IMPACT OF TERRORISM ON ECONOMIC DEVELOPMENT IN PAKISTAN

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Abstract

In the recent history, Pakistan is facing the menace of terrorism. Besides facing the consequences of Afghan War, Pakistan is also affected by various ethnic, religious and linguistic conflicts which have increased terrorists' activities. These conflicts have severely affected the socio-economic structure of Pakistan. To gauge the impact of terrorism on Pakistan's economic growth Solow economic growth model has been used. Using data on terrorism from Global Terrorism Database, co-integration analysis for the period 1981-2012 has been applied. The analysis suggests that terrorism has negatively affected the economic growth in Pakistan. Among the various variables that were used the terrorism is most significant and major contributor in reducing the economic growth. However, study finds that foreign assistance that is provided to Pakistan in the aftermath of the participations in Afghan war and the war against terrorism; in the shape of aid, grants and debt rescheduling etc. has a positive impact on the economic growth.

Keywords: Economic Growth, Terrorism, Co integration
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Introduction

Terrorism can be defined as the "the premeditated use or threat of use of violence by individuals or sub-national groups to obtain a political or social objective through the intimidation of a large audience, beyond that of the immediate victim" (Sandler and Enders, 2005). Terrorism is not a recent phenomenon; however it gained much importance in literature after 9/11 attacks on the US in 2001. Although it's a global phenomena, Middle East and South Asia are specifically affected due to the War on terror initiated after the 9/11 attacks. The Taliban Government in Afghanistan was considered to be providing the base for terrorist activities of Al-Qaeda by the United States (US) and her allies. After the 9/11 incident Afghanistan was attacked by the US and NATO forces in 2001. Pakistan, a neighboring country of Afghanistan, was also affected due to the war on terror and its aftermath.

Terrorism not only affected the social fabric of Pakistani society but also has economic repercussions for a developing country like Pakistan. In fact, terrorism affects developing country much more severely than developed ones, as developed countries have diverse economies and terrorism results only in reallocation of resources to more secure sectors of economy, while in case of developing countries, where there is much concentration of resources in certain sectors, are more affected (Sandler and Enders, 2005). Pakistan has been a victim of terrorism for the last three decades, due to her involvement in wars in Afghanistan. Besides involvement in those wars, ethnic and sectarian conflicts among different factions and separatist nationalistic movements on Pakistani soil are other sources of terrorism in Pakistan. Such a situation resulted in ultimately slowing down the economic growth. Therefore, the present study contributes to the existing literature by providing evidence on the impact of terrorism on Pakistan's economic growth. This impact has been analyzed by using data from 1981 to 2012.

The organization of the paper is as follows: after the introduction the second section is devoted to the review of the literature, section three provides a brief history of insurgency in Pakistan, section four summarizes the theoretical and Empirical Model that has been used, while section five summarizes the empirical methodology and results. At the end conclusions emerging from the

study, policy implications and suggestions for the future research are presented.

Literature Review

The literature on the impact of terrorism on economic condition of a country is very limited however a brief review of the available literature is presented below. Bloomberg et al. (2002) present an economic model of terrorism, in which terrorist groups who are unhappy with the current situation in a country try to bring change by indulging in terrorist activities. Terrorist activities of such groups may have different results depending on the economic situation. Either they can reduce the economic activities by increasing terrorism, or if more economic incentives are present in the economy then terrorism is reduced for example, more employment opportunities can reduce the incentive to indulge in terrorist activities. Study is of the view that recessions in high income countries can result in higher probability of terrorist activities.

Bloomberg et al. (2004) empirically look into the impact of terrorism on 177 countries over the period 1968-2000. The study finds the impact of terrorism on economic growth as negative. Further findings show that terrorism results in shifting of resources from investment spending to government spending. However, the incidence of terrorism differs on different groups of countries. For example, although the terrorist acts are more frequent in advanced economies like that of the OECD countries but their impact was less significant than developing countries.

