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AN IMPLICATION OF IMPULSE RESPONSE FUNCTION IN THE PERSPECTIVE OF GREEN REVOLUTION, CREDIT DISBURSEMENT, AND FOSSIL FUEL UTILIZATION IN PAKISTAN

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ABSTRACT

Recently, credit disbursement and fossil fuel utilization increased to enhance wheat production so peasants could benefit from the green revolution. To look at the impact of credit disbursement, fossil fuel utilization, and the determinants of the green revolution were arranged to investigate the association among them. For this purpose, the study employed the time series in the perspective of Pakistan, spanning 1971 to 2019. Modern econometrics techniques like Johansen cointegration, vector autoregressive and impulse response function were employed along with a number of diagnostics tests. Evidence of the Johansen model shows significant long-run cointegration among the green revolution, credit disbursement, fossil fuel, and total wheat production. The Johansen test elaborates that 1% increase in credit disbursement and fossil fuel increases the total wheat production by 0.57% and 0.04 % respectively. Moreover, the determinants of the green revolution also positively affect wheat production. While the coefficient, residual and stability diagnostic tests are in favor of the study. The findings of the impulse response function state that all the concerned variables positively affect the total wheat production in the coming years. The study suggested that the government and private sector should invest in research and development to introduce the organic chemical and forming to avoid soil fertility and environmental degradation.

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INTRODUCTION

Agriculture and other sectors play an extensive and indispensable role in any economy's socio-economic development and economic growth (Singh et al., 2016; Ali et al., 2020). Agriculture is still the largest sector in terms of livelihood and provides the raw material for many industries in the economy. In developing economies like India and Pakistan, labour mainly participates in agriculture. The inhabitants of rural and urban areas are directly or indirectly contingent on agriculture. Pakistan is the world's 5th populated country, so its food requirements are increasing. Therefore, the agriculture sector has considered the backbone of the economy (GOP, 2020). Moreover, the population of the whole world is increasing, which is also creating massive pressure on the demand for agricultural goods. Nowadays, it has become a core source of revenue for the economy (export). However, agriculture's share in the gross domestic product has declined as it contributes about 19.3 percent to the gross income (GOP, 2020). However, we know that agriculture has much more potential, which can achieve while employing the latest technological innovation. In Pakistan, there are two types of cropping seasons. The first season is "Kharif," which includes Rice, Sugarcane, Cotton, Maize, Moong, Mash, Bajra, and Jowar, cultivated from April to June and harvested from October to December. The "Rabi" second cropping season runs from October through December and is harvested in April and May. Wheat, Gramme, Masoor, Tobacco, Rapeseed, and Barley are the Rabi crops (GOP, 2020; Rehman et al., 2016a). Wheat is one of the significant and second-biggest crops cultivated in Pakistan. However, about 80% of peasants produce their lands in the "Rabi" season and grow wheat on 40% land out of the total cultivable land. Besides providing energy and protein, it is a staple food item. In Pakistan, wheat flour consumption per adult is 124kg per year and delivers 72% calories daily (Zegeye et al., 2022).

After a much-admired improvement in agricultural technology, pesticides, and fertilizers, wheat is still cultivated on only 40 percent of total cultivable land. Nevertheless, peasants persistently focus on wheat production and provide food security despite the increasing papulation (Asim et al., 2015; GOP, 2020). The statistics of wheat production have presented in Figure 1. In Pakistan, about 70% to 80% of the area is watered through a canal, and almost 93 percent of freshwater resources are used in irrigation (Anetor et al., 2016; Rehman et al., 2016b). However, the added value is subject to agricultural labor, available finance, inputs like fertilizers, improved seeds, and pesticides. Akudugu (2016) elaborated with the help of Cobb-Douglas Production Function while utilizing the data from 1972 to 2017 that due to its positive impact on the output, it is considered that fertilizers are the fundamental pillar of the high yield and are believed to contribute up to 50 percent in the product (Eyasmin et al., 2017). In sub-Saharan Africa, participation of improved seeds, fertilizers, pesticides, and new agri-based technology is required to get a high yield (Admassie and Abebaw, 2021; Payumo et al., 2017).

