn, can raise the cost of R&D investment, negatively impact innovation rates (Chang and Rajput, 2018; Peng et al., 2022; Koh, 2007). Terrorism incidents can also affect domestic investment, causing uncertainty and decreased capital accumulation. With limited capital, governments may allocate more of their budget towards necessities, further reducing a country's innovation activities as shown in the following hypothesis:

H1: Terrorism reduces innovation activity

2.2 Theoretical Mechanism

Terrorism affects innovation activity through the following channels: (1) domestic investment, (2) FDI, and (3) trade openness.

2.2.1. Terrorism and domestic investment

The existing literature indicates that investment stimulates innovation activities, particularly investment in R&D, whether private or public. Such investment increases the number of patents and trademarks. However, investors always require a safe and peaceful environment and developed infrastructure such as roads, railways, and telecommunication facilities. Terrorism incidents discourage domestic investment, increasing the cost of capital due to higher investment risks which, in turn, reduces capital accumulation in the country. Additionally, due to the rise in terrorism incidents, public development funds are often allocated to security-related matters, leaving private investors with an unfavorable investment environment (Eckstein & Tsiddon, 2004; Persitz, 2007; Llussa' & Tavares, 2011).

Terrorism incidents increase uncertainty in a country, reducing short-term and long-term public and private investment projects (Hashmi & Chang, 2021; Uche et al., 2022b; Gaibulloev & Sandler, 2008). Moreover, terrorism also deteriorates physical capital, reduces trade flows, and lowers returns on investment due to high-risk elements (Gohar et al., 2022a, 2023; Abadie & Gardeazabal, 2008). Terrorist attacks are a type of risk that creates uncertainty (Brück, 2006), leading to increased insecurity for investors (Tufail, 2010) which, in turn, leads to economic distortion and inefficiencies. As a result, the rise in terrorism incidents decreases domestic investment, which reduces innovation activity as shown in the following hypotheses:

H2a: Domestic investment increases innovation activity,

H2b: Terrorist activities decrease domestic investment.

2.2.2. Terrorism and Foreign Direct Investment

FDI boosts capital accumulation, employment, and technology transfer, among other economic benefits. Despite having more natural resources, most developing nations need help to generate high-tech products; as a result, these nations look to FDI for knowledge transfer. According to Cheung and Lin (2004), developing nations primarily attract FDI to acquire new technology, skilled workforce, and other reverse engineering procedures. High-tech products produced by MNCs have the potential to boost global market competition. Additionally, MNCs invest more in R&D, which generates the newest concepts, production techniques, and processes, fostering innovation and technical growth in the host nation (Zhang, 2014; Grossman & Helpman, 1991).

FDI has emerged as an innovation stimulator; however, terrorism decreases FDI, indirectly reducing innovation activities. Terrorism increases risk, leading to declining FDI (Abadie et al., 2008; Filer & Stanisic, 2016; Bandyopadhyay et al., 2013). Chang et al. (2019a; 2019b) and Blomberg and Mody's (2005) study concluded that violence in any form affects FDI inflows, but the influence is different in developing and developed countries. Terrorism incidents increase the cost of security, insurance, and doing business, as well as uncertainty, which affects overall FDI inflows in the host country (Xue et al., 2023a, 2023b; Dash et al., 2023) as shown in the following hypotheses:

H3 a: FDI increases innovation activity,

H3 b: Terrorism hurts foreign direct investment.

2.2.3. Terrorism and Trade Openness

Some argue that trade openness is the main driver of domestic and global innovation. Opening up to trade enhances competitiveness, pushing businesses to adopt cutting-edge technology and innovation to keep up with market demands. By being open and acquiring a broad knowledge base, developing economies can benefit from technology transfer, which increases their internal output. This practice is accelerated by international trade, which acts as the primary channel for disseminating modern technology and establishes the integration of global knowledge into domestic production processes. These efforts can help improve the quality of the market's supply chain, create cutting-edge products and services, and increase competition in the current business climate (Wacziarg, 2002; Xue et al., 2023c, 2023d).

In addition, terrorism affects various macroeconomic variables, including trade openness. Trade between countries requires a risk-free environment and a secure goods and services supply chain. Terrorist attacks are a risk that creates uncertainty (Derindag et al., 2023a, 2023b; Brück, 2006) and increase security costs and insurance premiums (Keefer & Loayza, 2008). As a result, due to terrorism, trade costs increase, ultimately reducing trade volume between countries. Trade openness promotes innovation, but terrorism reduces trade openness, leading us to develop the following hypotheses:

H4a: Trade openness increases innovation activity,

H4b: Terrorism hurts trade openness.

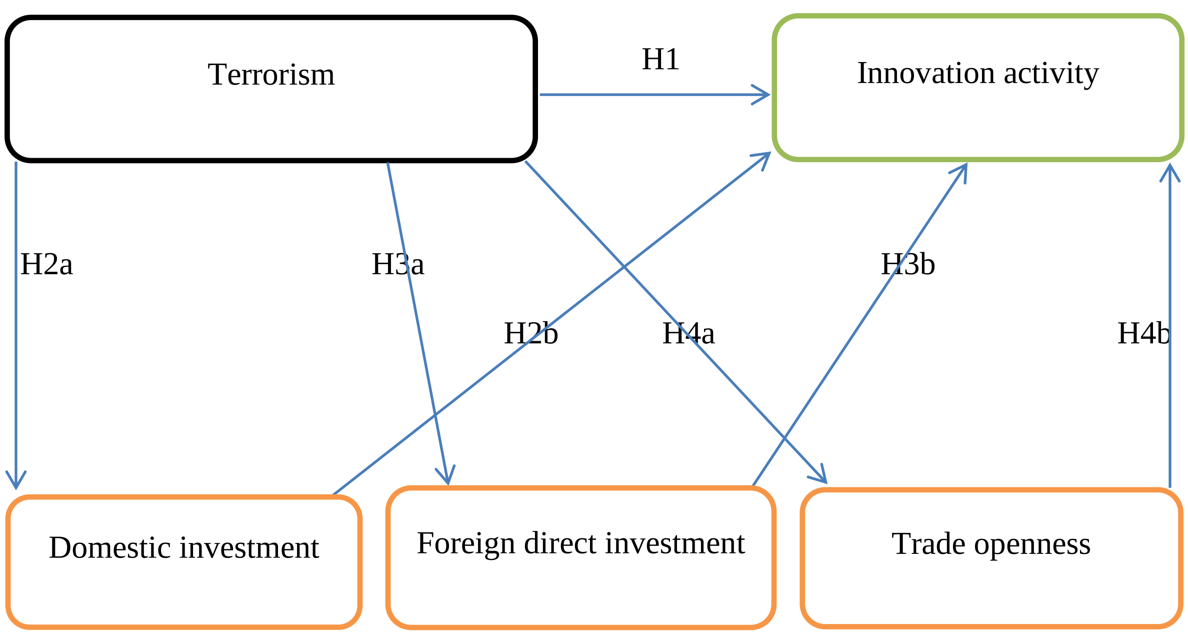

Figure 1: Conceptual mechanism

3. Methodology

In this section, we outline our basic model, describe the estimation techniques used to conduct our analysis and present the data on related variables and their sources.

3.1. Empirical model

3.1.1. Basic model

Benchmark model is given below:

$$Inv_{i,t} = \beta_1 + \beta_2 TTR_{i,t} + \beta_3 POP_{i,t} + \beta_4 INDUST_{i,t} + \beta_5 TO + \beta_6 HTX_{i,t} + \beta_7 TCG_{i,t} + \beta 8 EDU_{i,t} + \varepsilon_{i,t} \quad (1)$$

The measure of innovation t, denoted by $Inv_{i,t}$, is indicated by the number of resident and non-resident patents and trademarks in the nation i at the time. TCG represents technical cooperation grants, HTX stands for high technology exports, TO denotes trade openness, INDUST stands for the share of the manufacturing sector, and EDU represents secondary education. The error term is denoted by $\varepsilon_{i,t}$. We used a simple ordinary least squares (OLS) method to estimate our basic model. The variables used in Equation 1 are in line with the study of Syed et al. (2019) Hashmi et al. (2021a, 2021b, 2022), Uddin et al. (2022), and Zakeria et al. (2019).

3.1.2. System GMM Estimation

System Generalized Method of Moments (GMM) is a commonly used technique to handle endogeneity issues in panel data. The basic model for GMM estimation is presented below:

$$Y_{i,t} = \beta_1 Y_{i,t-1} + \alpha_1 X_{i,t} + \alpha' X + \sigma_i + v_t + u_{i,t} \quad (2)$$

The explained variable $Y_{i,t}$ in the equation represents innovation, measured as the total count of patents held by residents and non-residents and the number of trademarks in a specific country i at a given time t. The dependent variable also includes the lag of the explained variable, denoted as $Y_{i,t-1}$. The main independent variable is terrorism, which we measure as the total number of casualties and injuries resulting from terrorist activities in a specific country during a specific period. We also include control variables denoted as X, unobservable country-specific effect as σ_i, common time effect as v_t , and the idiosyncratic error term is represented as $u_{i,t}$.

We estimate Equation 2 using the Generalized Method of Moments (GMM) approach. To account for persistent data series, we use the two-system GMM estimator proposed by Blundell and Bond (1998), which is more efficient than difference GMM and is robust to autocorrelation and heteroskedasticity. We follow the methods used by Chang et al. (2020c), Derindag et al. (2022), Roper and Hewitt-Dundas (2015), Hsu et al. (2014), Wang et al. (2019), and Pradhan et al. (2018).

3.1.3. Panel Quantile estimation

The GMM estimator is widely employed as an empirical tool to estimate the impact of technical innovation, mainly due to the endogeneity problem. However, the empirical distribution of patent or trademark data makes existing GMM estimators practically unfeasible. Earlier methods simply summarized the average association between terrorism and technological progress using conditional mean functions under the assumption of normality. However, this approach only provides a partial picture of the relationship between the controlled factors, particularly when the data is concentrated at different points along the conditional distribution of the outcome variable. Quantile regression can address this issue by outlining the complete distribution of the dependent variables provided (Koenker & Bassett, 1978). Thus, we used quantile regression to further explore the influence of terrorism on innovation.

We followed Koenker and Bassett's (1978) method, and the basic model of panel quantile regression is provided below:

$$Q_\tau\left(Inov_{i,t}\middle|X_{i,t}\right) = \beta(\tau)X_{i,t} + \upsilon_{i,t} \tag{3}$$

In the equation, the subscript i represents the country and the subscript t represents the period. The symbol Q_τ represents the quantile, and $\beta(\tau)$ represents the parameter of interest, which varies with the quantile τ. The dependent variable is represented by $Q_\tau\left(Inov_{i,t}\middle|X_{i,t}\right)$ while the explanatory variables are included in the vector $X_{i,t}$ which includes terrorism. The error term is denoted by $\upsilon_{i,t}$.