Sandler and Enders (2005) have similar views as they compare the impact of terrorism on developed and developing countries. Study argues that developed countries have vast economy and any terrorist activity may result in reallocating of resources among various sectors of the economy, but however, this is not the case with the developing countries and any major terrorist act may jeopardize the economic growth. Like their vast economies, developed countries have better institutions and markets and can absorb effects of terrorism. They can provide necessary fiscal and monetary stimuli to absorb the effects of terrorism, while many developing countries lack this ability. Besides, developing countries are more dependent on other countries as compared to developed ones. Therefore, any economic shock

induced by terrorism in other countries can affect their economic growth.

Koh (2007) examines the impact of war of terrorism on global economy and the allocation of resources to research and development (R&D). Various costs that terrorism may have on the economy include the crowding out of private R&D expenditure by the military R&D expenditure to counter terrorism, thereby reducing economic growth. Besides, international corporations pursuing investment in other countries evaluate country risk and spend higher amount on security which acts as a barrier to the flow of investment to the developing countries and also increase the operational costs. Counter terrorism measures increase expenditure on security which also reduces expenditure on private R&D. The crowding out of private R&D by security related R&D would reduce the rate of innovation over time, thereby reducing economic growth in longer run.

Gaibulloev and Sandler (2009) investigated the impact of terrorism on per capita growth in Asia for the period 1970-2004. Study found significant growth limiting impact of terrorism. The impact seems to be stronger in the developing countries as compared to developed one because of the developed countries' resilience to terrorism due to their robust economies. Terrorist activities generated by internal conflicts were found to be twice as effective in reducing growth as compared to those of international conflicts. The main growth reducing impact comes from the crowding in of government expenditure and a loss of investment associated with the increase in terrorist activities.

Not only the terrorism affect the country where these activities are taking place, but also have their impact on the neighboring countries. Murdoch and Sandler (2004) analyzed the impact of civil wars on the neighboring countries. Study found growth reduction not only in the affected country but also it passed its effect to the neighboring country. The growth limiting impacts have both short run and long run impact on the affected economy as well as neighboring economies. In the short run, civil war can reduce the economic growth by as high as 85 percent in the affected economy, but however in the long run this effect is 30 percent. While for neighboring country the short run growth reducing impact is 24 percent, and 30 percent in the long run.

Gries et al. (2009) investigated the causality between terrorism and economic growth for seven western countries for the period 1950 to 2004. The causality runs from economic growth to terrorism as the poor economic performance manifested in low opportunity costs of violence, which may in turn, increase the conflicts and thus terrorism. On the other hand terrorism may cause low economic growth because accumulation and allocation of resources may be negatively affected by terrorism. Results indicate that important economic and political events have profound impact on the pattern of terrorism and also on economic growth. Besides, in most countries cases it is the economic growth that statistically causes the terrorism, however, their economies are resilient enough to withstand such terrorist attacks. Economic performance although make terrorism opportunity costs high enough to thwart such incidents, but it is also suggested that economic performance is not the only criteria to counter terrorism and political and social consideration must be taken into account by policy makers to counter terrorism.

Terrorism, Sectarianism, Ethnic Conflicts in Pakistan

Afghan War

Pakistan has been suffering from terrorism for the last three decades. Due to its geo-strategic position, Pakistan became a centre stage of terrorist activities. When the USSR attacked Afghanistan in 1979, Pakistan being a neighboring country had also to face the brunt of that invasion. It was first the Afghans who started their resistance with old weapons. Pakistan finding itself to be the next in the list of conquered countries by the USSR, had to retaliate by helping Afghans to stop the Soviet invasion. Afterwards, the US and her western allies joined the bandwagon to counter the spread of communist ideology. Pakistan served as the primary logistical channel for the Afghan resistance. The military aid from Pakistan and the US and financial backing from Arab countries enabled Afghans to drive the USSR out of Afghanistan in 1989.