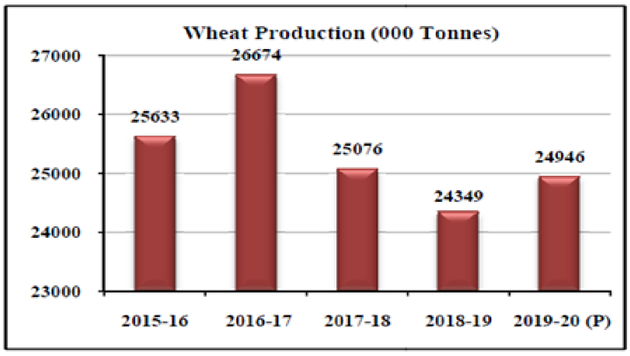

Figure 1. Wheat Production (Source: Economic Survey 2019-20).

However, the work of Twumasi et al. (2019), Jan et al. (2017), Ahmad et al. (2015), and Asim et al. (2015) exposed that credit disbursement for the cultivation of wheat amplified the production significantly. On the other hand, water shortage, less rainfall, and land degradation also reduce food production (Sarkar et al., 2020). After a careful estimation, nearly 80 percent of agriculture in the world depends on rain-fed land, assisting in meeting 80% of global foodstuff (Bakhshianlamouki et al., 2020; Rehman et al., 2015). However, the 40 percent area of Uzbekistan and 95 percent area of North Africa and West Asia are rainfed areas that are influenced by water deficiencies (Tadesse et al., 2017).

While in Pakistan, about 12.53 million hectares of land are irrigated with tube wells, 6.35 million hectares with a channel and a residual 3.59 million hectares of land have no irrigation facility (GOP, 2020). Inadequate water availability for the cultivation of wheat reduces its productivity (Oweis and Hachum, 2006; Bashir et al., 2010; Tavakkoli and Oweis, 2004). Micro-watershed management can minimize water deficiencies (Zakaria et al., 2012). With the implementation of this method, a country can intensify water per unit cropped area, which in turn enhances the total yield (Oweis and Hachum, 2001; Ramotra and Giakwad, 2012; Rehman et al., 2016b).

METHODOLOGY

This work is arranged to capture the impact of the green revolution's components on economic growth with particular reference to Pakistan by utilizing the annual data for 1971–2019. For this purpose, data were collected from world development indicators and different issues of the Pakistan Economy Survey. The total wheat production was measured in thousand metric tonnes (TMT) and employed as the dependent variable. While, independent factors included the total cultivated area for the wheat crop (Million Hector, (MH)), fossil fuel utilization (Thousand Litter (TL)), total credit disbursement (Billion Rupees (BR)), improved seeds (Thousand Tonnes), fertilizers (Thousand Tonnes), pesticides (Thousand Litter), irrigation (Million Acre Feet) and gross domestic product (Current US$) as a proxy of economic growth.

Firstly, we applied a technique to investigate the stationarity in the data. It is a prerequisite to check the stationarity in the annual data. This work used the augmented Dickey and Fuller (1981) and Phillips–Perron tests (1988), recognized and considered appropriate stationarity procedures. Mathematically, the ADF test is expressed.

$$\Delta A_t = \beta A_{t-1} + \sum_{j=1}^{p} \beta\, \Delta A_{t-1} + \eta_t \quad (1)$$

$$\Delta A_t = \delta_0 + \alpha A_{t-1} + \sum_{j=1}^{p} \beta_i\, \Delta A_{t-1} + \eta_t \quad (2)$$

$$\Delta A_t = \delta_0 + \delta_{1t} + \alpha A_{t-1} + \sum_{j=1}^{p} \beta_i\, \Delta A_{t-1} + \eta_t \quad (3)$$

Where " δ_0 " is intercept and δ_{1t} is the coefficient term, while η_t is the white noise and precis "j" starts "1" towards "p" are the lags which are determined by the Akaike information criteria. While the PP test allows a slight hypothesis regarding the distribution of white noise. The test PP is reported as:

$$\Delta A_t = \alpha + \beta A_{t-1} + \varepsilon_t \quad (4)$$

The ADF includes different lags to the right side to eliminate the serial correlation problem, whereas the PP test removes the serial correlation. Then, Johansen cointegration was used to assess the long-term relationship between total wheat production and descriptive variables, recognizing the stationarity. This study scrutinizes the long-term movements of variables utilizing the Johansen cointegration test (1988, 1991). This test comprises trace and max eigenvalue. Both tests are expressed as follows.