3.1.4. Empirical Models of Mechanism Analysis

3.1.4.1. Channel 1: Domestic Investment

The mathematical model for domestic investment in channel one is given below:

$$Inov_{i,t} = \beta_1 Inov_{i,t-1} + \beta_2 GFCF_{i,t} + \beta_3 FDI_{i,t} + \beta_4 HTX_{i,t} + \beta_5 TCG + \beta_6 RGDP_{i,t} + \beta_7 TO_{i,t} + \beta_8 STP_{i,t} + \sigma_i + v_t + \varepsilon_{i,t} \tag{4}$$

$$GFCF_{i,t} = \beta_1 GFCF_{i,t-1} + \beta_2 TTR_{i,t} + \beta_3 TO_{i,t} + \beta_4 ER_{i,t} + \beta_5 FD + \beta_6 INF_{i,t} + \sigma_i + v_t + \varepsilon_{i,t} \tag{5}$$

The variable $Inov_{i,t}$ represents the dependent variable and measures innovation activity, which is scaled by the total number of patents (for residents and non-residents) and the number of trademarks in Country i at time t. GFCF (gross fixed capital formation) is used as a proxy for domestic investment, while FDI (foreign direct investment) represents foreign investment. HTX (high technology export) and TCG (technical cooperation grants) are additional independent variables. RGDP (real GDP), TO (trade openness), and STP (number of scientific and technical papers) are also included as independent variables. TTR (terrorism) is the main variable of interest, while ER (exchange rate) and INF (inflation rate) are control variables. FD (financial development) is also included, and we use domestic private credit as a proxy for financial development. $\sigma_i\sigma_i$ represents unobservable country-specific effects, v_t represents the common time effect, and $\varepsilon_{i,t}$ is the error term. Variables used in Equations 4 and 5 are in line with the studies of Piscitello & Thakur-Wernz (2023), Siddique (2017), Persitz, (2007), and Mehmood & Mehmood (2016).

3.1.4.2. Channel 2 Foreign Direct Investment

Foreign direct investment (FDI) is a crucial means of technology diffusion from one country to another. Consequently, FDI promotes capital accumulation and innovation in the host country. Cheung and Lin (2004) argue that FDI is attractive to developing nations because it facilitates acquiring new technology, skilled personnel, and other forms of reverse engineering. Multinational corporations (MNCs) are responsible for transferring technology to the host country (Javorcik, 2004; Borensztein et al., 1998). However, research has shown that terrorism reduces FDI inflows, thus negatively affecting innovation activity. Terrorism increases risk, resulting in declining FDI inflows (Abadie et al., 2008). The mathematical model for domestic investment, which represents one channel through which terrorism affects innovation activity, is given below:

$$Inov_{i,t} = \beta_1 Inov_{i,t-1} + \beta_2 FDI_{i,t} + \beta_3 RGDP_{i,t} + \beta_4 TO_{i,t} + \beta_5 POP + \beta_6 TCG_{i,t} + \beta_7 FD_{i,t} + \sigma_i + v_t + \varepsilon_{i,t} \quad (6)$$

$$FDI_{i,t} = \beta_1 FDI_{i,t-1} + \beta_2 TTR_{i,t} + \beta_3 INF_{i,t} + \beta_4 RGDP_{i,t} + \beta_5 FD + \beta_6 INC_{i,t} + \beta_7 ER_{i,t} + \sigma_i + v_t + \varepsilon_{i,t} \quad (7)$$

The dependent variable, $Inov_{i,t}$, represents innovation and is measured by the total number of patents granted to residents and non-residents and the number of trademarks registered in country i at time t. FDI stands for foreign direct investment, RGDP is real GDP, TO is trade openness, POP represents the population, TCG is technical cooperation grant, TTR represents terrorism, ER is the exchange rate, INF is inflation, and INC is income. We used domestic private credit as a proxy for financial development (FD). Σi represents the unobservable country-specific effects, while the common time effects are denoted by v_t. The error term is $\varepsilon_{i,t}$. These variables are matching with the studies of Cheung and Ping (2004), Chen et al. (2022), Farooq (2014), and Ukwueze et al. (2019).

3.1.4.3. Channel 3 Trade Openness

Trade openness is important in promoting innovation activity, as it increases competition and encourages firms to adopt innovative practices. However, terrorism can reduce trade openness by increasing risks and trade costs. Therefore, we believe that trade openness can be considered a channel through which terrorism affects innovation activity. The mathematical model for the impact of terrorism on trade openness can be represented as follows:

$$Inov_{i,t} = \beta_1 Inov_{i,t-1} + \beta_2 TO_{i,t} + \beta_3 TCG_{i,t} + \beta_4 R\&D_{i,t} + \beta_5 POP + \beta_6 INDUST_{i,t} + \sigma_i + v_t + \varepsilon_{i,t} \quad (8)$$

$$TO_{i,t} = \beta_1 TO_{i,t-1} + \beta_2 TTR_{i,t} + \beta_3 ER_{i,t} + \beta_4 INF_{i,t} + \beta_5 FD + \beta_6 FDI_{i,t} + \beta_7 POP + \sigma_i + v_t + \varepsilon_{i,t} \quad (9)$$

in which $Inov_{i,t}$ is the explained variable that represents innovation, which is scaled by the total patent counts of residents and non-residents and the number of trademarks in country i at time t. FDI refers to foreign direct investment, TO is trade openness, POP is population density, TCG represents technical cooperation grants, TTR represents terrorism, ER is the exchange rate, and INDUST is the share of the manufacturing industry. R&D refers to research and development expenditure, while INF is the inflation rate. σ_i represents unobservable country-specific effects, v_t represents the common time effect, and $\varepsilon_{i,t}$ is the error term. Variables used in Equations 8 and 9 are similar to the studies of Wacziarg, (2002), Malik & Zaman (2013), Mirza & Verdier (2008), and Dotta & Munyo(2019).

3.2. Data and variables

For the empirical analysis in this study, we utilized annual data spanning from 1990 to 2022 for 31 countries. We selected these countries based on data availability for innovation and terrorism variables. All the variables, except terrorism, were obtained from the World Bank Development Indicators (WDI). The data on terrorism was obtained from the Global Terrorism Database (GTD). The details of all variables are provided below:

3.2.1. Dependent variables

In the field of innovation and technological advancement, patents and trademarks have been widely used as reliable indicators of national innovation, according to numerous studies by Griliches (1990), Jalles (2010), Hsu et al. (2014), Roper and Hewitt-Dundas (2015), Wang et al. (2019), and Wen et al. (2018). In this study, we also use patents and trademarks as our dependent variables in the core regression. Patents refer to the legal protection of an invention, where the applicant is granted sole ownership of the technology or invention for a specific period after inspection and approval by the state's regulatory body. Patent applications for intermediate outputs reflect technological innovation more accurately since they represent the embodiment of resource input and efficiency (Hsu et al., 2014; Jalles, 2010). Trademarks, conversely, are used to distinguish the goods or services of one company from another. They are more closely associated with commercialization than patents and cover a broader range of activities, including products and services (Nie and Su, 2022; Sabir et al., 2019; Tu et al., 2023; Vy, Luu and Wong, 2023; Graham & Hancock, 2014). In service-intensive economies, trademarks are particularly important as they often contain significant advances that traditional R&D and patents cannot duplicate (Hai Yen et al., 2022; Jaiswal, Gupta, and Tiwari, 2022; Wang, et al., 2023; Wong, Thompson, and Teh, 2010, Millot, 2009). Hence, in our fundamental regression, we include data on patents and trademarks based on relevant literature.

3.2.2. Independent variable

In this study, terrorism was considered a key independent variable, and the data for terrorism was obtained from the Global Terrorism Database (GTD) established by LaFree & Dugan (2007). The GTD provides data on domestic and international terrorism and includes information on the frequency and severity of terrorist incidents, such as the number of deaths, injuries, and property damage. Various studies have used different proxies for terrorism; for example, Zakeria et al. (2019) used the number of deaths per year as a proxy for terrorism, Kumar et al. (2019) used the number of killed, injured, and property damage as a proxy, and Fareed et al. (2018) used the total number of terrorism incidents per year as a proxy. In this study, we used terrorism intensity, which measures the sum of deaths and injuries resulting from terrorist attacks per year, as a proxy for terrorism.

3.2.3. Other control variables

In our main regression, we included several control variables, such as population, manufacturing industry share, trade openness, secondary education, high technology export, and technology cooperation grant. As for the channel variables, we used domestic and foreign direct investments (FDI), where gross fixed capital formation served as a proxy for domestic investment. In the channel regressions, we included additional control variables such as inflation, real GDP, financial development, income, exchange rate, number of scientific articles, and population density. We took the natural logarithm of all variables. The data for all the mentioned variables were obtained from the World Bank Development Indicators (WDI).

3.2.4. Descriptive statistics

Table 1 provides a data description of the variables used in the study. The results indicate that the average number of patents for all selected countries is 8.02, with a standard deviation of 1.98. The average for trademarks is 9.96, with an SD of 1.29. It suggests that, on average, trademark counts are higher than patent counts in our data, and the variability of trademark counts is lower than that of patents across our selected countries. Additionally, the mean of terrorism for our chosen countries is 4.20, with a standard deviation of 2.26.

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Patents	821	8.023341	1.989512	3.332205	14.13875
Trademarks	791	9.961113	1.294277	6.568078	14.55955
Terrorism	750	4.202081	2.260756	0.000	9.879349
Population	868	17.76173	1.337499	15.07226	21.05257
Trade openness	862	-0.6396	0.555361	-6.60765	0.815096
Industry	795	2.766459	0.331397	1.979095	3.924657
Technical cooperation grant	607	18.62511	1.231828	9.903487	20.82816
High tech export	807	1.695421	1.554353	-6.62484	4.317416
Education	719	4.383879	0.309209	3.04015	4.839372
Domestic Investment	863	24.73305	1.778069	18.01318	29.27389

FDI	824	0.369195	1.281178	-7.52394	4.392628
Real GPD	868	8.822411	1.320725	6.018995	11.18103
Exchange rate	745	3.106582	2.783631	-5.94879	10.4111
Inflation	789	1.6258	1.222355	-4.79078	8.92021
Income	853	8.311778	1.427475	5.100866	10.84904
Financial development	767	3.726944	0.805914	1.19507	5.331128
Population density	868	4.394739	1.11217	2.021771	7.112027

4. Empirical Results

4.1. Primary findings

The results of our basic regression are presented in Table 2, where we employed a simple OLS estimation. The findings indicate that terrorism significantly negatively impacts both patent counts and trademarks.