After the USSR left, Pakistan and the Afghans were left alone by their former allies and a ruling power vacuum was created. A civil war for the power started in Afghanistan which had also repercussions for her neighboring country Pakistan. Various unstable

governments in Afghanistan were installed, but due to their weakness, Afghanistan faced worst kind of law and order situation in the country. It was during that time, Afghans (disappointed with civil war) were waiting for some strong government which could stabilize the law and order situation in Afghanistan.

This strong form of government came in the shape of former Afghan students (Taliban) of Madrassas (religious schools) operating in Afghanistan and Pakistan. Taliban had a strong government and controlled the law and order situation much more forcefully. But the government of Taliban was only formally accepted by Pakistan, Saudi Arabia and the UAE only. Their non-acceptance by other countries secluded them from mainstream global community. Finding a good base for propagation of their version of radical Islam, the earlier Arab Mujahedeen (those who fought against Soviet Union) also returned back along with new Arab, Central Asian Islamists and African Mujahedeen.

Al-Qaeda was founded by once blue eyed boy of the US, Osama bin Laden. After 9/11 attack, US alleged Al-Qaeda for this attack and in retaliation attacked Afghanistan, overthrew Taliban's government. Infuriated by foreign invasion on their motherland another war for independence of Afghanistan was started. Taliban were also joined by the other former Mujahedeen organizations. The US pressure on the then Pakistani president Musharaf government led Pakistan to take U turn by closing its ties with their former friends, i.e. Taliban. Since Afghanistan is a landlocked country, therefore, Pakistan provides the transit route for the US military equipment to Afghanistan. Pakistan also provided air bases to the US air force.

After the US attack on Afghanistan, tribal people in the Federally Administered Tribal Area (FATA) formed Tehrik-e-Taliban Pakistan (Student Movement of Pakistan). Some of those radical Islamists had previously fought against the USSR in Afghanistan and new recruits joined the Pakistani Taliban and took control of the most parts of the FATA and practically Pakistan government lost her control over most of the FATA. The Pakistani Taliban wanted to fight against the US in Afghanistan and also asked Pakistani government to take back her support to the US. Besides, they wanted to implement their own version of Islam in Pakistan. Pakistan's government retaliated by

starting military operations against the Taliban in FATA and Swat, where Taliban had control. Besides military operations the US started attacks on tribal areas of Pakistan by unmanned aerial vehicles (UAV) to target Taliban and Al-Qaeda leadership. The collateral damage in terms of human and property losses due to military operations and the UAV attacks resulted in retaliation by Taliban. They targeted military, police and other security agencies and current wave of terrorism in Pakistan is led by those Taliban.

Ethnic Conflict

During the eighties Pakistan was also in the grip of ethnic strife in the province of Sindh mainly in the capital city, Karachi. Various factions were involved in ethnic conflicts in Karachi. Karachi is the centre of economic activities. Due to ample business and employment opportunities, people from all over Pakistan are attracted to reside in Karachi. Besides the natives i.e. Sindhis, residents of other three provinces of Pakistan all came to Karachi. Over time, ethnic segregation continued and this segregation later resulted in ethnic conflicts. These conflicts started in mid 80's and were at peak in 1990's. Both Pakistan People's Party and Muslim League governments initiated military operations during 1990's. These operations were partially successful. Later on in the first decade of the twenty first century, although, these ethnic conflicts came to a halt, however, unrest still continued in the form of increased criminal activities. The most prominent of these criminal activities is extortion, especially from businessmen. Although, a new operation is being launched against these criminal activities, however, there is little success in controlling, which is evident from the rampant crimes in Karachi.