$$J_{trace}(h) = -R \sum_{l=h+1}^{n} \ln(1-\rho_l) \quad (5)$$

$$J_{\max}(h+1) = -R \ln(1-\rho_{h+1}) \quad (6)$$

Anyway, R represents the sample size ρ as the assessed value for the lth order. While the eigenvalue is extracted from the matrix *π*, *h* denotes the number of cointegrating vectors. J_{Trace} test (*h*) is executed to test the hypothesis N_0: rank ≤ *h* contrary to N_1: rank *π* > *h*. Whereas N_0: rank *π* ≤ *h* contrary to N_1: rank *π* = *h + 1* is checked for J_{Max} (*h + 1*) (Kocenda and Cerny, 2014; Praburaj et al., 2018).

Empirical Results

Table 1 descriptively elaborates the feature of the variables encompassed in this study from 1971 to 2019. Results elaborate that the average value of the total wheat production of 16624.9 TMT lies between 26674 (maximum) and 6476 (minimum). The average area devoted to wheat production is about 7812.55 MH. The average oil utilization in the production of wheat is about 183498 TL. The credit disbursement for the production of wheat is about 151729 BR. The utilization of improved seeds is about 168 MT. While the average use of fertilizers is about 2377.03 TT, along with the utilization of pesticides at about 2350.52 TL, the irrigation average is 16.9 MAF, and the gross domestic product is about 9.5 M$. All values of stated variables lie between the minimum and maximum values mentioned in Table 1, which are presented as follows. Figure 2 elaborates on the periodic intensification from 1971 to 2019. The unit root tests (ADF and PP tests) primarily analyze the data with a constant and deterministic trend for zero mean and constant variance. Whom estimations are presented in Tables 2 and 3.

Table 1. Descriptive analysis.

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarq-Bera
TWP	16624.9	16651	26674	6476	6148.24	0.009	1.74	3.19
TWA	7812.55	8058	9224	5797	992.26	-0.6	2.34	3.89
FF	183498	234563	330407	12671	103560	-0.49	1.74	5.2
CRD	151729	19515	972606	128.8	249590	1.94	5.78	46.77
IS	168.02	93.55	497.4	18.1	140.83	1.01	2.85	8.44
FZ	2377.03	2183.06	5040	283.2	1373.94	0.13	1.84	2.87
PS	2350.52	2183.06	5040	279.2	1345.2	0.1	1.86	2.73
IG	16.9	17.33	20.06	10.59	2.25	-0.67	2.64	3.96
G	9.5438	6.0678	3.1457	6.3256	9.1987	1.10018	2.84953	9.93114