Table 2: Results of OLS estimator for the impact of terrorism on innovation activity

	PATENT			TRADE MARK		
Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Terrorism	-.208*** (.030)	-.104*** (.025)	-.053** (.024)	-.121*** (.019)	-.083*** (.017)	-.083*** (.022)
Population	.965*** (.060)	.879*** (.047)	.929*** (.047)	.693*** (.033)	.660*** (.030)	.783*** (.033)
Industry	.029 (.175)	-.344** (.162)	-.027 (.169)	-.270** (.111)	-.328*** (.111)	-.238* (.123)
Trade openness		-.225** (.103)	-.028 (.085)		-.126 (.077)	-.080 (.079)
High-tech export		.669*** (.032)	.395*** (.040)		.286*** (.025)	.096** (.039)
Technical cooperation grant			-.180*** (.064)			-.176* (.070)
Education			1.675*** (.191)			1.346*** (.194)
Constant	-8.421*** (1.016)	-7.516*** (.834)	-13.129*** (1.755)	-1.152* (.656)	-1.125* (.604)	-5.722*** (2.02)
Observation	649	713	333	631	597	325
R^2	0.34	0.62	0.69	0.40	0.53	0.58

Note: The regressions were estimated using the OLS estimator with data from 31 economies between 1990 and 2022. Parentheses report robust standard errors (RSE). Significance levels are denoted at 10% = *, 5% = **, and 1% = ***.

In Table 2, Models 1 to 3 represent the dependent variable as patents; however, the dependent variable is a trademark from models 4 to 6. As shown in Table 2, the empirical findings in Model

1 show that terrorism significantly reduces the number of patents with a coefficient of -0.20 at a 1% significance level. Similarly, models 2 and 3 show that terrorism significantly decreases patent counts with coefficients of -0.104 and -0.053 at 1% and 5% significance levels, respectively.

Furthermore, the empirical results in the baseline estimation state that terrorism significantly decreases trademarks on average. As shown in Table 1, Model 4, the coefficient result is -0.12 and significant at 1%, indicating that terrorism significantly decreases trademark applications. Likewise, Models 5 and 6 in Table 2 show that terrorism substantially reduces the number of trademarks with coefficients of -0.083 and -0.083 at a 1% significance level, respectively. Overall baseline results indicate that terrorism significantly and negatively affects innovation activity.

4.2. Robustness analysis

The main findings suggest that terrorism hurts innovative performance. However, in our baseline regressions, reverse causality remains a significant concern. Hence, we perform several robustness checks to address potential endogeneity issues and confirm the consistency of our earlier findings.

4.2.1. Results of the GMM Model

Finding suitable instruments for our analysis was challenging, so we used the lag of the dependent variable as an instrument. The results in Table 3 show that terrorism significantly reduces the number of patents and trademarks. Model 1 shows a coefficient of -0.019 at a 10% significance level, indicating that an increase in terrorism leads to a decrease in patent counts. Similarly, Models 2 and 3 suggest that terrorism significantly decreases patent counts with coefficients of -0.018 and -0.030 at a 10% significance level, respectively. The empirical results in Model 4 indicate that terrorism significantly reduces the number of trademarks with a coefficient of -0.042 at a 10% significance level. However, the results of Models 5 and 6 suggest that terrorism has a negative but insignificant impact on trademarks, with coefficients of -0.024 and -0.031, respectively. Overall, the GMM estimation results indicate that terrorism significantly reduces innovation activity, with terrorism having a greater impact on patent counts than on trademark applications.

Table 3: GMM estimation for the impact of terrorism on innovation

	Patent			Trademark		
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Lagged dependent variable	.962*** (.018)	.919*** (.039)	.924*** (.101)	.685*** (.230)	.605** (.231)	.833*** (.204)
Terrorism	-.019* (.010)	-.018* (.010)	-.030* (.015	-.042* (.023)	-.024 (.029)	-.031 (.068)

Population	.019 (.034)	.015 (.040)	.009 (.066)	.449* (.233)	.445* (.227)	.125 (.105)
Industry	.032 (.181)	.127 (.232)	-.348 (.439)	-1.68* (.881)	-1.446* (.792)	.275 (.693)
Trade openness		-.053* (.027)	-.055* (.029)		.010 (.072)	-.056* (.031)
High-tech export		.064 (.052)	-.014 (.130)		.082 (.149)	.201 (.134)
Technical cooperation grant			.063 (.049)			-.078 (.048)
Education			.095 (.258)			-.027 (.487)
AR2(p-value)	0.875	0.223	0.075	0.222	0.378	0.626
Hansen J-test p-value	0.710	0.550	0.928	0.863	0.880	0.395
Diff. – in – Hansen p-value	0.762	0.669	0.123	0.839	0.673	0.393
No. of obs, no. of countries	613, 31	581,31	314,23	594, 31	565, 31	305, 22

The regressions were estimated using the GMM estimator based on data from 31 economies between 1990 and 2022. The AR(2) statistic was used to test for serial correlation in the first difference equations. The Hansen J-test of over-identification was used to check if the instruments were not over-identified. Additionally, we included differences-in-Hansen tests to verify the homogeneity of the instruments, with the null hypothesis being that the instruments are exogenous. The standard errors (RSE) are reported in parentheses. Significance levels are denoted at 10% = *, 5% = **, and 1% = ***.

First, Figures A.1 and A.2 show the cumulative distribution function of innovation variables, measured by patents and trademarks, respectively. These figures demonstrate a high degree of skewness. Second, Figure A illustrates how the coefficients vary with quantiles for the baseline model. The effect of terrorism on patents is inverse at lower and middle quantile levels and slightly decreases with higher quantiles. Additionally, the other variables have expected signs on average.

4.2.2. Results of Panel Quantile Regression

Table 4 shows the outcomes of panel quantile regression. According to the empirical results, terrorism significantly decreases patents, as provided in panel A. The results of panel A show that coefficients have a negative symbol and are significant at 10% in Q (10), with a coefficient of -0.059, and at Q (25) with a coefficient of -0.060, with a significance level of 10%. Results in Q (50) are -0.090 for the coefficient at a significance level of 1%, and Q (75) is -0.059 at a significance level of 1%. However, the result of Q (90) is not significant. Overall, we conclude that the results of panel A indicate that terrorism significantly reduces the number of patents.

Similarly, the results in Panel B in Table 4 indicate that terrorism significantly reduces trademarks. Empirical outcomes suggest that the coefficient (-0.10) with a negative mark is significant at 1% in Q (10). Moreover, results in Q (25) show a coefficient of -0.099 at a significance level of 5%. The coefficient results in Q (50), Q (75), and Q (90) are -0.070, -0.093, and -0.140, respectively, and significant at 1%. Overall, the results of panel quantile regression confirm that terrorism significantly reduces innovation activity.

Table 4: Panel quantile regression to estimate the impact of terrorism on innovation

Variable	*Q (0.10)*	*Q (0.25)*	*Q (0.50)*	*Q (0.75)*	*Q (0.90)*
Panel A: Patent	Model 1	Model 2	Model 3	Model 4	Model 5
Terrorism	-.0595*(.032)	-.060*(.031)	-.090***(.033)	-.059***(.020)	.012(.071)
Population	1.053***(.066)	.962***(.064)	.977***(.068)	.919***(.919)	.709***(.147)
Industry	.213(.232)	-.302(.223)	-.273(.235)	-.153(.144)	-.506(.510)
Trade openness	-.268*(.140)	-.204(.135)	.234(.142)	-.009(.087)	.510(.308)
High-tech export	.321***(.049)	.421***(.048)	.426***(.050)	.390***(.031)	.438***(.109)
Technical cooperation grant	.036(.087)	-.067(.084)	-.155*(.088)	-.271***(.054)	-.131(.192)
Education	2.668***(.233)	2.131***(.224)	1.404***(.236)	1.221***(.145)	1.379***(.512)
Obser., Countries	333,31	333,31	333, 31	333,31	333,31
Pseudo/ R – square	0.47	0.46	0.45	0.48	0.47
Panel B: Trademark	Model 1	Model 2	Model 3	Model 4	Model 5
Terrorism	-.100***(.020)	-.099**(.041)	-.070***(.015)	-.093***(.025)	-.140***(.037)
Obser., Countries	325,31	325,31	325,31	325,31	325,31
Pseudo R – square	0.43	0.40	0.44	0.42	0.40

Note: The control variables in Panel B are not published but can be made available upon request. Parentheses report RSE. Significance levels are denoted at 10% = *, 5% = **, and 1% = ***

4.3. Results of Mechanism Analysis

As previously mentioned, we have identified three potential channels through which terrorism can affect innovation activity: domestic investment FDI and trade openness. In this section, we provide the empirical results of mechanisms.

4.3.1. Empirical Results of Domestic Investment Channel

Theoretical literature has confirmed that domestic investment promotes innovation activity. However, terrorism has been found to reduce domestic investment. Therefore, we have identified domestic investment as one of the channels through which terrorism can affect innovation activity.

To estimate Equations 3 and 4, we used the system generalized method of moments (GMM).

The empirical results presented in Table 5 indicate that domestic investment significantly impacts innovation activity. Specifically, Models 1 and 2 show that domestic investment significantly increases the number of patents, with coefficients of 0.032 and 0.068 at 1% and 5% significance levels, respectively. However, the results of Model 3 suggest that domestic investment has a positive impact of 0.036 on the number of patent applications, but this impact is not statistically significant.

Table 5: GMM estimation for the impact of domestic investment on innovation

	Patent			Trademark		
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Lagged dependent variable	.908*** (.030)	.886*** (.036)	.996*** (.085)	.588** (.216)	.867*** (.119)	.763*** (.101)
Investment	.032*** (.010)	.068** (.030)	.036 (.166)	.167* (.089)	.078 (.079)	.142** (.051)
FDI	.019 (.019)	.037 (.029)	.021 (.050)	.053* (.028)	.153** (.060)	.016 (.034)
High-tech export	-.002 (.034)	.031 (.030)	.029 (.047)	-.021 (.053)	.066 (.056)	.019 (.022)
Technical cooperation grant		.013 (.013)	.033 (.102)		-.036* (.018)	-.023 (.041)
Real GDP		-.126 (.082)	-.101 (.209)		-.008 (.122)	-.111 (.081)
Trade openness			.217 (.199)			.307** (.137)
Scientific articles			-.066 (.099)			.054 (.072)
AR2(p-value)	0.059	0.091	0.135	0.776	0.390	0.715
Hansen J-test p-value	0.306	0.468	0.684	0.120	0.300	0.905
Diff. – in – Hansen p-value	0.901	0.576	0.848	0.577	0.143	0.495
Obs, countries	692,31	479,23	250,23	680,31	459,23	252,22

The regressions were estimated using the GMM (Generalized Method of Moments) estimator with data from 31 economies between 1990 and 2022. The p-values for serial correlation in the first difference equations are reported as AR(2). The Hansen J-test of over-identification indicates that the instruments are not over-identified. Differences-in-Hansen tests were also conducted to check the exogeneity of the instruments, with the null hypothesis being that the instruments are exogenous. The reported RSE (Residual Standard Error) values are enclosed in parentheses. Significance levels are denoted at 10% = *, 5% = **, and 1% = ***.

Furthermore, Models 4 and 6 demonstrate that domestic investment significantly increases the number of trademark applications, with coefficients of 0.167 and 0.142 at 10% and 5% significance levels, respectively. In contrast, the results of Model 5 suggest that domestic investment has a positive impact of 0.078 on trademark applications, but this impact is not statistically significant. Overall, domestic investment plays a significant role in enhancing innovation activity.