Sectarian Conflict

Pakistan was also plagued by sectarian conflict in 1980s. These sectarian conflicts involved mainly two major sects of Islam, both living in Pakistan. During the eighties, Zia Ul Haq regime tried to implement Islam in Pakistan. However, since there are differences over some religious issues between those two sects, therefore, the implementation of Islam by Zia regime was not equally acceptable. During the Afghan War in 1980's, funds flow from Middle Eastern

countries to religious factions to fight against former Soviet Union in Afghanistan. These funds, however, also enabled religious factions to build their militant groups, which were later used in sectarian conflicts (Chandran, 2003).A wave of terrorism based on sectarian differences resulted in killing and injuring of key leaders of both factions and also resulted in collateral damage to private citizens and property.

Besides those religious and ethnic conflicts, another factor came in the shape of Baloch nationalism. Baluchistan was formerly an independent state, which in 1951 decided to merge with Pakistan. However after some time Balochs felt that their resources were exploited by central government, while they are not given their due share in those resources. This is because Balochistan is rich in oil and gas, and the biggest natural gas reserve in Pakistan is situated in Balochistan. This sense of deprivation led them to start militant struggle. Military operations were carried out against those militants in 70's and uprising was suppressed. However this new kind of militancy again started in 2000's.

Data and Estimation

Theoretical and Empirical Model.

In theoretical context, Terrorism have adverse impacts on the economic growth, these impacts are transmitted through various channels. First and foremost, terrorism destroys physical and human capital of a country. Terrorism often results in the collapse of health and educational infrastructure; leading to scarcity in the clean drinking water and facilities of sanitation, medical care, deterioration in the standard of education, low enrollment rates all of these have negative implications for economic growth. Second, it restricts the trade and business activities leading to restrain the economic growth. Third, due to increased perception of risks, terrorism may reduce the inflows of Foreign Direct Investment (FDI) and as FDI is a crucial part in the investment activities in most of the developing countries and any decrease in FDI will reduce the economic growth. Besides FDI, instability and risks in a country will also result in reducing the investment by its own residents and will also cause the capital flight. Fourth, terrorism also diverts the public expenditure from developmental activities towards less productive defense activities. Fifth, terrorism

also causes the displacement of people in the terrorism hit areas and it not only creates social problems but also results in economic problems.

To derive the theoretical model for the present study, the Solow (1957) new classical model provides the necessary foundations; however, it has ignored the role of human capital in the determination of economic growth. To overcome this Mankiw, Romer and Weil (1992) has incorporated the human capital in the growth models. So we can specify the model as:

Economic growth (Y) is assumed as a function of the stocks of physical capital (K), Labor force (PoP), Human capital (HC) and a vector of other variables (Z) including terrorism and technology.

Y = f (K, PoP, HC; Z)

On the basis of the theory and available empirical studies[4] on the terrorism, the following reduced form equation can be derived:

$$y_t = \propto + \beta pop_t + \gamma k_t + \omega hc_t + \delta op_t + \rho fa_t + \theta ter_t + \varepsilon_t$$

Where, y_t denotes per capita GDP and is used as dependent variables. α is intercept while pop, k, hc, op, fa and ter represents population growth rate, human capital, gross capital formation, openness, foreign assistance and terrorism. The $\beta, \gamma, \omega, \delta, \rho$ and θ are coefficients of respective variables and ε_t is the error term.

In the study data has been used for the period 1981-2012. The detailed description of the variables and their data sources is presented in table 1A in the appendix.

4- See Murdoch J.C. and Sandler T. (2004), Bloomberg et. al. (2004)

Empirical Methodologies and the Results

Before estimating the model the first step is to check for the stationarity. According to Newbold (1974) in the case the series is not stationarity (or the presence of unit root) the OLS estimation may yield spurious results. To check the stationarity of the variables Augmented Dickey Fuller (ADF) test has been used and the results are summarized in Table 2A in the appendix.

Results reveal that all the variables are non-stationary at level so the null hypothesis of unit root at level cannot be rejected. But in the case of first difference, null hypothesis of unit root is rejected for all the variables hence all the variables are integrated of order 1 i.e. I(1). To handle the spurious regression most appropriate way is to use the co-integration technique. To test the co-integration among the variables, there are two main techniques; Engle and Granger (1987), and Johansen (1988) approach. As the number of variables in the study is more than two, so we apply cointegration procedure developed by Johansen (1988).