Source: Author(s) calculation

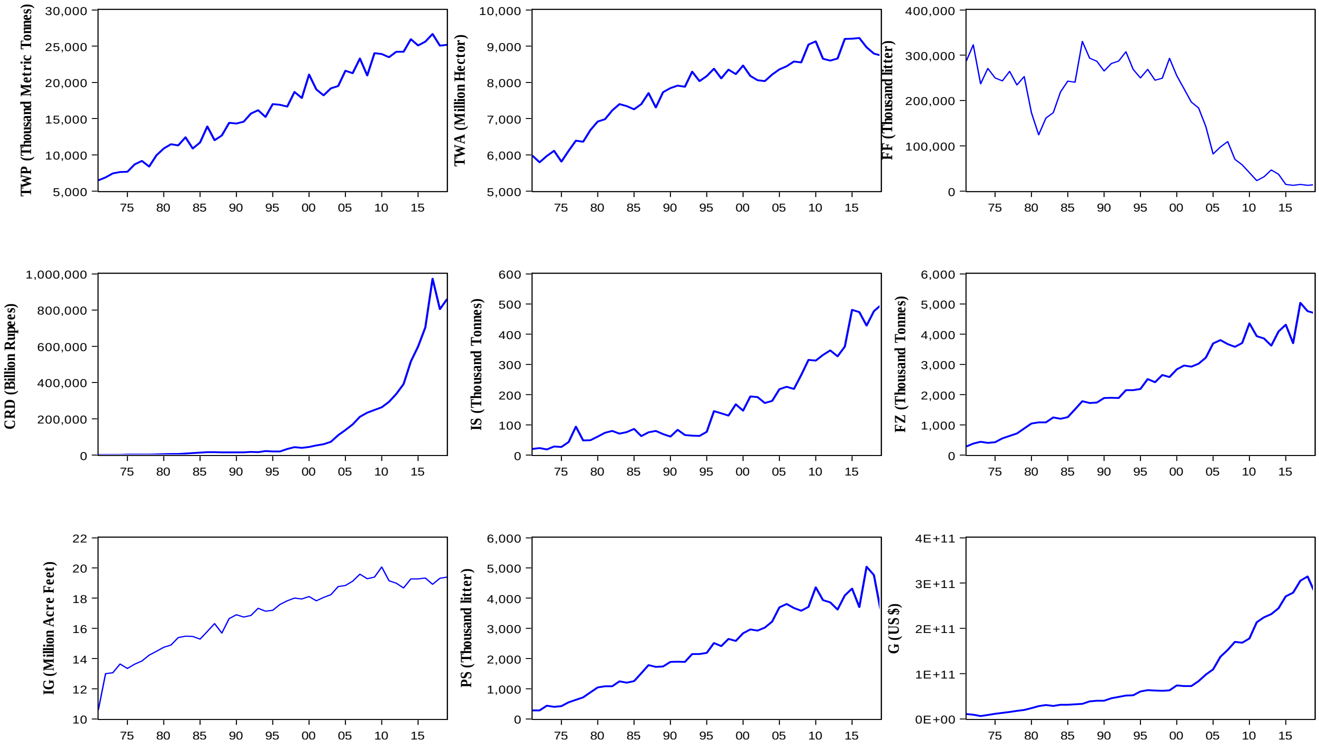

Fig 2. The trend of the variables.

Table 2. ADF results.

Variables	Constant Value		1st Difference Value		
	t-state	Prob.	t-state	Prob.	Conclusion
TWP	-0.88	0.78	-8.37	0.00	I(1)
TWA	-2.05	0.26	-8.37	0.00	I(1)
FF	-0.70	0.83	-7.92	0.00	I(1)
CRD	2.69	1.00	-6.94	0.00	I(1)
IS	0.90	0.99	-7.62	0.00	I(1)
FZ	-0.05	0.94	-8.15	0.00	I(1)
PS	-1.17	0.67	-9.48	0.00	I(1)
IG	-2.60	0.16	-11.12	0.00	I(1)
G	1.75	0.99	-3.71	0.00	I(1)

Source: Author(s) calculation

Table 3. PP results.

Variables	Constant Values		1st difference		
	t-state	Prob.	t-state	Prob.	Conclusion
TWP	-0.90	0.77	-18.21	0.00	I(1)
TWA	-1.81	0.36	-8.82	0.00	I(1)
FF	-0.60	0.85	-7.87	0.00	I(1)
CRD	2.70	1.00	-7.07	0.00	I(1)
IS	2.51	1.00	-7.93	0.00	I(1)
FZ	0.18	0.96	-25.36	0.00	I(1)
PS	-1.31	0.61	-8.52	0.00	I(1)
IG	-3.76	0.00	-12.22	0.00	I(0)
G	1.65	0.99	-3.57	0.00	I(1)

Source: Author(s) calculation

Table 4. Trace statistics.

Null Hypothesis	Alternative Hypothesis	Eigen Values	Trace Value	5% Critical Value	Prob.	Hypothesized no. of CE (s)
N_0: h = 0	N_1: h = 1	0.97	350.03	197.37	0.00	None*
N_0: h ≤ 1	N_1: h = 2	0.63	177.05	159.52	0.00	At most 1*
N_0: h ≤ 2	N_1: h = 3	0.54	129.28	125.61	0.02	At most 2*
N_0: h ≤ 3	N_1: h = 4	0.50	91.80	95.75	0.09	At most 3

Source: Author(s) calculation.