Table 6: GMM estimation for the impact of terrorism on domestic investment

Variable	Model 1	Model 2	Model 3
Lagged dependent variable	.013***(.008)	.050***(.016	.038***(.016)
Terrorism	-.017*(.009)	-.023**(.009)	-.018**(.008)
Trade openness	.002(.021)	-.045*(.024)	-.051**(.022)
Exchange rate	-.060(.056)	-.025(.057)	.038(.030)
Financial development		-.280***(.085)	-.261**(.093)
Inflation			-.004(.026)
AR2(p-value)	0.121	0.312	0.060
Hansen J-test p-value	0.056	0.052	0.079
Diff. – in – Hansen p-value	0.364	0.535	0.228
Obs, countries	620,31	557,25	515,24

Note: The regressions were estimated using the GMM estimator with data from 31 economies between 1990 and 2022. The p-values for serial correlation in the first difference equations are reported as AR(2). The Hansen J-test of over-identification indicates that the instruments are not over-identified. Differences-in-Hansen tests were included to check the exogeneity of the instruments with the null hypothesis that the instruments are exogenous. Parentheses report RSE (Residual Standard Error). Significance levels are denoted as 10% = *, 5% = **, and 1% = ***.

The empirical results presented in Table 6 confirm that terrorism hurts domestic investment. The coefficient results from Models 1 to 3 are -0.017, -0.023, and -0.018, with a significance level of 10%, 5%, and 5%, respectively. These findings prove that terrorism significantly decreases domestic investment as investors seek a peaceful environment to mitigate risks. Due to the increase in terrorism incidents, investors tend to fly their capital to other countries, reducing domestic investment. It is unfortunate, as domestic investment fosters innovation. However, due to the rise in terrorism incidents, governments usually divert public funds to security-related matters, leaving private investors with a less pleasant investment environment (Eckstein & Tsiddon, 2004; Persitz, 2007; Llussa' & Tavares, 2011). Therefore, we consider domestic investment as a channel through which terrorism affects innovation activity.

4.3.2. Empirical Results of Foreign Direct Investment Channel

Equations 6 and 7 were estimated using system generalized methods of moments (GMM).

Table 7 displays the results of the impact of FDI on innovation, which indicate that FDI has a positive and significant effect on innovation. The three models with dependent variable patents (Models 1-3) show that an increase in FDI leads to a significant increase in the number of patents. The coefficient estimates for Models 1, 2, and 3 are 0.064, 0.053, and 0.054, respectively, with 1%, 10%, and 5% significance levels. These results suggest that FDI promotes innovation by increasing the number of patents.

Similarly, the results of Models 4-6 indicate that FDI significantly positively affects the number of trademarks. The coefficient estimates for Models 4, 5, and 6 are 0.077, 0.116, and 0.087, respectively, with a significance level of 5%. Thus, the empirical results support the assumption that FDI enhances innovation activity by increasing the number of trademarks.

Table 7: GMM estimation for the Impact of FDI on innovation

	Patent			Trademark		
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Lagged dependent variable	.989*** (.051)	.953*** (.039)	.907*** (.046)	.973*** (.059)	.830*** (.073)	.752*** (.074)
FDI	.064*** (.019	.053* (.027)	.054** (.026)	.077** (.036)	.116** (.047)	.087** (.033)
Real GDP	.010 (.049)	-.082 (.053)	-.043 (.047)	.026 (.064)	.021 (.057)	.031 (.071)
Trade openness	.001 (.018)	-.029 (.036)	-.018 (.032)	-.005 (.012)	-.003 (.021)	.003 (.028)
Population		.041* (.021)	.003 (.033)		.130*** (.037	.095** (.038)
Technical cooperation grant		.015 (.009)	.024* (.012)		-.046** (.017)	-.032* (.018)
Financial development			.159 (.120)			.307** (.113)
AR2(p-value)	0.310	0.418	0.420	0.437	0.381	0.785
Hansen J-test p-value	0.079	0.079	0.297	0.259	0.290	0.141
Diff. – in – Hansen p-value	0.064	0.065	0.357	0.171	0.624	0.383
Obs, countries	727,31	503,23	489,22	709,31	486,23	475,22

The regressions were estimated using a GMM (Generalized Method of Moments) estimator, with data from 31 economies from 1990 to 2022. The p-values for serial correlation in the first difference equations are reported as AR(2). The Hansen J-test of over-identification indicates that the instruments are not over-identified. Differences-in-Hansen tests were also conducted to check the exogeneity of the instruments, with the null hypothesis being that the instruments are exogenous. The reported RSE (Residual Standard Error) values are enclosed in parentheses. The significance levels are 10% =*, 5% =**, and 1% = ***.

Table 8: GMM estimation for the impact of terrorism on FDI

Variable	Model 1	Model 2	Model 3
Lagged dependent variable	.380*** (.114)	.337*** (.108)	.404*** (.118)
Terrorism	-.059* (.034)	-.055* (.030)	-.057* (.029)
Inflation	-.044 (.080	.002 (.073)	-.018 (.056)
Real GDP	-.307 (.192)	-.984** (.383)	-.696* (.366)
Financial development	.857* (.440)	.715 (.448)	.287 (.340)
Income		.775* (.433)	.695 (.493)
Exchange rate			-.036 (.140)

AR2(p-value)	0.826	0.887	0.155
Hansen J-test p-value	0.445	0.632	0.504
Diff. – in – Hansen p-value	0.756	0.785	0.681
Obser, countries	727, 31	503,23	489,22

The regressions in the analysis were estimated using a GMM estimator with data from 31 economies between 1990 and 2022. The p-values for serial correlation in the first difference equations were reported as AR (2). The Hansen J-test of over-identification was conducted to confirm that the instruments used in the analysis were not over-identified. Differences-in-Hansen tests were also included to check the exogeneity of the instruments, with the null hypothesis that the instruments are exogenous. The results were reported with standard errors in parentheses, and the significance level was denoted by *, **, and *** for 10%, 5%, and 1% levels of significance, respectively.

Table 8 presents the results of the impact of terrorism on FDI. The coefficients from Models 1 to 3 are -0.059, -0.055, and -0.057, respectively, and significant at the 10% level. These results indicate that terrorism has a significant negative effect on FDI inflows. It can be attributed to the increased risk and uncertainty caused by terrorist attacks, discouraging foreign investors from investing in the country. Additionally, terrorism raises the overall cost of doing business by increasing insurance and security costs. These empirical findings are consistent with the results of Enders and Sandler (1996) that terrorism reduces net FDI inflows. Therefore, we can conclude that FDI is a channel through which terrorism affects innovation activity.

4.3.3. Empirical results of trade openness channel

To estimate Equations 8 and 9, we employed the system generalized method of moments (GMM).

The empirical results presented in Table 9 indicate that trade openness positively and significantly impacts innovation activity. Specifically, results from Models 1 to 3 in Table 9 show that trade openness has a positive but insignificant effect on patents, with coefficient values of 0.087, 0.0004, and 0.013, respectively. In addition, the results from Model 1 show that trade openness positively impacts trademarks, with a coefficient value of 0.034, significant at the 5% level. Similarly, according to results from Model 5 in Table 9, trade openness increases trademarks, with a coefficient value of 0.037 and significant at the 1% level. Furthermore, results from Model 6 in Table 9 indicate that trade openness increases the number of trademarks, with a coefficient value of 0.029 and significant at the 10% level. Overall, the results suggest that trade openness increases innovation activity but has a greater effect on trademarks than patents.

The results from Models 1 to 3 in Table 10 suggest that terrorism reduces trade openness, with coefficients of -0.114, -0.124, and -0.071, respectively, and significance at the 10% level. Terrorist attacks create uncertainty and increase security costs and insurance premiums (Brück, 2006; Keefer & Loayza, 2008), which in turn leads to an increase in trade costs and ultimately reduces the volume of trade between countries.

Table 9: GMM estimation for the impact of trade openness on innovation activity

	Patent			Trade mark		
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Lagged dependent	.985*** (.048)	.929*** (.035)	.844*** (.085)	1.059*** (.023)	1.044*** (.040)	1.035*** (.073)
Trade openness	.087 (.322)	.0004 (.033)	.013 (.035)	.034** (.012)	.037*** (.012)	.029* (.015)
Technical cooperation grant	.006 (.020)	.034* (.018)	.009 (.032)	-.026* (.013)	-.027* (.013)	-.022 (.019)
R&D Expenditure	-.127 (.124)	.098* (.054)	.214 (.140)	.025 (.051)	-.006 (.041)	-.032 (.082)
Population density		.024 (.111)	.047 (.200)		.033 (.068)	.045 (.074)
Share of manufacturing Industry			.411 (.438)			-.031 (.228)
AR2(p-value)	0.192	0.213	0.237	0.748	0.752	0.927
Hansen J-test p-value	0.393	0.506	0.308	0.785	0.958	0.833
Diff. – in – Hansen p-value	0.288	0.440	0.506	0.300	0.693	0.667
No. of obs, no. of countries	264, 22	264, 22	250, 22	260, 21	260, 21	246, 21

The regressions were estimated using the Generalized Method of Moments (GMM) estimator with data from 31 economies from 1990 to 2022. The p-values for serial correlation in the first difference equations were reported as AR (2). The Hansen J-test of over-identification indicates that the instruments are not over-identified. Differences-in-Hansen tests were conducted to check the exogeneity of the instruments, with the null hypothesis being that the instruments are exogenous. The standard errors are reported in parentheses. The significance levels are as follows: 10%=, 5%=, and 1%=.

Table 10: GMM estimation for the impact of terrorism on trade openness

Variable	Model 1	Model2	Model3
Lag dependent variable	.257** (.111)	.244 (.181)	.862*** (.251)
Terrorism	-.114* (.056)	-.124* (.064)	-.071* (.041)
Exchange rate	-.049 (.052)	-.053 (.075)	.169 (.117)
Inflation	.009 (.069)	.038 (.034)	.054 (.121)
FDI		-.128 (.088)	-.086 (.073)
Population density			-.104 (.109)
AR2(p-value)	0.140	0.125	0.150
Hansen J-test p-value	0.182	0.645	0.187
Diff. – in – Hansen p-value	0.889	0.987	0.261
No. of obs, no. of countries	578,30	558,30	558,30

The regressions were estimated using the Generalized Method of Moments (GMM) estimator with data from 31 economies from 1990 to 2022. The p-values for serial correlation in the first difference equations are reported as AR (2). The Hansen J-test of over-identification indicates that the instruments are not over-identified. Differences-in-Hansen tests were conducted to check the exogeneity of the instruments, with the null hypothesis being that the instruments are exogenous. The standard errors are reported in parentheses. The significance levels are as follows: 10%=, *5%*=, and 1%=.