There are four different steps involved while testing cointegration, in the first step order of stationarity is determined and variable must be stationary at same level. We have already found that variables are stationary at first difference i.e. series of the model are I (1). Therefore, the cointegration can be determined between the variables. Second step involves choosing the optimal lag length. To determine the lag length VAR model has been used and on the basis of AIC criteria, the lag length of one for the model is determined. Next step deals with determining the number of co-integrating vectors. In the study, both trace statistic and eigen value statistic are used.

The results of both of the statistics are summarized in tables in the appendix3A and table 4A respectively. In the fourth step the normalized equation of the co integration equation is analyzed, the

results of the normalized cointegrating equation are presented in table 1. Both the Trace and Maximum Eigen value tests suggest that there exist three co-integrating vectors.

Table 1:

Normalized cointegrating coefficients

Name of the variable	Coefficient	Standard Error	T statistic
POP	-1.834202*	0.05509	-33.29464
KT	0.332599*	0.03312	10.04224
HC	0.100521*	0.01409	7.134208
TER	-0.031129*	0.00228	-13.65307
OP	0.132276*	0.0389	3.400411
FA	0.050816*	0.0044	11.54909
Log likelihood:	284.1438		
Adjustment Coefficient	-0.33774*	-0.1152	2.931745

* denotes significance at 5% level

The normalized cointegration coefficients (summarized in table 1) reveal that in the long run population growth rate is a major obstacle to economic growth in Pakistan as its coefficient is largest among the selected variables. These finding are in accordance with the Malthusian theorem and many other studies including Naqvi (2010). It highlights the importance of the extended efforts to cap the ever-growing population in Pakistan. Although the gross capital formation is positively affecting the economic growth in Pakistan but the coefficient is not significant. Primary school enrollment is found to be having a positive and significant relationship with per capita GDP; these results are consistent with the theory and numerous studies also come to the same conclusion that human capital have a positive role in economic growth (Mankiw, 1992). Consistent with expectations, openness is significant with positive sign in all the specifications. It supports the findings of Akram (2010), Pattilo (2002), Coe (1995), and Lucas (1988). The coefficient for indicator of terrorism shows negative and statistically significant impact on economic growth. This implies that terrorist activities in Pakistan are resulting in hampering of economic growth. This finding is in accordance with the findings of the earlier panel data studies of Gaibulloev (2009), Bloomberg (2004) and Murdoch (2004).

Results also indicate that during the period of Afghan wars where Pakistan has received most of its economic assistance, the per

capita GDP growth rate is 22.3 percent higher than the other period. This result may indicate that Pakistan has used foreign economic assistance for its growth. However, it seems from the data that these funds were utilized in non developmental sector and a sense of false boom in economic growth is created. This is because if these funds were used in developmental activities, then it was more likely that economic growth would have maintained itself after the drying up of foreign aid. This is evident from the annual growth rate of per capita GDP, which was as high as 7.05 and 4.92 percent in 1980 and 1981 (when Pakistan was receiving more foreign assistance) as compared -0.76 percent and 1.17 percent in 1993 and 1994 (when Pakistan was receiving less foreign economic assistance). If Pakistan uses these funds sagaciously by developing basic infrastructure then it may have been able to minimize the negative consequences of the terrorism and there was a possibility that positive effect may outweigh the negative impacts of terrorism on the economic growth.

Conclusions, Policy Implications and Future Research Directions:

Over the years continued state of insurgency in Pakistan is causing damages to the country in all the aspects including economic aspect. Besides the non measurable loss to humans, other major economic costs of the terrorism include poverty, capital flight, destruction of infrastructure, reduction in FDI and exports, low public revenues and diversion of the development expenditure to the expenditure on law and order maintenance and so forth. All these economic costs have significant impact on economic growth, e.g. one of the major contributors is the recent violence and terrorist activities in Pakistan which caused the overall GDP growth in 2010 to fell to 1.6 per cent.