Table 5. Max-Eigen statistics.

Null Hypothesis	Alternative Hypothesis	Eigen Values	Max-Eigen Value	5%Critical value	Prob.	Hypothesized no. of CE (s)
N_0: h = 0	N_1: h = 1	0.97	172.98	58.43	0.00	None*
N_0: h ≤ 1	N_1: h = 2	0.63	74.76	52.36	0.03	At most 1*
N_0: h ≤ 2	N_1: h = 3	0.54	53.47	46.23	0.04	At most 2*
N_0: h ≤ 3	N_1: h = 4	0.50	32.89	40.07	0.16	At most 3

Source: Author(s) calculation.

The results elaborate that all the concerning variables are stationary at first difference. So, we discard the null hypothesis of non-stationarity. After a detailed examination of mean and covariance, the Johansen cointegration test was applied. This technique is utilized to determine the long term affiliation between the variables. Moreover, this method comprises two segments: trace statistics and the max-Eigen values. The results of the Johansen tests are presented in Tables 4 and 5. The trace statistics find the three cointegrated vectors because their trace values are more than the 5% critical value. While the second part also affirms three cointegrating vectors as the max-Eigen statistic value is more than 5% critical. In light of the results, all variables in the Johansen cointegration are endogenously and exogenously cumulatively cointegrated. Moreover, the long-term affiliation does prevail among the total wheat production and the possible determinants of the green revolution included in this work. Table 6 depicts that if there is a one percent increase in the TWA, FF, CRD, FZ, IS, IG and G then the total wheat production will be enhanced by 0.694%, 0.572%, 0.049%, 0.782%, 0.153%, 2.615% and 1.729%, respectively.

The study employed a number of coefficients, residual and stability diagnostic tests. The results of the CUSUM and CUSUMSQ are stable because their respective lines are within the boundaries at a 5% significance level. These outcomes suggest that the model is reliable and stable in the existing circumstances.

Table 6. Normalized Cointegrating.

1 Cointegrating Equation(s)								
Coefficients (standard error in parentheses)								
Ln TWP	Ln TWA	Ln FF	Ln CRD	Ln IS	Ln FZ	Ln PS	Ln IG	Ln G
1.000000	0.694	0.572	0.049	0.153	0.782	0.681	2.615	1.729
-	(0.716)	(0.058)	(0.064)	(0.074)	(0.206)	-0.316	(0.965)	(0.147)

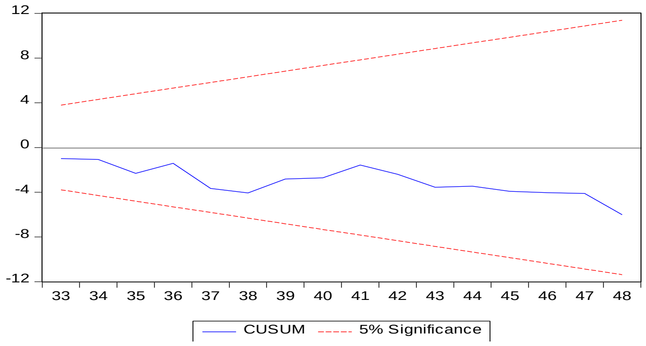

Figure 3. Stability Check CUSUM Test.

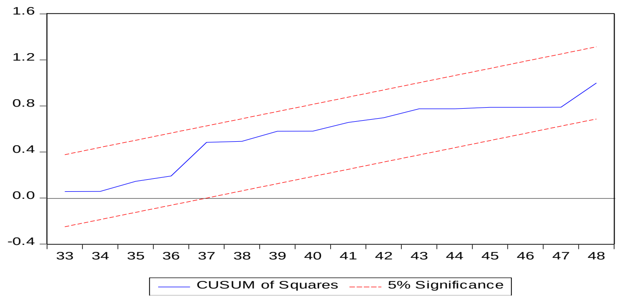

Figure 4. Stability Check CUSUMQ Test.