4.4. Empirical results of further robustness tests

The results of additional robustness tests show that terrorism significantly negatively impacts innovation activity. After removing outliers from patent counts data, the coefficients for patents and trademarks are significant at a 10% level. Similarly, after removing outliers of trademarks, the results indicate a significant decrease in innovation activity due to terrorism. These findings suggest that the effect of terrorism is more pronounced on patents than trademarks. Table 11 provides a detailed overview of these results.

Table 11: Additional robustness checks to estimate the impact of terrorism on innovation activity

Variable	Patent	Trademark
Panel A: Adding additional controls		
Lagged dependent variable	.977***(.125)	.669***(.113)
Terrorism	-.029*(.016)	.113(.047)
Panel B: Removing outlier base patent		
Lagged dependent variable	.863***(.082)	.816***(.138)
Terrorism	-.027*(.014)	-.065*(.036)
Panel C: Removing outlier base Trademark		
Lagged dependent variable	.887***(.044)	.710***(.192)
Terrorism	-.018*(.010)	.013(.044)
Panel D: Removing outlier base terrorism		
Lagged dependent variable	.898***(.062)	.814***(.194)
Terrorism	-.032**(.013)	-.027(.036)

The regressions in Table 11 use a GMM estimator to analyze the impact of terrorism on innovation in four different panels (A to D), with data from 31 economies between 1990 and 2022. In panel A, patents are the dependent variable in column (1), while trademarks are the dependent variable in column (2). The p-values for serial correlation in the first difference equations are reported as AR (2). The Hansen J-test of over-identification indicates that the instruments are not over-identified. Differences-in-Hansen tests are included to check the exogeneity of instruments, with the null hypothesis that the instruments are exogenous. Country controls, observations, endogeneity tests, constants, and control variables are not published but are available on demand. The coefficients are reported in parentheses, and RSE is reported as a standard error measure. The significance level at 10%, 5%, and 1% are denoted as *, **, and ***, respectively.

5. Concluding remarks and policy implications

Using a panel dataset on terrorism and innovation for 31 economies from 1990-2022, and after filtering and deleting lost observations, this study utilized unbalanced panel data to explore the influence of terrorism on innovation activity. Initially, we employed simple OLS for baseline results. Then, the system generalized method of moment (GMM) approach and panel quantile approaches were used for robustness checks and to handle endogeneity issues. The baseline empirical results of estimation indicate that terrorism significantly reduces innovation activity. Furthermore, the results of the generalized method of moment (GMM) approach and panel quantile approach also support our baseline results. Increasing terrorism incidents reduce both the number of patents and trademarks.

This study aims to identify the channels through which terrorism affects innovation activity, specifically domestic investment, foreign direct investment (FDI), and trade openness. We systematically analyzed the effects of terrorism on these channel variables and their impact on innovation activity using the system GMM approach. The empirical results reveal that the first channel variable, domestic investment, significantly increases patents and trademarks. However, the findings on the effects of terrorism on domestic investment suggest that terrorism significantly reduces domestic investment. These results are consistent with the studies conducted by Eckstein & Tsiddon (2004) and Persitz (2007).

In addition, terrorism also disrupts physical capital and reduces trade due to higher risk and lower profits on investment, as Abadie & Gardeazabal (2008) noted. Terrorist attacks create uncertainty and increase insecurity for investors, leading to economic distortions and inefficiencies, as found by Brück (2006) and Tufail (2010). Moreover, the empirical results of the second channel variable, FDI, indicate that FDI significantly increases both patent and trademark applications. These results align with the findings of Zhang (2014), where multinational corporations invest more money in research and development, generating cutting-edge concepts, new production and processing techniques, and boosting innovation and technological advancement in the host country. Furthermore, FDI inflows facilitate technology transfer between countries, which fosters innovation in the domestic country.

The empirical findings on the influence of terrorism on FDI indicate that terrorism significantly reduces FDI inflows. This result is consistent with the conclusions of Abadie et al. (2008), who found that terrorism increases risk, leading to a decline in FDI. Moreover, violence affects FDI inflows, but the impact differs in developing and developed countries (Blomberg & Mody, 2005). Terrorism incidents increase the cost of security, insurance, and doing business and create uncertainty, which affects overall FDI inflows in the domestic country (Shahzad et al., 2016).

Moreover, it is argued that trade openness is the primary driver of innovation activity due to increased competition, which compels businesses to adopt the latest ideas and technologies to keep up with market norms. Developing economies benefit from technology transfer through openness and the acquisition of a broad knowledge base, which increases their internal output. International trade plays a crucial role in accelerating this activity by serving as the primary conduit for transmitting new technologies and establishing the integration of foreign know-how into domestic manufacturing processes. These efforts can help improve the quality of the market's supply chain, creating cutting-edge products and services and increasing competition in the current business climate (Wacziarg, 2002).

Furthermore, terrorism impacts various macroeconomic variables, including trade openness. Trade flow between countries requires a risk-free environment and a secure goods and services supply chain. Terrorist attacks create uncertainty (Brück, 2006), which leads to higher security costs and insurance premiums (Keefer & Loayza, 2008). Additionally, the results of additional robustness checks, such as removing outliers from dependent and independent variables and adding extra variables to the primary regression, support our baseline findings that terrorism significantly reduces innovation activities.

Policymakers can implement the following policy measures based on the fundamental results and assumed mechanisms. They should closely monitor the security and stability of sovereign nations to create a safe and peaceful investment atmosphere for both domestic and foreign investors. It will ensure sustainable domestic investment and FDI. Similarly, trade openness can be expanded in countries free from conflicts and terrorism in their social, political, and economic environments. It can increase capital accumulation, technology transfer opportunities, skilled labor, and specialized managerial practices, stimulating overall innovation activity.

References

Ali, W., Gohar, R., Chang, B. H., & Wong, W. K. (2022). Revisiting the impacts of globalization, renewable energy consumption, and economic growth on environmental quality in South Asia. *Advances in Decision Sciences*, *26*(3), 78-98.

Akkemik, A. K. (2012). Assessing the Importance of International Tourism for the Turkish Economy: A Social Accounting Matrix Analysis. *Tourism Management,* 33 (4), 790–801. doi:10.1016/j.tourman.2011.09.002.

Abadie, Alberto, and Javier Gardeazabal. (2008). Terrorism and the World Economy. *European Economic Review,* 52 (1), 1–27. doi.org/10.1016/j.euroecorev.2007.08.005.

Bandyopadhyay, Subhayu, Todd Sandler, and Javed Younas. (2013). Foreign Direct Investment, Aid, and Terrorism. *Oxford Economic Papers,* 66 (1) 25–50. doi.org/10.1093/oep/gpt026.

Bird, Graham, S. Brock Blomberg, and Gregory D. Hess. (2008). International Terrorism: Causes, Consequences and Cures. *The World Economy,* 31 (2), 255–74. doi.org/10.1111/j.1467-9701.2007.01089.x.

Borensztein, E., J. De Gregorio, and J-W. Lee. (1998). How Does Foreign Direct Investment Affect Economic Growth? *Journal of International Economics,* 45 (1), 115–35. doi.org/10.1016/s0022-1996(97)00033-0.

Blomberg, S.Brock, Gregory D. Hess, and Akila Weerapana. (2004). Economic Conditions and Terrorism. *European Journal of Political Economy,* 20 (2), 463–78. doi.org/10.1016/j.ejpoleco.2004.02.002.

Blomberg, S. Brock, and Ashoka Mody. (2005). How Severely Does Violence Deter International Investment? Department of Economics, Claremont McKenna College, Claremont, CA, Typescript

Brück, T. (2006). *The economic analysis of terrorism*. London, Routledge

Chang, B. H., Gohar, R., Derindag, O. F., & Uche, E. (2022a). COVID-19, lockdown measures and their impact on food and healthcare prices: empirical evidence using a dynamic ARDL model. *Journal of Economic Studies, (ahead-of-print)*.

Chang, B. H., Derindag, O. F., Hacievliyagil, N., & Canakci, M. (2022b). Exchange rate response to economic policy uncertainty: evidence beyond asymmetry. *Humanities and Social Sciences Communications, 9*(1), 1-14.

Chang, B. H., and Rajput, S. K. O. (2018). Do the changes in macroeconomic variables have a symmetric or asymmetric effect on stock prices? Evidence from Pakistan. *South Asian Journal of Business Studies*, *7*(3), 312-331.

Chang, B. H., Meo, M. S., Syed, Q. R., & Abro, Z. (2019a). Dynamic analysis of the relationship between stock prices and macroeconomic variables. *South Asian Journal of Business Studies*, *8*(3), 229-245.

Chang, B. H., Rajput, S. K. O., Bhutto, N. A., & Abro, Z. (2020a). Asymmetric effect of extreme changes in the exchange rate volatility on the US imports: Evidence from multiple threshold nonlinear autoregressive distributed lag model. *Studies in economics and finance*, *37*(2), 293-309.

Chang, B. H., Sharif, A., Aman, A., Suki, N. M., Salman, A., and Khan, S. A. R. (2020b). The asymmetric effects of oil price on sectoral Islamic stocks: New evidence from quantile-on-quantile regression approach. *Resources Policy*, 65, 101571.

Chang, B. H., Rajput, S. K. O., Ahmed, P., & Hayat, Z. (2020c). Does Gold Act as a Hedge or a Safe Haven? Evidence from Pakistan. *The Pakistan Development Review*, 59(1), 69-80.

Chang, B. H. (2020). Oil prices and E7 stock prices: an asymmetric evidence using multiple threshold nonlinear ARDL model. *Environmental Science and Pollution Research*, 1-12.

Chang, B. H., Rajput, S. K. O., & Bhutto, N. A. (2019b). Impact of exchange rate volatility on the US exports: a new evidence from multiple threshold nonlinear ARDL model. *Journal of International Commerce, Economics and Policy*, *10*(02), 1950009.

Chang, B. H., Rajput, S. K. O., and Ghumro, N. H. (2018). Asymmetric impact of exchange rate changes on the trade balance: Does global financial crisis matter? *Annals of Financial Economics*, 1850015.

Cheung, Kui-yin, and Ping Lin. (2004). Spillover Effects of FDI on Innovation in China: Evidence from the Provincial Data. *China Economic Review*, 15 (1), 25–44. doi.org/10.1016/s1043-951x(03)00027-0.

Cheung, K. Y., & Ping, L. (2004). Spillover effects of FDI on innovation in China: Evidence from the provincial data. *China economic review*, 15(1), 25-44.

Chen, Y., Jiang, H., Liang, Y., & Pan, S. (2022). The impact of foreign direct investment on innovation: evidence from patent filings and citations in China. *Journal of Comparative Economics*, 50(4), 917-945.

Crain, Nicole V., and W. Mark Crain. (2006). Terrorized Economies. *Public Choice*, 128 (1–2), 317–49. doi.org/10.1007/s11127-006-9056-6.

Coe, D., Helpman, E., (1995). International R&D spillovers. *European Economic Review*, 39, 859–887.