Our study also reveals the same picture, as one percent increase in terrorist incidents is resulting in reducing the per capita GDP growth by 0.39 percent. This impact may not reveal the negative externalities associated with terrorist activities like the lost FDI, reduction in international trade, loss of trade and business activities in Pakistan due to fear of terrorism. With this background it is very clear that terrorism has significantly affected our economy and for a sustainable economic growth, Pakistan needs peace and harmony. So it is important that all sort of action be taken to curb the terrorism.

Another important implication that emerged from the present study is that over the years the economic aid that is being provided by the donor agencies, in the aftermath of the Pakistan participation in the wars against terrorism, has helped the country. Therefore it is strongly recommended that at this critical juncture of country's history, international community may once again stand with Pakistan (not by word but with actions) to help the country by providing assistance in the shape of grants and debt rescheduling and access to the markets. Because underdevelopment and poverty, can provide fertile grounds to terrorists for new recruits.

It may also be noted that as the effects of terrorism are transmitted to economic growth through various channels including FDI, Exports, Stock Exchange activities and so forth. So it is equally important that future studies may be conducted that could analyze the impact of terrorism on the above stated individual components of GDP.

Note:

The views presented in the paper are the author's personal and do not reflect the views of the affiliated institutions.

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Appendix

Table 1A:
Data and Variables Description

Sr. No.	Name of Variable	Data Source	Comment
1.	Per Capita GDP (Yt)	WDI[5]	Current GDP in PKR/ Population
2.	Investment (Kt)	WDI	Gross capital formation as percentage of GDP used as proxy for Physical Capital/Investment
3.	Labour (pop)	WDI	Population growth rate
4.	Openness (op)	WDI	(Exports + Imports)/GDP*100.
5.	Foreign Assistance (FA)	--------	Dummy variable[6] to capture the structural policy break in the economic growth and terrorism relationship.
5.	Human Capital (HC)	Publications of the State Bank of Pakistan (SBP)	Primary School Enrolment used as proxy for human capital.
6	Terrorism (TR)	Global Terrorism Database	Number of terrorist events in a year.[7]

5-WDI stands for World Development Indicators 2014

6-For the period 1981-87 and 2002-2008 it has been assigned value 1 because during that period due to the participation in the Afghan War against Soviet Union and war against terrorism after 9/11; Pakistan has been provided foreign assistance in the shape of aid, grants, debt rescheduling etc. But during the middle period 1988-2001 and also after 2008 (due to lack of confidence between Pakistan and USA on war on terror) very little assistance is provided as compared to the war periods. It worth noting that as the foreign assistance provided to Pakistan during period of Afghan Jihad and War against terrorism is many fold, so only use of data of Aids/Grant or Concessional loan etc. may not serve the purpose therefore a dummy variable is being used.

7-Although in some of the empirical studies other indicator like number of causalities, injuries and damage to physical assets. But a terrorism event, whether it results in human or physical loss or not, give negative signals to economic agents both local and foreign. Consequently, Exports, FDI and activities in Stock Exchanges etc are badly affected.

Table 2A:

Results of ADF Test

Name of Variable	Level			1st Difference		
	Intercept	**Trend & Intercept**	**None**	**Intercept**	**Trend**	**None**
Yt	-0.392870	-2.947643	2.558856	-3.088032	……	……
Kt	-1.386556	-1.215438	0.3830636	-4.814776	……	……
PoPt	-1.224127	-2.933984	-1.483096	-6.794995	……	……
HCt	-1.191100	-1.972801	2.1125515	-4.869828	……	……
TERt	-1.530764	-1.760168	0.5003665	-4.525888	……	……
Opt	-2.229294	-2.409988	-0.11777	-5.134892	……	……

Null Hypothesis: Existence of unit root, * and ** denotes the rejection of Null at 1% and 5% level respectively