Data carry a lot of information; to extract that information, VAR is the best approach, as it deals with all variables on the same line, meaning that there are no endogenous and exogenous variables. Moreover, the VAR method has also employed some policy experiments to divert the course of the variables. Sims (1980) introduced this approach to capture the variables' connection and fluctuating response. When one variable fluctuates from its equilibrium position, then what will be the response of other variables in the system, outcomes of the VAR are demonstrated in Table 7.

The result denotes a long-term association among the variables. To dig up further, we take the help of the impulse response function, which thoroughly explains the response of one variable when the other variable in the system fluctuates from its position. The result of the vector autoregressive approach is presented in Figure 05.

When a standard deviation shock of possible determinants of the green revolution is given to the total wheat production, the results show that the fossil fuel, credit disbursement improved seeds, fertilizers, pesticides, and the availability of water (irrigation) enhanced the wheat production in the long run and positivity and significantly affect the growth rate of the country.

Table 7. Vector Auto-Regressive Model.

	Ln TWP	Ln TWA	Ln FF	Ln CRD	Ln IS	Ln FZ	Ln PS	Ln IG	Ln G
Ln TWP(-1)	0.065	-0.010	1.002	-0.076	0.610	0.155	0.089	0.087	-0.032
	-0.191	-0.061	-0.700	-0.448	-0.630	-0.256	-0.275	-0.049	-0.232
	[0.338]	[-0.164]	[1.431]	[-0.171]	[0.968]	[0.606]	[0.323]	[1.766]	[-0.141]