Cuglesan, N., & Ilik, G. (2022). THE ROMANIAN PRESIDENCY OF THE COUNCIL OF THE EUROPEAN UNION. GREAT EXPECTATIONS?. Journal of Liberty and International Affairs, 8(3), 459-474. https://doi.org/10.47305/JLIA2283459c

Cukierman, Alex. (2004). Comment on: 'Macroeconomic Consequences of Terror: Theory and the Case of Israel. *Journal of Monetary Economics*, 51 (5), 1003–6. doi.org/10.1016/j.jmoneco.2004.05.002.

Dash, Sonali, et al. "Artificial Intelligence Models for Blockchain-Based Intelligent Networks Systems: Concepts, Methodologies, Tools, and Applications." In Handbook of Research on Quantum Computing for Smart Environments, edited by Amit Kumar Tyagi, 343-363. Hershey, PA: IGI Global, 2023. https://doi.org/10.4018/978-1-6684-6697-1.ch019

Dash, S., Parida, P., Sahu, G., & Khalaf, O. I. (2023). Artificial Intelligence Models for Blockchain-Based Intelligent Networks Systems: Concepts, Methodologies, Tools, and Applications. I*n Handbook of Research on Quantum Computing for Smart Environments* (pp. 343-363). IGI Global.

Derindag, O. F., Chang, B. H., Gohar, R., & Salman, A. (2022). Exchange Rate Effect on the Household Consumption in BRICST Countries: Evidence from MATNARDL Model. *Journal of International Commerce, Economics and Policy*, 2250010.

Derindag, O. F., Chang, B. H., Gohar, R., Wong, W. K., & Bhutto, N. A. (2023a). Food prices response to global and national factors: Evidence beyond asymmetry. *Cogent Economics & Finance*, *11*(1), 2187128.

Derindag, O. F., Maydybura, A., Kalra, A., Wong, W. K., & Chang, B. H. (2023b). Carbon emissions and the rising effect of trade openness and foreign direct investment: Evidence from a threshold regression model. *Heliyon*, *9*(07), e17448.

Dotta, V., & Munyo, I. (2019). Trade openness and innovation. *The Innovation Journal*, 24(2), 1-13.

Enders, Walter, and Todd Sandler. (1996). Terrorism and Foreign Direct Investment in Spain and Greece. *Kyklos*, 49 (3), 331–52. doi.org/10.1111/j.1467-6435.1996.tb01400.x.

Fareed, Zeeshan, Muhammad Saeed Meo, Bushra Zulfiqar, Farrukh Shahzad, and Nianyong Wang. (2018). Nexus of Tourism, Terrorism, and Economic Growth in Thailand: New Evidence from Asymmetric ARDL Cointegration Approach. *Asia Pacific Journal of Tourism Research*, 23 (12), 1129–41. doi.org/10.1080/10941665.2018.1528289.

Filer, Randall K., and Dragana Stanišić. (2016). The Effect of Terrorist Incidents on Capital Flows. *Review of Development Economics*, 20 (2), 502–13. doi.org/10.1111/rode.12246.

Farooq, M. (2014). Impact of terrorism on foreign direct investment and key indicators of development in Pakistan. *City University Research Journal*, 4(1).

Gaibulloev, Khusrav, and Todd Sandler. (2008). Growth Consequences of Terrorism in Western Europe. *Kyklos*, 61 (3), 411–24. doi.org/10.1111/j.1467-6435.2008.00409.x.

Grossman, G., Helpman, E., (1991). *Innovation and Growth in the Global Economy*. MIT Press, Cambridge, MA

Graham, Stuart J. H., and Galen Hancock. (2013). The USPTO Economics Research Agenda. *The Journal of Technology Transfer*, 39 (3), 335–44. doi.org/10.1007/s10961-013-9299-6.

Griliches, Zvi. (1990). Patent Statistics as Economic Indicators: A Survey. *Journal of Economic Literature*, 28 (4),: 1661-707. Accessed April 12, 2020. www.jstor.org/stable/2727442.

Gohar, R., Bagadeem, S., Chang, B. H., & Zong, M. (2022). Do the income and price changes affect consumption in the emerging 7 countries? Empirical evidence using quantile ARDL model. *Annals of Financial Economics*, *17*(04), 2250024.

Gohar, R., Bhatty, K., Osman, M., Wong, W. K., & Chang, B. H. (2022b). Oil prices and sectorial stock indices of Pakistan: Empirical evidence using bootstrap ARDL model. Advances in Decision Sciences, 26(4), 1-27.

Gohar, R., Salman, A., Uche, E., Derindag, O. F., & Chang, B. H. (2023). Does US infectious disease equity market volatility index predict G7 stock returns? Evidence beyond symmetry. *Annals of Financial Economics*, *18*(02), 2250028.

Gohar, R., Chang, B. H., Derindag, O. F., & Abro, Z. (2022d). Nexus between consumption, income, and price changes: Asymmetric Evidence from NARDL Model. *ETIKONOMI*, *21*(2), 213-228.
Gohar, R., Osman, M., Uche, E., Auxilia, P. M., & Chang, B. H. (2022). The economic policy uncertainty extreme dynamics and its effect on the exchange rate. *Global Economy Journal*, *22*(03), 2350006.
Goswami, S., Sagar, A. K., Nand, P., & Khalaf, O. I. (2022, May). Time Series Analysis Using Stacked LSTM Model for Indian Stock Market. In *2022 IEEE IAS Global Conference on Emerging Technologies (GlobConET)* (pp. 399-405). IEEE. doi: 10.1109/GlobConET53749.2022.9872386.
Hai Yen, T. T., Wong, W. K., Al-Abyadh, M. H. A., Muda, I., Julca-Guerrero, F., Hishan, S. S., & Islam, M. M. (2023). The impact of ecological innovation and corporate social responsibilities on the sustainable development: Moderating role of environmental ethics. *Economic Research-Ekonomska Istraživanja*, *36*(3), 2153260.
Hashmi, S. M., & Chang, B. H. (2021) Asymmetric effect of macroeconomic variables on the emerging stock indices: A quantile ARDL approach. *International Journal of Finance & Economics.* https://doi.org/10.1002/ijfe.2461.
Hashmi, S. M., Chang, B. H., & Shahbaz, M. (2021b). Asymmetric effect of exchange rate volatility on India's cross-border trade: Evidence from global financial crisis and multiple threshold nonlinear autoregressive distributed lag model. *Australian Economic Papers*, *60*(1), 64-97.
Hashmi, S.M., Chang, B.H. and Rong, L. (2021b). Asymmetric effect of COVID-19 pandemic on E7 stock indices: Evidence from quantile-on-quantile regression approach. *Research in International Business and Finance*, *58*, p.101485.
Hashmi, S. M., Chang, B. H., Huang, L., & Uche, E. (2022). Revisiting the relationship between oil prices, exchange rate, and stock prices: An application of quantile ARDL model. *Resources Policy*, *75*, 102543.
Hsu, Po-Hsuan, Xuan Tian, and Yan Xu. (2014). Financial Development and Innovation: Cross-Country Evidence. *Journal of Financial Economics*, 112 (1), 116–35. doi.org/10.1016/j.jfineco.2013.12.002.
Ilik, G., & Adamczyk, A. (2017). Finalité politique or just a step forward: the Lisbon Treaty and the identity of the European Union as a global actor. *J. Liberty & Int'l Aff.*, *3*, 9. Retrieved from https://e-jlia.com/index.php/jlia/article/view/89
Ilievski, N. L., & Ilik, G. (2018). The end of politics: deconstruction, decline and alternative of the state. *J. Liberty & Int'l Aff.*, *4*, 28. Retrieved from https://e-jlia.com/index.php/jlia/article/view/108
Ilik, G., & Ferraro, A. V. (2021). New technologies and the discourses of human rights, politics, and society. *Journal of Liberty and International Affairs*, *7*(Special Issue), 18. https://doi.org/10.47305/JLIA2137118i

Ilievski, N. L., & Ilik, G. (2016). The Freedom as a Fruit of Individual Liberty: Operationalization of Liberty and Demystification of Freedom. *J. Liberty & Int'l Aff.*, *2*, 27. Retrieved from https://e-jlia.com/index.php/jlia/article/view/58

Jaiswal, R., Gupta, S., & Tiwari, A. K. (2022). Delineation of blockchain technology in finance: A scientometric view. *Annals of Financial Economics*, 17(04), 2250025.

Javorcik, Beata Smarzynska. (2004). Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers Through Backward Linkages. *American Economic Review*, 94 (3), 605–27. doi.org/10.1257/0002828041464605.

Jalles, João Tovar. (2010). How to Measure Innovation? New Evidence of the Technology–Growth Linkage. *Research in Economics*, 64 (2), 81–96. doi.org/10.1016/j.rie.2009.10.007.

Jebril, I., Dhanaraj, P., Abdulsahib, G. M., Palanisamy, S., Prabhu, T., & Khalaf, O. I. (2022). Analysis of Electrically Couple SRR EBG Structure for Sub 6 GHz Wireless Applications. *Advances in Decision Sciences*, *26*(5), 102-123. https://doi.org/10.47654/v26y2022i5p102-123

Keefer, P. and Loayza, N. (eds) (2008). *Terrorism, Economic Development, and Political Openness*, Cambridge University Press, New York.

Koh, Winston T.H. (2007). Terrorism and Its Impact on Economic Growth and Technological Innovation. *Technological Forecasting and Social Change,* 74 (2), 129–38. doi.org/10.1016/j.techfore.2006.01.005.

Kumar, R.R, Shahzad, S.J.H, Stauvermann, Kumar. N, (2019). Non-Linear effects of terrorism on economic growth in Pakistan: Accounting for capital per worker and structural breaks, *The Singapore Economic Review*, 1950014. doi:10.1142/s0217590819500140.

Koenker, Roger, and Gilbert Bassett. (1978). Regression Quantiles. *Econometrica.* 46 (1), 33. doi.org/10.2307/1913643.

Liu, Xiaohui, and Chenggang Wang. (2003). Does Foreign Direct Investment Facilitate Technological Progress? *Research Policy,* 32 (6), 945–53. doi.org/10.1016/s0048-7333(02)00094-x.

Llussá, Fernanda, and José Tavares. (2011). Which Terror at Which Cost? On the Economic Consequences of Terrorist Attacks. *Economics Letters,* 110 (1), 52–55. doi.org/10.1016/j.econlet.2010.09.011.

Malik, Z., & Zaman, K. (2013). Macroeconomic consequences of terrorism in Pakistan. *Journal of Policy Modeling*, 35(6), 1103-1123.

Mehmood, S., & Mehmood, B. (2016). Hamering effect of terrorism on investment: The South Asian perspective. *Science International*, 28(2).

Maydybura, A., Gohar, R., Salman, A., Wong, W. K., & Chang, B. H. (2022). The Asymmetric Effect of the Extreme Changes in the Economic Policy Uncertainty on the Exchange Rates: Evidence from Emerging Seven Countries. *Annals of Financial Economics,* 2250031.