Table 3A:

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	**Eigen value**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.960441	221.0520	125.6154	0.0000
At most 1 *	0.914253	137.0733	95.75366	0.0000
At most 2 *	0.706240	73.20802	69.81889	0.0261
At most 3	0.554040	41.35823	47.85613	0.1775
At most 4	0.447416	20.36257	29.79707	0.3985
At most 5	0.170817	4.940702	15.49471	0.8151
At most 6	0.002709	0.070523	3.841466	0.7906
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level				
*** denotes rejection of the hypothesis at the 0.05 level**				
****MacKinnon-Haug-Michelis (1999) p-values**				

Table 4A:

Unrestricted Cointegration Rank Test (Maximum Eigen value)

Hypothesized No. of CE(s)	**Eigen value**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.960441	83.97874	46.23142	0.0000
At most 1 *	0.914253	63.86523	40.07757	0.0000
At most 2	0.706240	31.84980	33.87687	0.0856
At most 3	0.554040	20.99565	27.58434	0.2765
At most 4	0.447416	15.42187	21.13162	0.2604
At most 5	0.170817	4.870179	14.26460	0.7581
At most 6	0.002709	0.070523	3.841466	0.7906
Max-eigen value test indicates 2 cointegratingeqn(s) at the 0.05 level				
*** denotes rejection of the hypothesis at the 0.05 level**				
****MacKinnon-Haug-Michelis (1999) p-values**				

Unit Root Test:

Unit root test is used to check weather data is stationary or not. A process is said to be stationary if its probability distribution remains unchanged as time proceeds and we can say that data generation process does not changed. To test the unit root most widely used test is Augmented Dickey Fuller (ADF) test. The general form of ADF test can be written at level and first difference form as follows.

$$\Delta x_t = \alpha x_{t-1} + \sum_{i=1}^{k} \beta_i \Delta x_{t-1} + \vartheta + \gamma_t + \varepsilon_t$$

$$\Delta\Delta x_t = \alpha \Delta x_{t-1} + \sum_{i=1}^{k} \beta_i \Delta\Delta x_{t-1} + \vartheta + \gamma_t + \varepsilon_t$$

Co-integration:

This technique depends on direct investigation of cointegration in the vector auto regressive (VAR) representation. It yields maximum likelihood estimators of the unconstrained cointegration vectors and it allows one to explicitly test for number of cointegration vectors so that the weaknesses of Engle- Granger (1987) two-step procedure are overcome. Engle and Granger (1987) technique is a two-step methodology and stability deviations from the relationship is examined by using the coefficients estimated after fitting static regression. However, the test suffers from a number of short comings. The basic assumption of the technique is that the cointegrating vector is unique, bounding to a model that is a linear combination of independent cointegrating vectors. However, if cointegrating vector is not unique it fails to address the situation. Moreover, it examines only the dominant cointegrating vector between series.

If there is a VAR of order p

$$yt = \alpha_1 y_{t-1} + \alpha_2 y_{t-2} \ldots\ldots\ldots\ldots \alpha_p y_{t-p} + \beta x_t + \epsilon_t$$

Where y_t is a k-vector of non-stationary I (1) variables, is a x_t is a d-vector of deterministic variables, and ϵ_t is a vector of innovations. We may rewrite this VAR as,

$$\Delta yt = \bigcup y_{t-1} + \sum_{i=1}^{p-1} \bigvee_i \Delta y_{t-i} \quad + \beta x_t + \epsilon_t$$

Where

$$U = \sum_{i=1}^{p} A_i - I$$

$$V_i = -\sum_{j=i+1}^{p} A_j$$

Granger's representation theorem asserts that if the coefficient matrix U has reduced rank r,k then there exists k×r matrices α and β each with rank r such that U= αβ' and $\beta' y_t$ is I(0). r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. The elements of are α known as the adjustment parameters. Johansen's method is to estimate the matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of U.