Source: Author(s) calculation

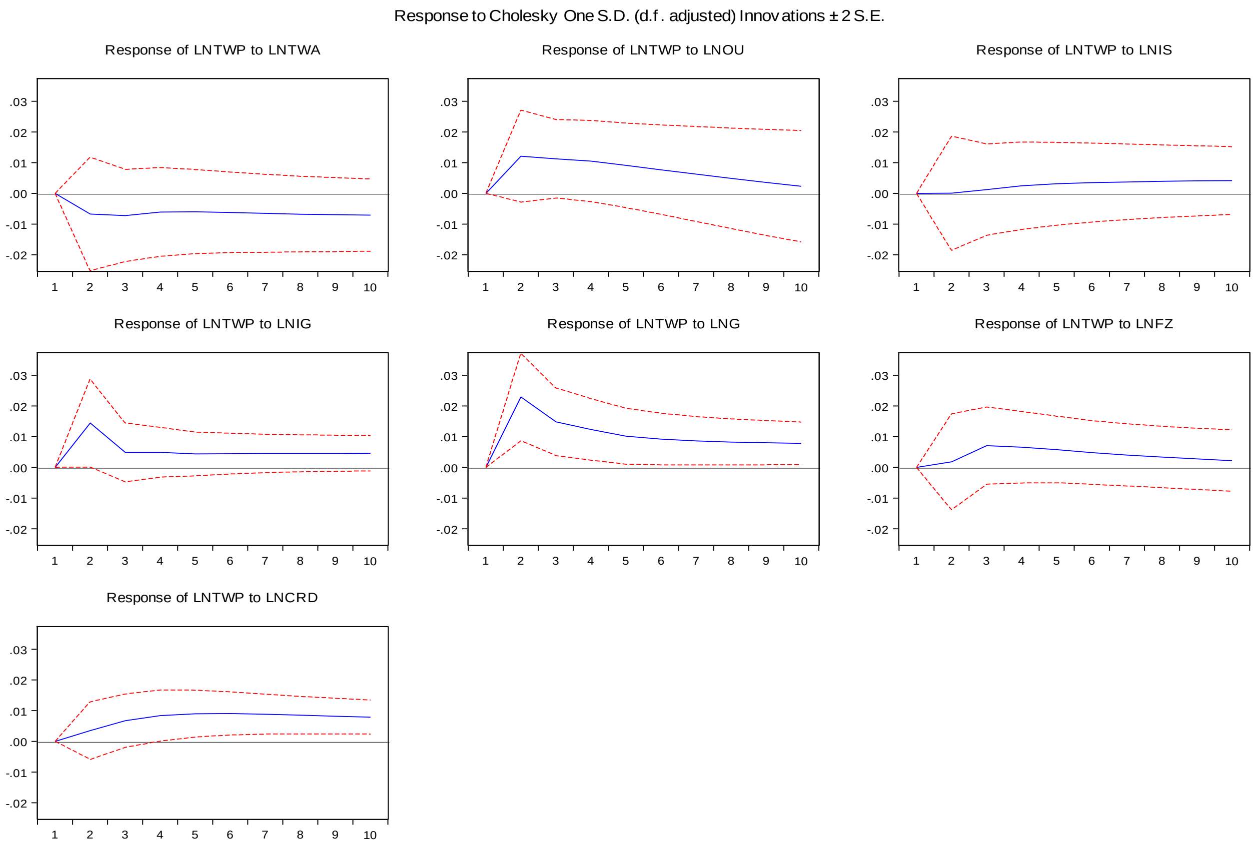

Figure 5. Impulse Response Function.

However, if the standard shock of the total wheat area is given to all the variables, then the response shows that the change of regions cultivated for wheat FF, Crd, Is, Fz, Ps, Ig, and growth rate is positively influenced. When an ordinary shock of fossil fuel is given to the green revolution factors, then the response shows that with an increase in the oil utilization, all the variables increased positively except the irrigation or the growth rate because, with the application of the oil utilization, the country has to import more oil which creates a gap between the balance of payment. With fossil fuel utilization, no doubt the water availability increases, but it also increases the cost of production, which in turn reduces the profit volume for the peasant.

Discussion

Precisely, credit disbursement, fossil fuel, and components of the green revolution have a positive relationship in the perspective of economic literature. More land was planted to meet the country's food requirements, and knowledge and technical developments were applied throughout the country. Improved seeds entail good pesticides, fertilizers, and irrigation availability. Tapping pressure on the industrial sector notably creates job opportunities to increase agricultural necessities to accomplish these requirements. Therefore, it will positively affect the growth rate. However, to irrigate the cultivated land needs be enhanced water reservoirs. It also can assist in producing more power which indirectly facilitates industrial growth.

In the 60s, the green revolution was introduced in Pakistan. However, in the same era, new inputs appeared and were employed in Pakistan to attain a high production level. The improved seeds, pesticides, fertilizers, and watering via tube well were considered the major components of the green revolution. To grow the agricultural sector, the Pakistan government introduces numerous developmental programs. This strategy affected agricultural production remarkably in Pakistan. These results substantiate the findings of Hamit-Haggar (2012) for Canada, Marrero (2010) for Europe, Admassie and Abebaw (2021) for Ethiopia, Nasir and Rehman (2011) for Pakistan, Kanjilal and Ghosh (2013) for India, and Shahbaz et al. (2015) for the United Arab Emirates, Ullah and Khan (2020) for Pakistan. We are well aware that the country's population is increasing, so there is always pressure on the agricultural sector to ensure food availability. For this purpose, more and more land was utilized for cultivation every year. The chemical fertilizers which are more effective and significantly affect production are readily available in the market. Once, peasants refused to use the high yield seeds, but now improved seeds are popular among the peasant. Fossil fuel utilization has increased to a greater extent, and currently, peasants are installing solar panels to irrigate their cultivated lands. Most importantly, credit availability to the peasants is very effective in the economy. Even the government has started to provide tractors to the peasant in very suitable conditions in the different agricultural areas of Pakistan.

CONCLUSION AND RECOMMENDATIONS

Pakistan's growing population has put pressure on the government to address the issue of food insecurity. This can be accomplished by enhancing agricultural growth. In this context, the farm sector has earned too much popularity in Pakistan's history and is remembered as a green revolution. The Johansen technique was employed for the required objective to assess the long-run connection between endogenous and exogenous variables. The model implies that all green revolution components favorably contribute to total wheat production in Pakistan.

Explicitly, the study has some suggestions. Generally, it is considered that the industrial sector is responsible for environmental degradation and pollution. But now, it is known that different research works showed that both industrial and agricultural sectors are responsible for environmental degradation. For example, we lost various birds with the heavy utilization of chemical fertilizers. Moreover, due to repeated cultivation processes, extensive fertilizers deplete soil fertility and even soil cleft. This spectacle triggered soil percolation, where the preservation of soil water capacity declines.

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