Mangalampalli, S., Karri, G.R., Kumar, M. *et al*. DRLBTSA: Deep reinforcement learning based task-scheduling algorithm in cloud computing. *Multimed Tools Appl* (2023). https://doi.org/10.1007/s11042-023-16008-2

Mirza, D., & Verdier, T. (2008). International trade, security and transnational terrorism: Theory and a survey of empirics. *Journal of Comparative Economics*, 36(2), 179-194.

Meierrieks, Daniel, and Thomas Gries. (2013). Causality between Terrorism and Economic Growth. *Journal of Peace Research,* 50 (1), 91–104. doi.org/10.1177/0022343312445650.

Millot, V. (2009). Trademarks as an Indicator of Product and Marketing Innovations. IN: OECD Science, Technology and Industry Working Papers 2009/06.

Nie, Y., & Su, J. (2022). Evaluating the Green Innovation Ability of Engineering Teams in a Hesitation Fuzzy Environment. *Advances in Decision Sciences*, *26*(Special), 53-76.

Noman, M., Maydybura, A., Channa, K. A., Wong, W. K., & Chang, B. H. (2023). Impact of cashless bank payments on economic growth: Evidence from G7 countries. *Advances in Decision Sciences, 27*(1), 1-22.

Peng, B., Chang, B. H., Yang, L., & Zhu, C. (2022). Exchange rate and energy demand in G7 countries: Fresh insights from Quantile ARDL model. *Energy Strategy Reviews, 44*, 100986.

Pradhan, Rudra P., Mak B. Arvin, Mahendhiran Nair, Sara E. Bennett, Sahar Bahmani, and John H. Hall. (2018). Endogenous Dynamics between Innovation, Financial Markets, Venture Capital and Economic Growth: Evidence from Europe. *Journal of Multinational Financial Management,* 45 (6), 15–34. doi.org/10.1016/j.mulfin.2018.01.002.

Persitz, D. (2007). The economic effects of terrorism: Counterfactual analysis of the case of Israel. Department of Economics, Tel Aviv University.

Piscitello, L., & Thakur-Wernz, P. (2023). Impact of domestic and foreign knowledge mechanisms on the innovation performance of Indian firms. *International Business Review*, 32(4), 102107.

Roper, Stephen, & Nola Hewitt-Dundas. (2015). Knowledge Stocks, Knowledge Flows and Innovation: Evidence from Matched Patents and Innovation Panel Data. *Research Policy*, 44 (7), 1327–40. doi.org/10.1016/j.respol.2015.03.003.

Sandler, T., & Enders, W. (2007). An economic perspective on transnational terrorism. In *The economic analysis of terrorism* (pp. 29-44). Routledge.

Sabir, S., Latif, R., Qayyum, U., & Abass, K. (2019). Financial development, technology and economic development: the role of institutions in developing countries. *Annals of Financial Economics*, 14(03), 1950012.

Siddique, H. M. A., Liaqat, R., & Ullah, K. (2017). Impact of terrorism on investment: Evidence from Pakistan. *Bulletin of Business and Economics (BBE)*, 6(4), 195-199.

Shahzad, Syed Jawad Hussain, Muhammad Zakaria, Mobeen Ur Rehman, Tanveer Ahmed, and Bashir Ahmed Fida. (2015). Relationship Between FDI, Terrorism and Economic Growth in Pakistan: Pre and Post 9/11 Analysis. *Social Indicators Research,* 127 (1), 179–94. doi.org/10.1007/s11205-015-0950-5.

Sharif, H., Hameedur, R., Ghaida, M. A., Haneen, A. K., & Osamah, I. K. (2023). A Blockchain-Based Approach for Healthcare Data Interoperability. *Int. J. Advance Soft Compu. Appl*, Vol. 15, No. 2.

Syed, Q. R., Malik, W. S., & Chang, B. H. (2019). Volatility Spillover Effect of Federal Reserve'S Balance Sheet On The Financial And Goods Markets Of Indo-Pak Region. *Annals of Financial Economics*, *14*(03), 1950015.

Tang, Z., Xie, H., Du, C., Liu, Y., Khalaf, O. I., & Allimuthu, U. K. (2022). Machine learning assisted energy optimization in smart grid for smart city applications. *Journal of Interconnection Networks*, *22*(Supp03), 2144006. https://doi.org/10.1142/S0219265921440060

Tu, V.T.N., Giang, V.T., Phuoc, H.A., Thien, N.T.H., Thanh, T.Q., Hue, N.T., Khanh, M.Q., & Hai, L.T.T. 2023. "Impact of Factors on Students' E-Learning Outcomes Evidence from Pedagogical Universities in Vietnam with Applications in Decision Sciences," *Advances in Decision Sciences*, 27(2), 28-45.

Tufail, A. (2010). Terrorist Attacks and Community Responses. *PAK Institute for Peace Studies*, January, Pakistan

Uche, E., Chang, B. H., & Effiom, L. (2022a) Household consumption and exchange rate extreme dynamics: Multiple asymmetric threshold non-linear autoregressive distributed lag model perspective. *International Journal of Finance & Economics*.

Uche, E., Chang, B. H., & Gohar, R. (2022b). Consumption optimization in G7 countries: Evidence of heterogeneous asymmetry in income and price differentials. *Journal of International Commerce, Economics and Policy*, 13(1), 2250002.

Uddin, M., Alam, A., Yazdifar, H., & Shubita, M. (2022). Terrorism, innovation and venture capital. *Journal of Economic Studies*, 49(2), 330-345.

Ukwueze, E. R., Asogwa, H. T., Nwodo, O. S., & Ogbonna, O. E. (2019). Impact of terrorism on foreign direct investment in Nigeria. In *The impact of global terrorism on economic and political development* (pp. 235-247). Emerald Publishing Limited.

Vy, N. N. T., Luu, T. Q., & Wong, W. K. (2022). Impact of globalization on innovation of Vietnamese small and medium enterprises (early view). *Asian Academy of Management Journal*.

Wang, F., Wong, W. K., Wang, Z., Albasher, G., Alsultan, N., & Fatemah, A. (2023). Emerging pathways to sustainable economic development: An interdisciplinary exploration of resource efficiency, technological innovation, and ecosystem resilience in resource-rich regions. *Resources Policy*, 85, 103747.

Wang, Quan-Jing, Gen-Fu Feng, Yin E. Chen, Jun Wen, and Chun-Ping Chang. (2019). The Impacts of Government Ideology on Innovation: What Are the Main Implications? *Research Policy*, 48 (5), 1232–47. doi.org/10.1016/j.respol.2018.12.009.

Wang, X., Chang, B. H., Uche, E., & Zhao, Q. (2022). The asymmetric effect of income and price changes on the consumption expenditures: evidence from G7 countries using nonlinear bounds testing approach. *Portuguese Economic Journal*, 1-19.

Wong, W. K., Thompson, H. E., & Teh, K. (2010). Was there Abnormal Trading in the S&P 500 Index Options Prior to the September 11 Attacks? *Multinational Finance Journal*, vol. 5, no. 1/2, pp. 1–46.

Wacziarg, R. (2001). Measuring the Dynamic Gains from Trade." *The World Bank Economic Review*, 15 (3), 393-429. doi: 10.1093/wber/15.3.393

Wen Jun, Mingbo Zheng, Gen-Fu Feng, Sunwu Winfred Chen and Chun-Ping Chang. (2018). Corruption and Innovation: Linear and Nonlinear investigation of OECD countries. *The Singapore Economic Review*, 65 (01), 103–29. doi.org/10.1142/s0217590818500273.

WIPO. (2017). Making a Mark: An Introduction to Trademarks for Small and Medium-Sized Enterprises. IN: World Intellectual Property Organization, Geneva.

Xue, X., Poonia, M., Abdulsahib, G. M., Bajaj, R. K., Khalaf, O. I., Dhumras, H., & Shukla, V. (2023a). On Cohesive Fuzzy Sets, Operations and Properties with Applications in Electromagnetic Signals and Solar Activities. *Symmetry*, *15*(3), 595.

Xue, X., Marappan, R., Raju, S. K., Raghavan, R., Rajan, R., Khalaf, O. I., & Abdulsahib, G. M. (2023b). Modelling and Analysis of Hybrid Transformation for Lossless Big Medical Image Compression. *Bioengineering*, *10*(3), 333.

Xue, X., Chinnaperumal, S., Abdulsahib, G. M., Manyam, R. R., Marappan, R., Raju, S. K., & Khalaf, O. I. (2023c). Design and Analysis of a Deep Learning Ensemble Framework Model for the Detection of COVID-19 and Pneumonia Using Large-Scale CT Scan and X-ray Image Datasets. *Bioengineering*, *10*(3), 363.

Xue, X., Poonia, M., Abdulsahib, G. M., Bajaj, R. K., Khalaf, O. I., Dhumras, H., & Shukla, V. (2023). On Cohesive Fuzzy Sets, Operations and Properties with Applications in Electromagnetic Signals and Solar Activities. *Symmetry*, *15*(3), 595. https://doi.org/10.3390/sym15030595

Xue, X., Shanmugam, R., Palanisamy, S., Khalaf, O. I., Selvaraj, D., & Abdulsahib, G. M. (2023d). A hybrid cross layer with harris-hawk-optimization-based efficient routing for wireless sensor networks. *Symmetry*, *15*(2), 438.

Xue, X., Marappan, R., Raju, S. K., Raghavan, R., Rajan, R., Khalaf, O. I., & Abdulsahib, G. M. (2023). Modelling and Analysis of Hybrid Transformation for Lossless Big Medical Image Compression. *Bioengineering*, *10*(3), 333. https://doi.org/10.3390/bioengineering10030333

Xue, X., Chinnaperumal, S., Abdulsahib, G. M., Manyam, R. R., Marappan, R., Raju, S. K., & Khalaf, O. I. (2023). Design and Analysis of a Deep Learning Ensemble Framework Model for the Detection of COVID-19 and Pneumonia Using Large-Scale CT Scan and X-ray Image Datasets. *Bioengineering*, *10*(3), 363. https://doi.org/10.3390/bioengineering10030363

Xue, X., Shanmugam, R., Palanisamy, S., Khalaf, O. I., Selvaraj, D., & Abdulsahib, G. M. (2023). A hybrid cross layer with harris-hawk-optimization-based efficient routing for wireless sensor networks. *Symmetry*, *15*(2), 438. https://doi.org/10.3390/sym15020438

Xu, Bin. (2000). Multinational Enterprises, Technology Diffusion, and Host Country Productivity Growth. *Journal of Development Economics*, 62 (2), 477–93. doi.org/10.1016/s0304-3878(00)00093-6

Zakaria, Muhammad, Wen Jun, and Haseeb Ahmed. (2019). Effect of Terrorism on Economic Growth in Pakistan: An Empirical Analysis. *Economic Research-Ekonomska Istraživanja,* 32 (1), 1794–1812. doi.org/10.1080/1331677x.2019.1638290.

Zhang, Kevin Honglin. (2014). How Does Foreign Direct Investment Affect Industrial Competitiveness? Evidence from China. *China Economic Review*, 30 (9), 530–39. doi.org/10.1016/j.chieco.2013.08.003.

Appendix

Figure A: Estimates across quantiles (baseline).

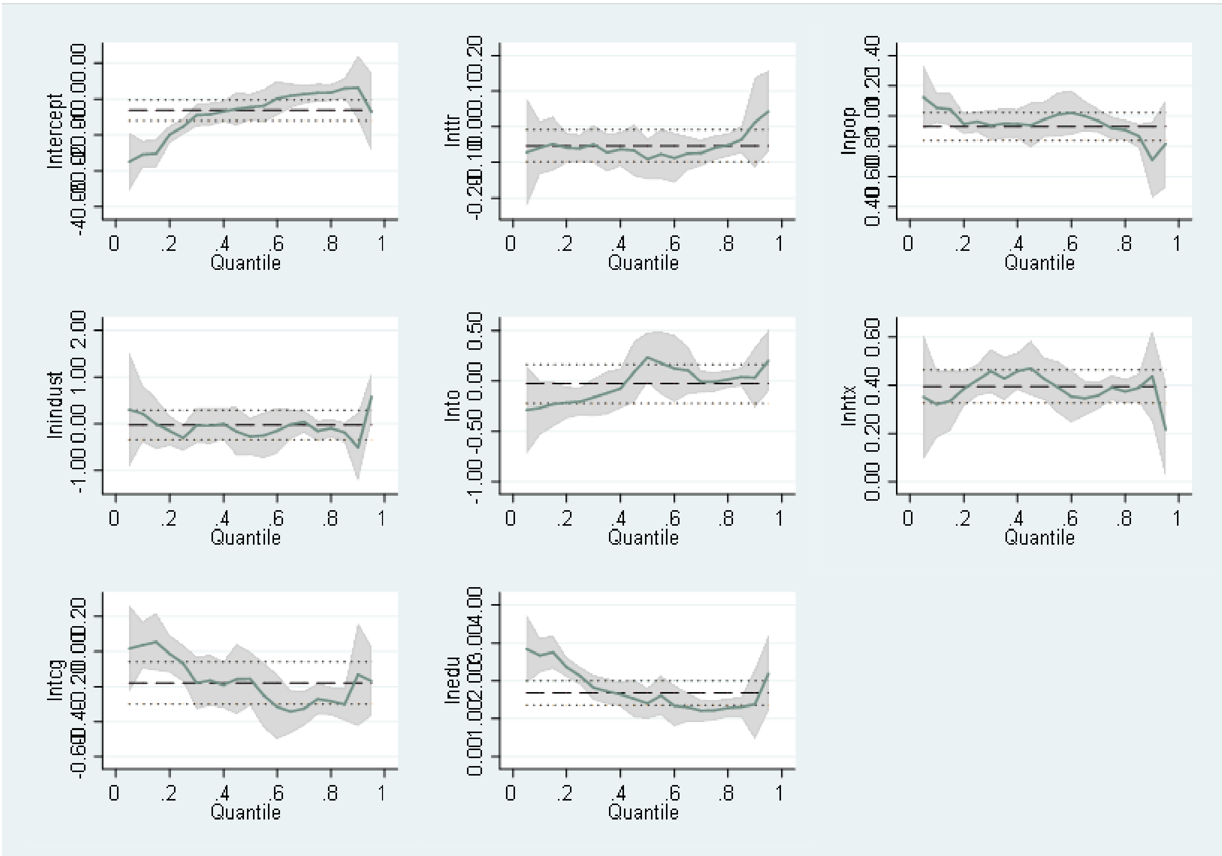

Figure A.1: Quintile of patents applications

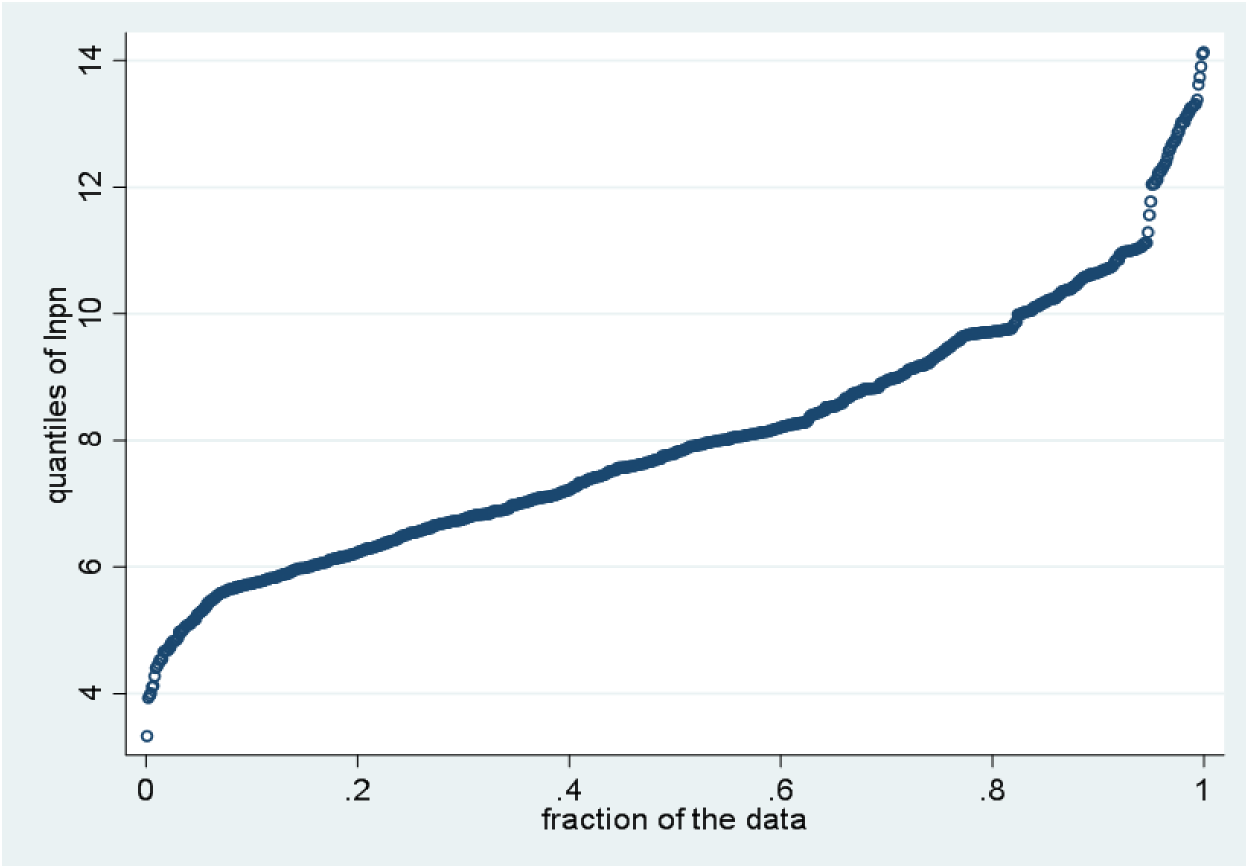

Figure A.2: Quintile of trademark applications

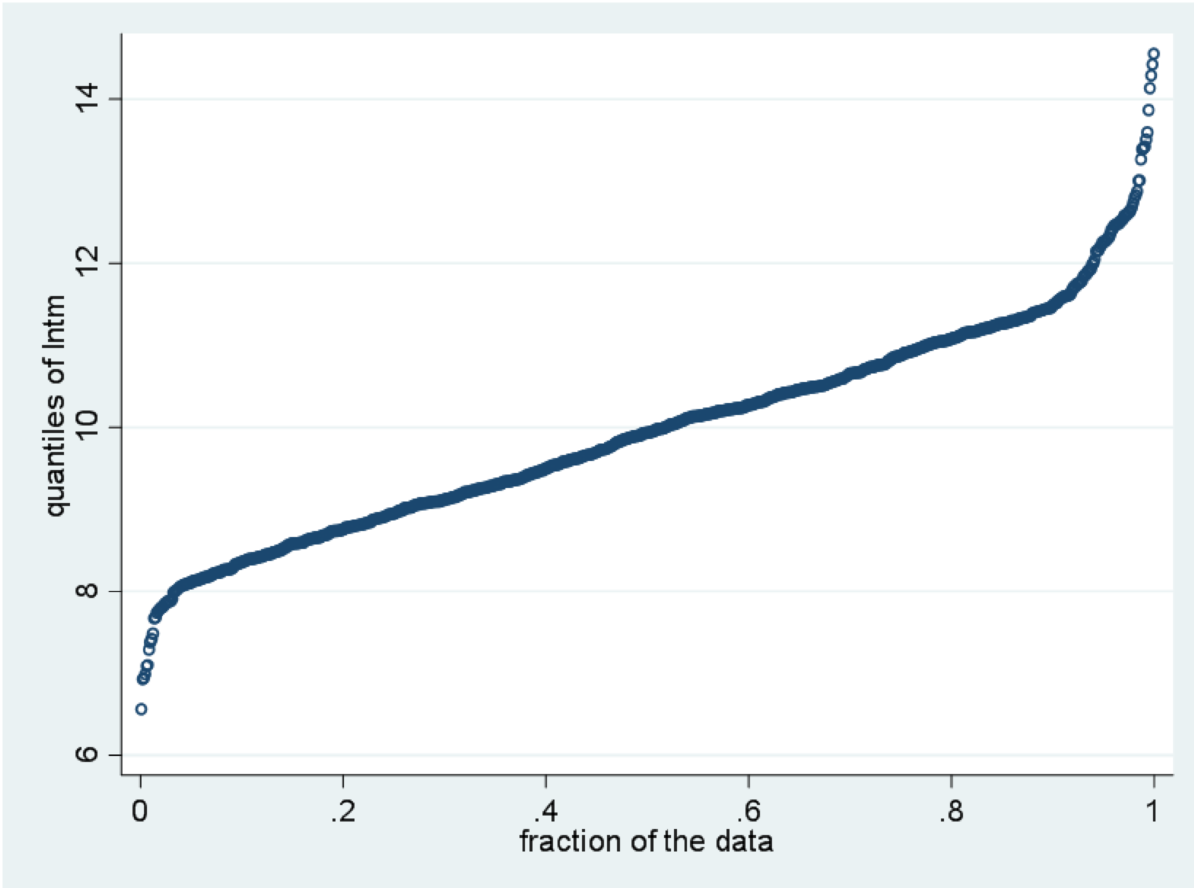

Table A. List of countries

Country	Country
Algeria	Kenya
Bangladesh	Mexico
Chile	Pakistan
China	Peru
Colombia	Philippines
Ecuador	Russian Federation
Egypt, Arab Rep.	Saudi Arabia
France	Spain
Georgia	Sri Lanka
Germany	Thailand
Greece	Turkey
India	United Kingdom
Indonesia	United States
Iran, Islamic Rep.	Venezuela
Ireland	
Israel	
Italy	